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SULPHUR MANAGEMENT FOR INCREASED PRODUCTIVITY OF INDIAN MUSTARD: A REVIEW

S.S. RATHORE[1], KAPILA SHEKHAWAT[2], B K KANDPAL[3], O.P. PREMI[4], S.P. SINGH[5], GOPI CHAND SINGH[6] AND DHIRAJ SINGH[7]

Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan, India 321 303
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ABSTRACT

Sulphur (S) is a crucial element for rapeseed-mustard in determining its seed yield, oil content, quality, and resistance to various biotic and abiotic stresses. Besides promoting chlorophyll formation and oil synthesis, it is an important constituent of seed protein, amino acids, various enzymes, and glucosinolate. Sulphur increases the seed yield of mustard by 12 to 48% under irrigated and 17 to 124% under rainfed conditions. In terms of agronomic efficiency, each kilogram of S increases the mustard yield by 7.7 kg. Intensification of agriculture and multiple cropping, coupled with use of high analysis S-free fertilizers and restricted use of organic manures, has accelerated the depletion of soil S reserves. Total S content in Indian soils ranged from 10 to 6319 mg kg^{-1}, but mean content is 30 to 300 mg kg^{-1} soil in most of agricultural soils. The increase in oil content of mustard due to S application is associated with the increase activity of an enzyme named acetyl-CoA carboxylase, which is also a precursor for oil synthesis. Sulphur is important for plants in another sense also that it dilutes the harmful effect of heavy metal toxicity caused by cadmium. Interaction of S with other nutrients is both synergistic and antagonistic. The recommendations for specific S fertilization for different zones in mustard based cropping systems have been made under All India Coordinated Research Project on Rapeseed-Mustard (AICRP-RM). In order to increase the S use efficiency, it is not only necessary to apply the correct amount (on soil test basis) in a balanced proportion with other limiting nutrient element in the soil, but it is equally important to apply it at the proper physiological stage of the plant. Although, the best time of S application is basal, but it may be top dressed also at 20-40 days of growth to get good yield. The experiments under AICRP-RM have revealed the higher response of mustard to foliar spray of thiourea at flowering and basal placement before sowing. Other than traditional S fertilizers, fortified S fertilizers, S coated fertilizers, liquid S fertilizers and moreover integrated use of S with organic manure has been proved better. In the present paper, the status of Indian soils, response of S to rapeseed-mustard, mainly Brassica juncea and enhancing S use efficiency through advancement in techniques including rate, method and sources of S have been reviewed.

Keywords: Sulphur, sources, rate, time of application, oil yield productivity, Indian mustard

INTRODUCTION

Sulphur (S) is one of the essential secondary macronutrient required for the growth, metabolism and development of all plants and is rightly called as the fourth major plant nutrient. S plays a vital role in different physiological and biochemical functions in plants. Sulphur deficiencies have been reported from more than 70 countries over the world, including India. Sulphur promotes oil synthesis, besides being an important constituent of seed protein, amino acid, enzymes, glucosinolate and chlorophyll (Holmes, 1980). Sulphur uptake and assimilation in rapeseed-mustard are crucial for determining yield, oil, quality and resistance to various stresses. Among the oilseed crops, rapeseed-mustard has the highest requirement of S. Sulphur increases the yield of mustard by 12 to 48% under irrigated, and by 17 to 124% under rainfed conditions (Aulakh and Pasricha, 1988). In terms of agronomic efficiency, each kilogram of S increases the yield of mustard by 7.7 kg (Katyal *et al.*, 1997). Rapeseed (*Brassica compestris* and *Brassica rapa L.*) has been observed to require 3-10 times more S than barley (Bole and Pitman 1984). Intensification of agriculture with high yielding crop varieties and multiple cropping, coupled with use of high analysis S-free fertilizers and restricted use of organic manures, has accelerated the deficiencies of S in arable lands. Continuous use of S free fertilizers has widened the ratio of N: P_2O_5: K_2O: S to 14.7:5.1:1.6:1 in India (TSI, 2014). There is urgent need to bring N: P_2O_5: K_2O: S to desired level through adoption of advanced techniques developed for sustainable S management. The average productivity of rapeseed-mustard in India is only 1145 kg ha^{-1} which needs to be enhanced up to 2562 kg ha^{-1} by 2030 for ensuring edible oil self reliance (DRMR, 2011). For attaining this productivity level, a comprehensive S management might play a major role. Improved S management will enhance oilseed productivity, especially of rapeseed-mustard through précised fertilizers addressing the deficiencies.

[1]Senior Scientist, [2]Scientist, [3]Principal Scientist, [4]Principal Scientist, [5]Senior Scientist (Plant Physiology), [6]Subject Matter Specialist, KVK, Bichpuri, [7]Director, DRMR Bharatpur (Rajasthan)

Sulphur in soil

The organic S compounds in the soil constitute up to 98% of the total soil S and it is a heterogeneous mixture of plant residues, animals and soil microorganisms. In many ways, S behaves and reacts in the soil as nitrogen. Like N, S is a mobile nutrient that may move rapidly through the soil, especially through sandy surface layers. Sulfate is negatively charged and is subjected to leaching. Soluble sulfates seldom accumulate in the upper soil layer (30 cm) because they are leached into the B-horizon. Sulphur often accumulates in the sub-soil where soluble Sulphur is absorbed by iron and aluminum oxides. Sulphur accumulation increases as subsoil acidity increases. Sulphur is mineralized from organic matter to sulfate and mineralization depends upon the C: S ratio. The critical range is 200-300:1. If it is < 200:1, then net mineralization and if it is > 300:1, net immobilization occur. Sulfate can be tied up (immobilized) by soil microbes if the residue contains a low amount of S. Sulfate can also volatilize as hydrogen sulfide (H_2S) under water logged condition.

Atmospheric S can contribute about 5-10 kg ha^{-1} of S per year. The absorption and translocation of S in the soil depends upon the soil characteristics also. For absorption study, Freundlich adsorption isotherms help in understanding movement and retention of added S in the soil. Among gypsum and K_2SO_4 as source of S, K_2SO_4 migrates deeper than gypsum. About 28 to 38% of the added S is retained in the 90 cm depth of the profile. Maximum increase in total S content by S application is recorded in upper soil layer. Soluble S accumulation increases in the 30 to 75 cm of depth, where as proportion of sorbed fraction of S increases with depth. Building up of S in the surface layer due to the increase in organic fraction in lower layer of the profile is through increase in soluble and sorbed fraction of S (Saha *et al*. 2002). Total S content in Indian soils ranged from 10 to 6319 mg kg^{-1}, but the mean content is found to be 30 to 300 mg kg^{-1} in most of the agricultural soils.

Most of the soils of Indo-Gangetic plains, red, latreitic and hill soils are prone to S deficiency while coastal soils are reported to be adequate in it. Sulphur deficiency is also wide spread in calcareous as well as medium and shallow black clay soils due to low organic matter content. Most of the saline soils and acid sulfate soils of Sundarban areas of West–Bengal and coastal Kerala contain excessive amount of S as sufide or soluble sulfate which causes severe injury in plants. So, there is wide variability in total S content in soils of various states of the country (Singh, 2000). Sulphur deficiency is most likely in coarse-textured soils, low in organic matter, high rainfall areas, crop rotations including pulses and oilseed, continuous use of S-free fertilizers and sites away from industrial activity associated with the emission of S containing gasses. Determining S deficiency is not simple but a combination approach of integrating several factors in to the S deficiency equation can be useful. Like in plants, in soils also there are some indicators, which help in diagnosing deficiency in soil (Tucker, 2002).

Response of rapeseed-mustard to sulphur

Sulphur has some specific role in oilseed crops. Rapeseed-mustard requires 0.33 to 0.40% S in leaf for obtaining 90% of its potential yield (Cheema and Arora, 1984). Oilseeds (*Brassica* species/cultivars) vary in their sensitivity to sulphur deficiency and S requirement for optimum seed yield and quality (Malhi *et al.*, 2005). Plant tissue should contain one part of S for every 15-20 parts of N for optimum growth and production. Its concentration varies among species and it ranges from 0.1-0.6 % of the dry matter (De Kok *et al*., 1997). Sulphur partitioning at various growth stages of Indian mustard shows that the maximum S concentration lies in the leaves (Fig. 1).

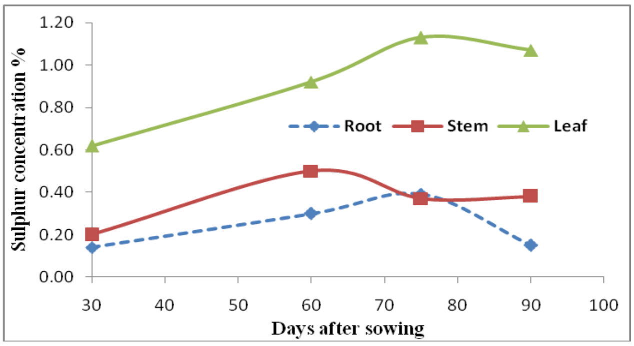


Fig 1: Sulphur content in Indian mustard

Plants contain a large variety of organic S compound, as thiol (glutathione) and secondary S compound (allins, glucosinolate, phytochelatine etc.) which play important role in the physiology and protection against environmental stress and pests (De Kok *et al*, 1998). Sulphur deficiency results in accumulation of amides and carbohydrates and in turn, retards the formation of chlorophyll and causes stunted plant growth and pale green coloration of young leaves.

Sulphur is an essential element in forming protein, enzyme, vitamins and chlorophyll in rapeseed-mustard like in other plants. Three S containing amino acids *viz*. methionine (21% S), cysteine (26% S) and cystine (27% S) are the building blocks of proteins. Out of the total plant S, about 90% is present in these amino acids (Tandon and Messick, 2002). Sulphur is also a constituent of plant hormones like thiamine and biotin, both of which are involved in carbohydrate metabolism. Cysteine is the precursor of glutathione, a water-soluble thiol compound which functions in the protection of plant against oxidative stress, heavy metal toxicity and xenobiotics. Sulphur helps in the synthesis of sulfhadryl protein, –SH group which helps the plant to tolerate dry and cold stress condition. Sulphur compounds are also of great importance for food and quality and for the production of phyto-pharmaceuticals. It activates certain enzyme systems and is a component of some vitamins (Vitamin A). Sulphur is found in mustard oil glycoside, which imparts characteristics odors and flavor to plants like mustard. Many plant species, particularly Brassicaceae crops, incorporate S into a wide range of secondary compounds such as the sulfation of flavonol, desulfoglucosinolate, choline, and gallic acid glucoside (Leustek and Saito, 1999). Several studies show that glucosinate levels in Brassicaceae vegetables will change in response to S and nitrogen fertilizer treatments (Aires *et al.*, 2006). Chhonkar and Shroti (2011) reported an increase in growth characters of mustard. Singh and Singh, 1983 reported enhancement of the chlorophyll synthesis in mustard, Sah *et al*. (2006) reported that all growth attributes increased significantly up to 40 kg S ha^{-1}. The results showed that the uptake of NPK and S by both seed and stover increased significantly with successive increase in N levels up to 120 kg N ha^{-1} and S levels up to 60 kg S ha^{-1} (Sah *et al*., 2006). Chlorophyll content in mustard increases with increasing levels of S up to 60 kg S/ha and linear regression was observed.

Yield attributes of Indian mustard increased significantly with increasing level of S up to 45 kg ha^{-1} (Issa and Sharma 2007). The increase in yield attributes of mustard with increasing level of S may be ascribed to the role of S in improving mineral nutrition of the crop (Chauhan *et al*. 2002, Rana *et al*. 2005). Optimum seed and oil yield of mustard occurred at about 20 kg S ha^{-1} (Zhao *et al*. 1994). The application of S at the rate of 100 kg ha^{-1} increased S uptake by 10–15 kg ha^{-1} and applications of N at a rate of 300 kg ha^{-1} increased S uptake by 29–34 kg ha^{-1} in double and single low varieties of oil seed rape. Deficiency of S results in severe yield losses to Indian mustard, due to its higher demand for the synthesis of protein, co-enzymes, S- containing amino acids and glucosinolates (De Kok et *al*., 2000). Sulphur starvation evokes alterations in the pools of several metabolites followed by disruption in nitrogen metabolism. In general, the S levels between 30-40 kg S ha^{-1} enhanced the oil and seed yield of Indian mustard (Fig 3).

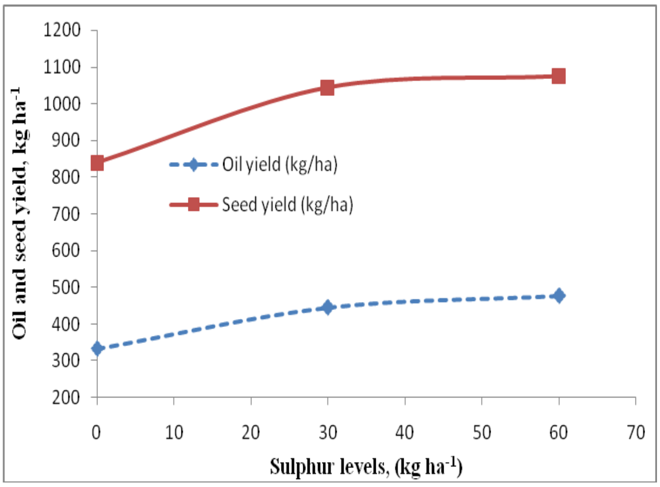


Fig3: Seed and oil yield of Indian mustard under different doses of Sulphur

A significant increase in yield was observed with increase in S levels up to 40 kg S ha^{-1} in mustard based cropping system. In rice-mustard sequence, the optimum seed yield of mustard was obtained at 40 kg S ha^{-1} at Behrampore and for blackgram-mustard at Dholi. Each successive increase in S level increased seed yield up to 20 kg S ha^{-1} at Dholi and Ludhiana, 40 kg S ha^{-1} at SK Nagar and 60 kg S ha^{-1} at Behrampore and Morena conditions (AICRP-RM, 2008). The various sources of S also have impact on different yield attributes and yield. Application of bentonite S gave significantly higher growth, yield attributes, seed yield, than to gypsum and wettable S (Fig 4).

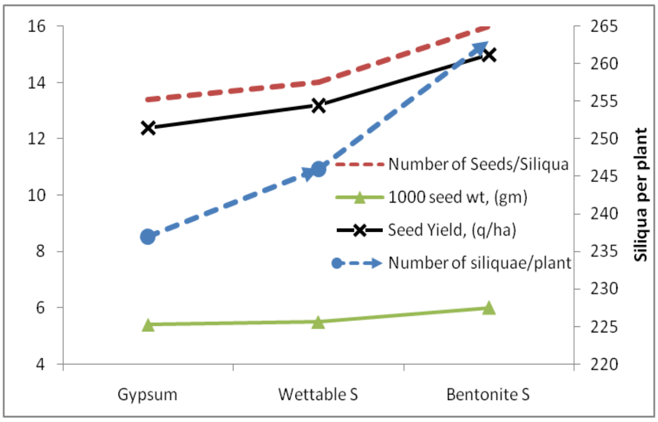


Fig 4: Response of Indian mustard to different S sources

Pandey *et al.* (2010) reported significant interaction between S levels with mustard genotypes with respect to grain yield (Table 1). Mustard variety Varuna and Kranti at 20 kg S ha^{-1} produced significantly higher.grain yield than Pusa Bold at 30 kg S ha^{-1}. Similarly these varieties at 30 kg S ha^{-1} level also produced significantly higher grain yield than Pusa bold at 40 kg S ha^{-1}.

Table 1: Effect of S levels on seed yield (kg ha^{-1}) of three mustard genotypes

Levels of S (kg ha^{-1})	Varieties		
	Varuna	Kranti	Pusa Bold
0	743.0	649.0	613.0
10	945.0	892.0	793.0
20	1077.0	1014.0	843.0
30	1143.0	1112.0	889.0
40	1178.0	1189.0	910.0
CD (P=0.05)	175.0		

AICRP-RM (2009) reported highest seed yield of mustard under black gram-mustard cropping system with 60 kg S ha^{-1} at Dholi (Fig 5). Pooled data for 6 years also revealed superiority of black gram-mustard sequence with application of 20 kg S ha^{-1} over other treatments.

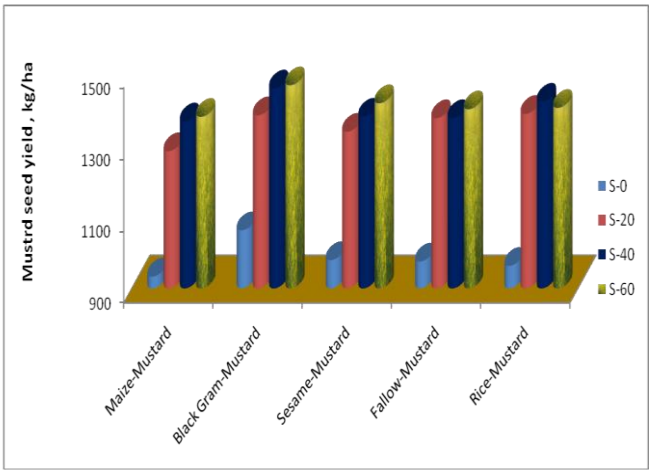


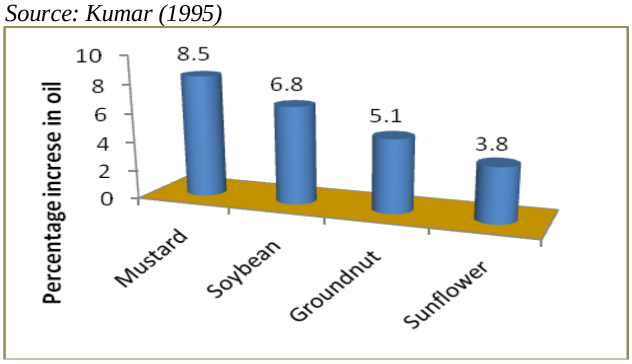
Fig. 5: Response of mustard under various cropping systems to sulphur levels

Sulphur application significantly increased the oil content in Indian mustard (Bhagat and Soni 2000; Saha and Mandal 2000; Chauhan *et al.*, 2002; AICRP-RM, 2003 and Shukla *et al.*, 2005; Rana *et al.*, 2005; Issa and Sharma 2007; Sardana *et al*, 2008; Degra 2008; Pandey *et al.*,2010; Nanjundan et al , 2011; Dash and Ghosh 2012). The increase in the oil content in the seeds of mustard is associated with the increase in acetyl-CoA carboxylase activity, which is also precursor for oil synthesis. Foremost, S is a constituent of methionine, the first amino acid required in the protein synthesis (acetyl-CoA carboxylase). Subsequently, S is associated to the proper functioning of nitrate reductase (Ahmad *et al.*, 1999), the enzyme regulating the flow of NO_3^--N into the amino acids and subsequently into protein synthesis. Hence, the application of S influences oil accumulation in developing seeds of mustard by enhancing protein synthesis (Inayat *et al.*, 2010). Kumar (1995) and Pankaj et al (2010) reported linear correlation between the levels of S and protein and oil content in toria (M27). Interestingly, higher levels of S maintained maximum protein and oil content in toria, otherwise there is negative correlation between these two important characters (Table 2). Sulphate-S application was reported to increase oil in canola seed also (Malhi and Gill 2002; Malhi *et al.*, 2005).

Table 2: Effect of different doses of S on yield, oil content and protein content of toria

Doses of S (kg ha^{-1})	Protein content in seed (%)	Oil content (%)	Oil yield (kg ha^{-1})	Seed yield (kg ha^{-1})
0	24.6	39.6	332.2	839
30	26.5	42.6	444.7	1044
60	27.6	44.3	476.6	1076
CD (5%)	1.1	1.2	29.9	66.0

Source: Kumar (1995)



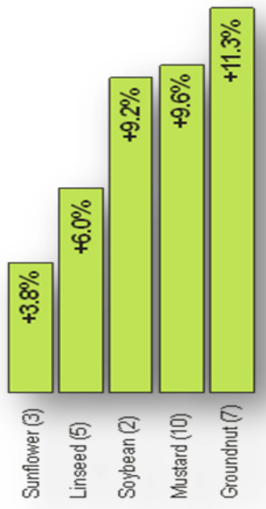


Fig 6: Increase in oil content of various oilseeds due to S application

Crops differ in their S requirement, absorption and their utilization capabilities within plant parts. Also, their capacity to mobilize native S reserves of the soil is different. Among all oilseed crops, maximum increase in oil content due to S application has been reported in Indian mustard (Fig 6). Relative susceptibility of oilseeds to S stress in general is in order of Raya> Mustard> Linseed> Sesame. Pankaj et al. (2010) also reported a reduction in eurecic acid in mustard with sulphur application. Not only oilseed crops, but their cultivars too vary in their yield potential and relative tolerance to S stress. Similarly, tolerance of mustard cultivars to stress were recorded in the order of Pusa Bold> Varuna> Gj-1. Magnitude of response varied from 26-35% over control S treatments. Oil content in Canola-4 and Hyola-401 is 3% higher than the hybrid 'PGSH-51' due to the effect of various doses of nitrogen and S, while the oleic acid content in these hybrids are double than 'PGSH-51'. 'PGSH-51' had erucic acid ranging from 23.2 and 29.4%. At higher S level there is 2-3% reduction in erucic acid content. Higher doses of S along with low doses of nitrogen affect the chain elongation enzyme system thereby leading to reduction in erucic synthesis (Table 3).

Table 3: Effect of N and S application on fatty acid composition and glucosinolate content in *Brassica juncea* cv. Varuna at Ludhiana

N (kg ha^{-1})	S ($kgha^{-1}$)	Glucosinolate (µ moles/g in defatted meal)	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Eicosenoic acid	Erucic acid
75	0	64	2.61	1.17	11.78	14.99	6.48	50.91	11.80
75	20	72	2.88	1.31	10.15	14.53	5.14	52.75	12.28
100	0	52	2.58	1.58	13.16	15.31	7.01	49.55	10.57
100	20	42	2.91	1.65	11.94	15.06	6.13	49.63	12.18
125	0	52	3.01	1.33	12.19	16.17	5.91	47.71	12.26
125	20	42	4.42	1.31	16.12	16.55	6.57	44.77	9.55

Source: AICRP-RM (2007)

Sulphur as phytoremediator

Sulphur is also an important element in diluting the harmful effect of heavy metal toxicity caused by cadmium. A complex is formed between S and cadmium, which is retained in the vacuoles as cell waste. The stability of the plastocyanin-cadmium complex is enhanced by additional S ions once the complex is in the vacuole (Oritz *et al.*, 1992). Sulfate salts increases cadmium uptake and tolerance by facilitating S uptake which enhances glutathione production which in turn increases plastocynin production, allowing the plant roots to complex more cadmium, reducing toxicity, and allowing more uptake of cadmium. High concentration of cadmium in the soil increases a toxin called malondialdehyde (MAD) content in both roots and shoots which results in dramatic reduction in growth parameters of the plant including plant height, root and shoot weight, tillers per plant, chlorophyll content and net photosynthetic rate. Increased S levels help to increase in growth parameters and a reduction in cadmium and MAD content. In addition super oxide dimutase (SOD) activity also reduces and glutathion content increases, indicating a positive effect of S in alleviating oxidative stress (Hassan *et al.*, 2005).

Interactive effect of S with other nutrients

The S uptake of the crop mostly depends upon the balance between the S and other nutrient element within the plant as well as soil. S has some synergistic and antagonistic effect with other nutrient elements. Since, N and S are both closely linked in protein metabolism, the interaction between N and S is reported to be synergistic. These two nutrients increased the concentration and uptake of each other in the plant. An antagonism between P and S has been established. However, several studies also reveal that there is a positive interaction between the two. The P and S interaction happened to be synergistic at low to medium level of P is maintained. Based on the results of three years of field experiments on mustard, maximum increase in oil yields was obtained at 75 kg ha^{-1} N and 60 kg S ha^{-1} S, which indicates a significant positive interaction between than. Adequate N: S ratio has been found to be 7.5:1 in grains, above which deficiency of S can be observed (Aulakh *et al.*, 1980).

Adequate S must be applied to rapeseed-mustard for optimum nitrogen utilization. Sulphur is also required for utilization of P and other essential nutrients. Sulphur ranks equal to N for optimizing crop yields and quality. It increases the size and weight of seed crops and enhances the efficiency of N for protein manufacture. S is major nutrient factor influencing partitioning of P: S and nitrogen accumulation in plant especially the symbiosis nitrogen fixation in legumes (Dwiwedi *et al.*, 2005).

The N and S relationships are very important in *oilseed Brassicas* (Jackson, 2000). The application of mineral S fertilizer dramatically increases seed yield and S uptake of oilseed rape (McNeill *et al*., 2005). Jackson (2000) investigated the four N rates in combination with three S rates and the results showed that the seed yield and oil content were closely related to available nitrogen. Oilseed crops, such as rape and mustard, are sensitive to S and/or K deficiency (Malhi *et al*., 2007). Oil content increases up to 46.6% with 45 kg S ha^{-1} as compared to the oil content of 42.8% with no S. The K and S interaction on protein content of rape and mustard showed that when applied with the lowest level of S, oil content significantly increased with each increment in K level. In contrast, at highest level of S, oil content decreased significantly with each increment in K level. On the other hand, at 30 kg S ha^{-1} rate, protein content increased when K level was increased to 60 kg K ha^{-1} (Amanullah *et al*., 2011).

Sulphur management in rapeseed-mustard

Rates of S application

The rate of S application also varies depending upon the soil and crop needs but 20-50 kg S ha^{-1} is generally recommended. The application rate should be correlated with both crop needs and S status in the soil (Table 4). The AICRP-RM trials on use of S for enhancement of quality and productivity revealed that 40 kg S ha^{-1} increased seed yield and net return in different mustard based cropping sequences. Application of sulphate-S at about 15-30 kg S ha^{-1} is usually sufficient to prevent S deficiency in canola on most of the S-deficient soils.

Table 4: S fertilizer recommendations based on available S status of soils

Available S in soil (mg kg^{-1})	**S fertility class**	**Increase in yield (%)**	**Soil deficiency class**	**Amount of S fertilizer added (kg ha^{-1})**		
				Cereal	**Oilseeds**	**Pulses**
<5	Very low	25-85	Very high	60	40	30
5-10	Low	20-50	High	45	30	20
10-15	Medium	5-20	Moderate	30	20	15
15-20	High	1-5	Low	15	10	10
>20	Very high	0	Very low	0	0	0

Source: Patel et al. (2001)

The trials under AICRP-RM have come out with many recommendations for the levels of S. Addition of S invariably in all types of soils in mustard along with zinc in zinc deficient soils was recommended during 1999-2000. In the cropping system mode for different zones, 40 kg S ha^{-1} should be applied in different cropping sequences involving mustard (2000-01). The adoption of guar-taramira system was remunerative with 40 kg S ha^{-1} over fallow–taramira sequence at Jobner and be adopted in semi-arid eastern plain zone of Rajasthan . Application of 40 Kg S ha^{-1} to toria crop proved to be remunerative at Shillongani and be adopted in Assam (2001-02) in cluster bean-mustard sequence. In pearl millet- mustard sequence, application of 80 Kg N + 30 kg P_2O_5 ha^{-1} along with 10 t FYM + 40 kg S + 25 kg $ZnSO_4$ in the mustard crop is recommended for southern parts of Haryana (2003-04). The S recommendation was also made as a part of INM as application of 10 t FYM ha^{-1} + 40 kg S ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} + 1 kg B ha^{-1} + seed treatment with Azotobactor for obtaining higher and sustainable yield of mustard (1998-99). Application of RDF + 10 t FYM 40 kg S + 25 kg zinc sulphate + 1 kg boron ha^{-1} (taramira) was found remunerative and can be adopted in semi-arid eastern plain zone of Rajasthan, particularly in soils having deficiency of these nutrients (2002-03) during 2004-2005, INM practices i.e RF + 2 t FYM (in seed furrows) + 40 kg S + 25 kg $ZnSO_4$ + 1 kg boron + Azotobector (seed treatment) is recommended for getting higher seed yield of mustard in zone V (Shillonganil) over recommended fertility level and 2 t FYM ha^{-1} (in furrows) + 40 kg S ha^{-1} (through gypsum) over 75% of recommended fertility was found more remunerative in moong-mustard cropping sequence and is recommended for North Gujarat condition. At SK Nagar, Gujarat application of 40 Kg S through gypsum was found remunerative at for North Gujrat areas and spray of thiourea (0.1%) at flower initiation along with basal application of 40 Kg S ha^{-1} through gypsum could be done in North – Western Part of Rajasthan during 2003-04.

Degra *et al.*, (2008) found significant increase in yield attributes and seed yield and significantly highest net returns, B: C ratio (2.5:1) of mustard up to 60 Kg S ha^{-1} at Durgapura, Rajasthan. At Bawal and Morena, highest seed yield 2060 kg ha^{-1} was obtained with 40 kg (S ha^{-1}) + thiourea (0.1%). At Sriganganagar, significantly higher seed yield (1883 kg ha^{-1}) was recorded at 40 kg S ha^{-1}+thiourea (0.05%), urea (2%), H_2SO_4 (0.1%) and 40 kg S ha^{-1}. The highest oil content (35.9%) was recorded with thiourea 0.1% spray. Glucosinolate content ranged from 115-154 (μ mole/g defatted meal) in different treatment (Table 7). Sulphur increased the yield of mustard by 12 to 48% under irrigation, and by 17 to 124% under rainfed conditions.

Method and time of application

In order to increase the S use efficiency, it is not only necessary to apply the correct amount (on soil test basis) in a balanced proportion with other limiting nutrient element in the soil, but it is equally important to apply it at the proper physiological stage of the plant. Since, S is leachable, like nitrate, it is safer to apply close to the time of plant uptake by splitting the doses. This is especially true for sandy soils. Band application is recommended, but broadcasting also works well if adequate rainfall or irrigation is available to leach the S into the root zone. Side-banding is the most effective way to apply sulphate-S fertilizers to produce maximum seed yield and to prevent any damage to mustard seedlings. In relatively moist areas, broadcast-incorporation methods can produce seed yield similar to side-banding in most years (Malhi, et *al.*, 2005). The S mineralizaiton rate is highest for crucifers (57- 85% of the total S added) and lowest for legume (up to 46% of total S added). Only limited amounts of sulphate S fertilizer can be safely applied near the seed. Application of sulphate-S to mustard at seeding time gives the highest increase in yield and S uptake (Malhi *et al.*, 2005).

The best yield response to sulphate S fertilizer was at 30 kg S ha^{-1} either incorporated or side banded before sowing, as illustrated (Fig7). Applications at sowing are generally more effective than at early flowering stages.

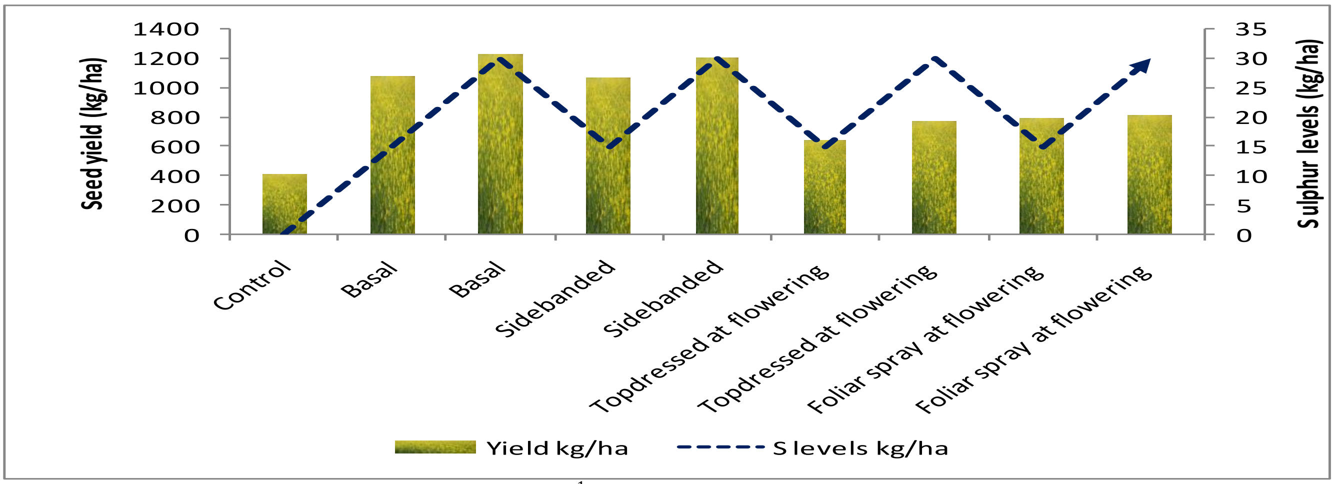


Fig. 7: Increase in seed yield (kg ha^{-1}) under different methods and levels of S fertilizers

Application of sulphate-S at bolting can significantly restore seed yield, while an application at early flowering can moderately correct S deficiency damage (Malhi, *et al*, 2005). Sulphur is less mobile than nitrogen within the plant parts. Since, S requirement of the crop is more at early growth stage, its application should be made prior to bud initiation or flowering to ensure better crop yields. However, on the basis of critical value of S in plants, application of S fertilizers should be done (Table 5). Deficiency of S in rapeseed-mustard could be determined by plant tissue test for total. But, the S provided by this method may be late to cure the S deficiency and restore seed yield of the current crop to optimum levels. The ratio of hydriodic acid reducible (HI-S): total S in plants at the rosette stage was found to be the most accurate index of status of S in plants, and a ratio of less than 0.38 may reduce seed yield due to S deficiency in canola plants (Maynard *et al*. 1983). If the N: S ratio is more than 15:1, S fertilization should be done. Histuda *et al.*, (2005) demonstrated that tolerance to low externals (<2.0 mg L^{-1}) and the critical tissue S levels for S deficiency varied significantly among species tested of oilseed *Brassica*.

Table 5: Critical levels of S in selected 45-55 days old crop plants

Crop	S concentration in dry matter (%)		
	Deficient	**Moderately sufficient**	**Sufficient**
Mustard, groundnut, soybean, cowpea, French bean	0.10-0.25	0.25-0.45	>0.45

In case, if the S application is missed at sowing, S may be top dressed to 20-40 days of growth to get good yield. The foliar spray of S is less effective as compared to its soil application because of the high S requirement of the crop. The trials under AICRP-RM, 2003 revealed better results of foliar spray of thiourea at flowering and basal placement of S before sowing (Table 6). If S deficiency symptoms appear on foliage, 3-5 sprays of 0.5% soluble sulfate salts like ammonium sulfate, potassium sulfate, zinc sulfate etc. can be done on the standing crop.

Table 6: Seed yield, net returns, and quality of mustard as influenced by foliar application of S sources

Treatment	S.K.Nagar		Sriganganagar	Ludhiana		
	Seed yield (kg ha^{-1})	**Net returns over control**	**Seed yield (kg ha^{-1})**	**Oil content (%)**	**Oil yield (kg ha^{-1})**	**Glucosinolate (µ mole/g defatted meal)**
Control	1707	-	1604	34.7	375	130
Thiourea (0.1%)	2087	3226	1696	35.9	429	142
40 kg S ha^{-1}	2249	6712	1799	35.2	405	149
40 kg S ha^{-1} + Thiourea (0.1%)	2039	4070	1883	33.4	411	134
$ZnSO_4$ (0.5%)	1921	4622	1667	33.2	372	126
CD at 5%	150	-	158	-	-	-

Source: AICRP-RM, 2003

Sources of sulphur

As the S containing fertilizers are expensive and therefore their efficient and judicious use should be made to incur higher benefits. The selection of S fertilizers commonly used for correction of deficiency in different soils and crops depend upon their cost and easy accessibility. Strategies for efficient management of S fertilizers are listed in Table 7.

Table 7: Sulphur carrying fertilizers and their management in different crops

S No.	Fertilizer	S content (%)	Management
1	Ammonium sulfate	24	Integrated N+S application, particularly for topdressing
2	Single super phosphate	16	Integrated P+S application for basal dose.
3	Potassium sulfate	18	Integrated K+S application for chloride sensitive crops
5	Elemental S	85	For fine textured calcareous soil. Application 3-4 weeks before planting in soil
6	Pyrite	22	Suitable for alkaline soil. Surface application before planting
7	Gypsum	18	For crops requiring high calcium
8	Zinc sulfate	15	Depending upon the zinc needs of the crop

Sardana, (2008) reported an increase in seed yield of 8.9% with foliar application of thiourea @ 0.05% at flower initiation to 22.2% with soil application of 20 kg S/ha as gypsum at sowing+ foliar application of thiourea @ 0.05% over control. Net returns and B: C ratio were higher with basal application of 20 kg S ha^{-1} through gypsum + foliar application of thiourea (0.05%) closely followed by spray of 0.15% Sic acid and soil application of gypsum to supply 40 kg S ha^{-1}. When pyrite is used as a source of S, it should be broadcasted as fine powder on soil surface under moist condition 7-10 days before sowing to ensure high conversion of unavailable S to plant available form. Application of bentonite S gave significantly higher growth, yield attributes, seed yield, oil yield, nutrients (NPS) uptake, net return , B: C ratio, production, economic and water use efficiency, than to gypsum and wettable S (Tetarwal *et al*., 2013). A variety of S-bentonite fertilizers have been produced to improve the effectiveness of granular elemental S. Particles of S-bentonite are sized for blending with solid N, P and K fertilizers. When it is applied to soil, this bentonite component imbibes soil moisture, causing fertilizer granules to disintegrate into finely divided S, which is more rapidly converted to SO_4^{2-}. Nibedita et al., 2009 reported maximum increase in seed and oil yield (Fig 8) of rapeseed (*Brassica campestris L.*) due to spray of 0.15 and 0.2 % nitrosulf (a liquid formulation with 33 % S).

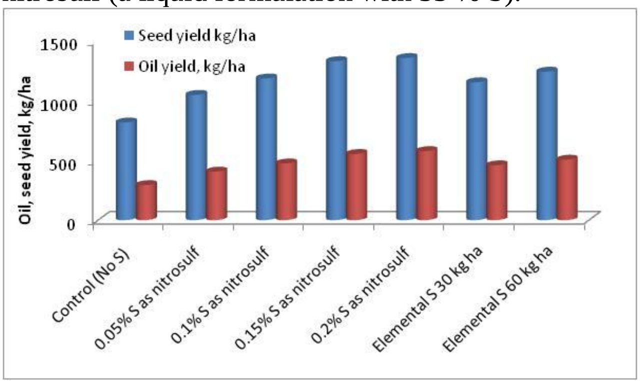


Fig 8: Effect of liquid and elemental S on seed and oil yield of rapeseed

Das and Ghosh (2012) observed maximum increase in seed yield due to magnesium sulphate at every level (Table 8). The maximum seed yield was obtained with 40 kg S ha^{-1} applied as magnesium sulphate. Further, better response was reported with $MgSO_4$ over gypsum at 40 and 60 kg S ha^{-1} to Indian mustard, an increase in seed yield was 14.3-22.5 %.

Table 8: Effect of sources and levels of S on seed yield of mustard

Source of S	S levels (kg ha^{-1})	Seed yield (kg ha^{-1})	% increase over control
Gypsum	20	1705	14.3
Magnisium sulphate	20	1777	19.1
Gypsum	40	1799	20.6
Magnisium sulphate	40	1828	22.5
Gypsum	60	1782	19.4
Magnisium sulphate	60	1806	21.0
Control	0	1492	-

Fortified S fertilizers

Elemental S can be readily incorporated into N/P fertilizer materials to provide 5% to 20% S. Monoammonium and diammonium phosphates (MAP or DAP) containing from about 5 to 20% S can be made. S in granulated triple superphosphate (TSP) and DAP fertilizers oxidizes faster than S alone in both acid and calcareous soils. This S-enriched SSP has received attention in the area with high leaching losses of plant nutrients because of its potential for reducing SO_4^{2-} leaching loss and also providing available SO_4^{2-} to meet crop needs during the whole growing season.

Sulphur Coated Fertilizers

S coated urea (SCU) is a controlled release N fertilizer consisting of an S shell around each urea particle. It contains 77% to 82% of urea (36% to 38% N) and 14% to 20% S coating.S coated urea has the greatest potential for use in situations where multiple applications of soluble N sources are needed Although S in the coating may not be sufficiently available to correct deficiencies during the early season of the first year after application, it will become an important source of plant available S in the latter growing season and succeeding year.S coating may also be used to intentionally supply plant nutrient S.

Liquid S Fertilizers

Low water solubility hampers the use of mainstream sulphate fertilizers such as ammonium sulphate and potassium sulphate. Hence the liquid or suspension S fertilizer formulations have gained importance. Ammonium thiosulphate solution (ATS) is a 60% aqueous solution with 12-0-0-26S analysis. Potassium thiosulphate (0-0-25-17S) and calcium thiosulphate solution is suited as a starter fertilizer for crops and situations requiring these other nutrients besides S. They are clear liquid fertilizers which are suitable for direct applications or blending, offers versatility to farmers and fertilizer retailers.

Integrated use of S with organic manure

Organic bound S is the potential source of plant available S in many soils. Therefore, use of organic manure improves the availability of S in soils and leaves residual effect for longer time. Application of 20 (kg S ha^{-1}) + 5 t FYM to a crop carries significant residual effect for the succeeding crop and it also increases utilization efficiency of native S. Integrated effect of pyrite in combination with 10 t ha^{-1} of FYM or pressmud results in significant increase in yield than their alone application.Catch crop may help to avoid S deficiency and increase synchrony between plant demand and available soil S in the crop rotation. Though they can't fulfill the need of S demanding crops, but they can make important supplement as nutrient source. Catch crop might reduce sulfate leaching and therefore increase the overall S use efficiency in crop rotation. Although all crops including leguminous, ryegrass etc. are beneficial, the best catch crop (legume on sandy soil), sequester 10-12 kg S ha^{-1} and poorest catch crop sequester < 3.0 kg S ha^{-1} (Erickson *et al*., 2000).

Conclusion

Sulphur is now known as the fourth major plant nutrient, along with N, P, and K. High yield of good quality produce becomes possible only when crops have access to optimum amount of S. Sulphur is a component of three main amino acids namely; cysteine, cystein and methionine, hence essential for protein synthesis. Presently the gap between the removal and addition of the S is 0.5 million tonnes of available S and it is likely to widen to further 2 million tonnes by the year 2025. S is the cheapest nutrient out of four major nutrients required by the crops (N, P, K and S). Its application is less expensive but gives high profits than other nutrients. Sulphur deficiency from Indian soils can only be eliminated by the proper management of S in crops. Application of S not only helps in sustaining high yields but also improves quality of the produce of rapeseed-mustard. Mustard responds well to S levels of 40-60 kg/ha through SSP, gypsum, or betonite S. The oil in rapeseed-mustard could increases by 3-9%. This is important in Indian context as the country is short of vegetable oils and is importing a sizable amount of foreign exchange every year. For obtaining the best-desired results from S application to the deficient soils, proper measures should be taken to improve the effectiveness of the S fertilizers. Strategies need to be developed to encourage more use of S through judicious mix of fertilizer S, byproduct S, and organic manure attaining sustainable high mustard productivity.

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EFFECT OF PHOSPHORUS AND POTASSIUM ON YIELD AND NUTRIENT UPTAKE OF RICE UNDER IPNS IN AN INCEPTISOL OF ASSAM

K.N. DAS*, A. BASUMATARY AND SABINA AHMED

Department of Soil Science, Assam Agricultural University, Jorhat, Assam 785 013
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ABSTRACT

*A soil test crop response based field experiment was conducted in an Inceptisols (Aeric Endoaquepts) of Assam during Kharif season of 2011 following Ramamoorthy's Inductive-cum-targeted yield model to explicate the relationship between soil tests and response of winter rice to applied fertilizers under integrated plant nutrition system (IPNS). The nutrient requirement for producing one quintal of rice grain on an average was 1.75, 0.65 and 1.83 kg N, P and K, respectively. The results also indicated that integrated application of chemical fertilizers and FYM increased the grain and straw yield, and N, P and K uptake in rice as well as enhanced organic-C and available N, P and K in soil. Omission of nutrients caused yield loss between 18% (- P) and 15.3 % (- K) and uptake decreased by 44.0 and 28.9 %, respectively. Conversely, plots receiving P and K fertilizers alone could significantly increase grain yield by 4.7% and 10.2%, respectively over control. The P and K uptake were increased by 36.9 and 33.2 % respectively, over control due to individual addition of P and K with respective apparent recovery of 6.1 and 14.2 %. Apparent recovery increased by 21.3 and 74.9% for P and K, respectively with application of NPK together. Uptake of all the nutrients was significantly correlated with yield (r= 0.935**, 0.825** and 0.326** for N, P and K, respectively), suggesting interdependence of nutrient uptake that influenced yield. Build up of organic-C and available NPK was more pronounced in chemical fertilizer treated plots.*

Key words: Phosphorus, potassium, winter rice, soil test crop response, IPNS, nutrient uptake

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food grain in India contributing 41.5% to the total food grain production. *Sali* or winter rice is the dominant crop of Assam covering 17.73 lakh hectares out of the total rice area of 24.84 lakh hectare with a productivity of 1674 kg ha^{-1} as against the national average of 2240 kg ha^{-1}. Phosphorus (P) and potassium (K) along with N are essential macronutrients that must often be applied to maintain the productivity of cropped soils and prevent deficiencies of these nutrients from limiting crop yields. Deficiencies of P and K are sporadically but frequently observed in rice fields in Assam. Generally, rice grown on acid soils is susceptible to P-deficiency and shows symptoms during the seedling to maximum tillering stages. In contrast, K-deficiency symptoms typically appear during the seedling and boot stage. Potassium deficiency in rice has been documented on soils with a wide range of chemical properties in Assam, while deficiencies are most common on soils with pH <5.0 that have low soil K concentrations. Although P and K deficiencies of rice occur every year, they are relatively uncommon and research studies have seldom shown significant rice yield increase from P and K fertilization. Inceptisols occupy about 49.3% of the total area of Assam and are mostly acidic in reaction and contain high amounts of Fe and Al oxides and hydroxides. Fixation of applied P by such oxides and hydroxides is a common problem that hinders uptake of P by crops. Awareness about appropriate P and K application rates for rice in such soils among the farmers is critical to improve productivity. One of the reasons for lower productivity of rice in the state is the imbalanced fertilization of N, P and K nutrients. High cost of fertilizers is remaining constraint for the farmers to apply adequate amount of fertilizers to crop. Accurate fertilizer recommendations require fertilization trials to be conducted routinely to account for changes in production systems, cultivars, crop-nutrient removal due to increasing crop yields, and changes in soil fertility. Soil test based application of plant nutrient helps to realize higher response ratio and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000). In Assam, works on soil test crop response correlation under integrated plant nutrition system (STCR-IPNS) has not yet been initiated. Hence an effort was made to study the influence of integrated nutrient management on rice yield and tissue concentration of P and K in response to fertilizers application under IPNS in STCR experiment on acidic Inceptisols of Assam.

Corresponding author: E-mail ID: daskn388@gmail.com

MATERIALS AND METHODS

A field experiment based on STCR methodology with rice variety Ranjit was conducted at the Assam Agricultural University Experimental Farm, Jorhat located at a latitude of 26°48′N and longitude of 95°50′E during Kharif 2011 in Inceptisols (Aeric Endoaquepts). The soil of the experimental field was sandy clay loam with pH 5.1 and organic carbon 6.0 g kg^{-1}. The amount of available N, P_2O_5 and K_2O were 213, 15 and 90 kg ha^{-1}, respectively. The STCR-test crop experiment (Ramamoorthy *et al.*1967) composed of four gradient strips and four blocks which were fertilized with $N_0P_0K_0$, $N_{1/2}P_{1/2}K_{1/2}$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. The recommended fertilizers ($N_1P_1K_1$) were 60, 20 and 40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Each strip was divided into 24 treatments. Out of which 20 treatments constituted combinations of 5 levels of N (0, 30, 60, 90, 120 kg ha^{-1}), 4 levels of P_2O_5 (0, 30, 60, 90 kg ha^{-1}) and 3 levels of K_2O (0, 60, 120 kg ha^{-1}). Four controls were superimposed to different plots in each strip in a factorial randomized block design (Table 1). As per the treatments N, P and K nutrients were applied through urea, SSP and MOP, respectively. Four levels of FYM (0, 2.5, 5.0 and 10.0 t ha^{-1}) were also included in this study. Rice variety Ranjit was cultivated as a test crop as per the recommended cultural practices. Pre-sowing and post harvest soil samples were collected from each plot and were analysed for organic carbon available N, P and K following standard methods (Jackson, 1973). The plant samples collected at harvest were analysed for NPK contents and computed their respective uptake of nutrients in rice. Grain yield from different treatments, from each strip and from each block was also recorded. At maximum tillering whole plant sample (hill) with roots were collected and used for analysis of various parameters. Management of rice with respect to stand establishment, pest control and other practices closely followed Assam Agricultural University guidelines for transplanted rice production. The effects P and K on crop yield, nutrient uptake, soil organic carbon and available nutrients were evaluated. Apparent recovery also known as fertilizer use efficiency was computed by using the formula (Pillai and Varmadevan 1978).

Table 1: Treatment details for test crop experiment

Strip I	**Strip II**	**Strip III**	**Strip IV**
$N_0\ P_0\ K_0\ OM_0$	$N_0\ P_0\ K_0\ OM_0$	$N_0\ P_0\ K_0\ OM_0$	$N_0\ P_0\ K_0\ OM_0$
$N_0\ P_0\ K_0\ OM_1$	$N_0\ P_0\ K_0\ OM_1$	$N_0\ P_0\ K_0\ OM_1$	$N_0\ P_0\ K_0\ OM_1$
$N_0\ P_0\ K_0\ OM_2$	$N_0\ P_0\ K_0\ OM_2$	$N_0\ P_0\ K_0\ OM_2$	$N_0\ P_0\ K_0\ OM_2$
$N_0\ P_0\ K_0\ OM_3$	$N_0\ P_0\ K_0\ OM_3$	$N_0\ P_0\ K_0\ OM_3$	$N_0\ P_0\ K_0\ OM_3$
$N_0\ P_0\ K_2\ OM_1$	$N_0\ P_0\ K_2\ OM_2$	$N_0\ P_0\ K_2\ OM_3$	$N_0\ P_0\ K_2\ OM_0$
$N_0\ P_3\ K_0\ OM_3$	$N_0\ P_3\ K_0\ OM_0$	$N_0\ P_3\ K_0\ OM_1$	$N_0\ P_3\ K_0\ OM_2$
$N_1\ P_1\ K_0\ OM_3$	$N_1\ P_1\ K_0\ OM_0$	$N_1\ P_1\ K_0\ OM_1$	$N_1\ P_1\ K_0\ OM_2$
$N_1\ P_1\ K_1\ OM_3$	$N_1\ P_1\ K_1\ OM_0$	$N_1\ P_1\ K_1\ OM_1$	$N_1\ P_1\ K_1\ OM_2$
$N_2\ P_0\ K_1\ OM_3$	$N_2\ P_0\ K_1\ OM_0$	$N_2\ P_0\ K_1\ OM_1$	$N_2\ P_0\ K_1\ OM_2$
$N_2\ P_1\ K_0\ OM_2$	$N_2\ P_1\ K_0\ OM_3$	$N_2\ P_1\ K_0\ OM_0$	$N_2\ P_1\ K_0\ OM_1$
$N_2\ P_1\ K_1\ OM_2$	$N_2\ P_1\ K_1\ OM_3$	$N_2\ P_1\ K_1\ OM_0$	$N_2\ P_1\ K_1\ OM_1$
$N_2\ P_2\ K_0\ OM_2$	$N_2\ P_2\ K_0\ OM_3$	$N_2\ P_2\ K_0\ OM_0$	$N_2\ P_2\ K_0\ OM_1$
$N_2\ P_2\ K_1\ OM_2$	$N_2\ P_2\ K_1\ OM_3$	$N_2\ P_2\ K_1\ OM_0$	$N_2\ P_2\ K_1\ OM_1$
$N_2\ P_2\ K_2\ OM_2$	$N_2\ P_2\ K_2\ OM_3$	$N_2\ P_2\ K_2\ OM_0$	$N_2\ P_2\ K_2\ OM_1$
$N_3\ P_1\ K_1\ OM_1$	$N_3\ P_1\ K_1\ OM_2$	$N_3\ P_1\ K_1\ OM_3$	$N_3\ P_1\ K_1\ OM_0$
$N_3\ P_2\ K_2\ OM_1$	$N_3\ P_2\ K_2\ OM_2$	$N_3\ P_2\ K_2\ OM_3$	$N_3\ P_2\ K_2\ OM_0$
$N_3\ P_3\ K_0\ OM_1$	$N_3\ P_3\ K_0\ OM_2$	$N_3\ P_3\ K_0\ OM_3$	$N_3\ P_3\ K_0\ OM_0$
$N_3\ P_3\ K_1\ OM_1$	$N_3\ P_3\ K_1\ OM_5$	$N_3\ P_3\ K_1\ OM_3$	$N_3\ P_3\ K_1\ OM_0$
$N_3\ P_3\ K_2\ OM_0$	$N_3\ P_3\ K_2\ OM_1$	$N_3\ P_3\ K_2\ OM_2$	$N_3\ P_3\ K_2\ OM_3$
$N_4\ P_2\ K_1\ OM_0$	$N_4\ P_2\ K_1\ OM_1$	$N_4\ P_2\ K_1\ OM_2$	$N_4\ P_2\ K_1\ OM_3$
$N_4\ P_2\ K_2\ OM_0$	$N_4\ P_2\ K_2\ OM_1$	$N_4\ P_2\ K_2\ OM_2$	$N_4\ P_2\ K_2\ OM_3$
$N_4\ P_3\ K_1\ OM_0$	$N_4\ P_3\ K_1\ OM_1$	$N_4\ P_3\ K_1\ OM_2$	$N_4\ P_3\ K_1\ OM_3$
$N_4\ P_3\ K_2\ OM_0$	$N_4\ P_3\ K_2\ OM_1$	$N_4\ P_3\ K_2\ OM_2$	$N_4\ P_3\ K_2\ OM_3$
$N_4\ P_0\ K_0\ OM_3$	$N_4\ P_0\ K_0\ OM_0$	$N_4\ P_0\ K_0\ OM_1$	$N_4\ P_0\ K_0\ OM_2$

Where,

N_0 = 0 kg ha^{-1}	P_0 = 0 kg ha^{-1}	K_0 = 0 kg ha^{-1}	FYM (OM_0) = 0.0 t ha^{-1}
N_1 = 30 kg ha^{-1}	P_1 = 30 kg ha^{-1}	K_1 = 60 kg ha^{-1}	FYM (OM_1) = 2.5 t ha^{-1}
N_2 = 60 kg ha^{-1}	P_2 = 60 kg ha^{-1}	K_2 = 120 kg ha^{-1}	FYM (OM_2) = 5.0 t ha^{-1}
N_3 = 90 kg ha^{-1}	P_3 = 90 kg ha^{-1}		FYM (OM_3) = 10.0 t ha^{-1}
N_4 = 120 kg ha^{-1}			

RESULTS AND DISCUSSION

Crop trials were conducted with the basic assumption that fertilizer recommendations typically depend on crop response experiments in which spatial variability has been minimized for every independent variable affecting crop yield except for the nutrient in question, although many non-fertility variables *viz.* WHC, bulk density, soil erosion and other fertility variables significantly impact crop yield (Kastens *et al.* 2003).

Soil characteristics

In general, the soil of the experimental field was sandy clay in texture with pH 5.10, organic carbon 0.60%, CEC 7.8 cmol (p^+) kg^{-1}, available N 213.25 kg ha^{-1}, available P 15.68 kg ha^{-1} and available K 90.27 kg ha^{-1}. Strip wise range and mean values of soil organic carbon, available nutrients and grain yield are furnished in Table 3. The organic-C in treated plots, ranged from 5.6 to 9.6, 6.0 to 9.6, 6.2 to 9.6 and 6.2 to 7.8 g kg^{-1} with mean values of 7.4, 7.5, 7.7 and 7.8 kg^{-1} in strips I, II, III and IV, respectively. In control plots, it ranged from 5.6 to 6.5 with a mean of 6.0 g kg-^{1}. A perusal of the data (Table 2) indicates that the available N, P_2O_5 and K_2O varied from 169.1 to 250.9 kg ha^{-1}, 20.7 to 42.5 and 85.5 to 116.2 kg ha^{-1}, respectively in strip I, 182.5 to 270.5, 24.1 to 59.2 and 90 to 124.5 kg ha^{-1} in strip II , 185.2 to 270.6, 30.6 to 64.1 and 90.2 to 135.8 kg ha^{-1} in strip III and 195.4 to 290.6, 41.8 to 80.8 and 95.6 to 145.2 kg ha^{-1}, respectively in strip IV with a mean of 216.1, 32.4 and 100.7 kg ha^{-1}, 225.5, 42.9 and 108.2, 235.5, 53.1 and 114.0, and 238.0, 65.4 and 123.5 kg ha^{-1} for available NPK, respectively in their respective strips. It was observed that with increasing fertility in the strips, all the soil parameters as well as grain yield increased and the highest content was exhibited in strip L_2. This might be due to better nutrient uptake by the crop which favourably influenced the growth and yield of rice as reported by Santhi and Selvakumari (1999). Similar results were also reported by Srinivas and Angayarkanni (2008). Moreover, the results point out that a considerable variability existed in the soil test values and grain yield, which is a pre-requisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield targets (Santhi *et al.* 2002 and Chatterjee *et al.* 2010).

Table 2: Range and mean values of soil parameters under different strips

Particulars	Strip L_0	Strip $L_{1/2}$	Strip L_1	Strip L_2
Organic carbon (g kg-^{1})	5.6-9.6 (7.4)	6.0-9.6 (7.5)	6.0-9.6 (7.7)	6.2-7.8 (7.1)
Available N (kg ha^{-1})	169.1-250.9 (216.1)	182.5-270.5 (225.5)	185.2-270.6 (235.5)	195.4-290.6 (238.0)
Available P_2O_5 (kg ha^{-1})	20.7-42.5 (32.4)	24.1-59.2 (42.9)	30.6-64.1 (53.1)	41.8-80.8 (65.4)
Available K_2O (kg ha^{-1})	85.5-116.2 (100.7)	90-124.5 (108.2)	90.2-135.8 (114.0)	95.6-145.2 (123.5)
Grain yield (q ha^{-1})	30.0-48.0 (40.42)	32.5-50.7 (42.58)	34-50.8 (44.1)	38.5-50.8 (44.8)

Figures in parentheses indicate mean value

Yield

A perusal of the data (Table 2) exhibited that grain yield of rice ranged from 30.0 to 48.0, 32.5 to 50.75, 34 to 50.85 and 38.5 to 50.85 kg ha^{-1} with mean values of 40.42, 42.58, 44.12 and 44.8 kg ha^{-1} in strips I, II, III and IV, respectively. In control plots, it ranged from 30 to 38.5 with a mean of 33.8 kg ha^{-1}. Individual effect of the treatments showed that the highest grain and straw yield of 41.9 and 54.6 q ha^{-1} was recorded with application of FYM @ 5 t ha^{-1}, respectively (Table 4). However, it was comparable with the yield obtained with application of FYM @ 2.5 and 10 t ha^{-1}. Both the grain and straw yields obtained with FYM levels were significantly higher over the control. The improvement of soil chemical properties of the FYM treated plots provided environment for the superior growth of rice plants than on the plots without FYM treatments. Specifically the higher organic matter and available N, P and K (Table 3) provided an improved soil quality leading to improved crop productivity. The crop could also have benefited from the changes in soil physical properties as a result of FYM addition, (Ogbodo 2011). On the other hand, application of 5 t FYM ha^{-1} enhanced available N, P, and K status over other treatments and the benefits of this was reflected in yield of rice. Soil productivity is closely linked with soil organic matter status as it plays an important role in the improvement of soil structure and organic matter status.

Among the NPK fertilizer treated soils (Table 4), the grain and straw yields of rice cv. Ranjit were significantly higher in plots where fertilizers were applied either alone or in combination with each other than that where NPK were omitted (control). The highest yield of grain (48.4 q ha^{-1}) and straw (62.8 q ha^{-1}) were recorded in plots receiving all NPK fertilizers. Plots receiving P and K fertilizers alone showed significant yield increase over control and the magnitudes of increase were 4.7 and 10.2%, respectively. Conversely, omission of nutrients caused yield loss between 18% (- P) and 15.3 % (- K). These results were supported by the findings of Channabasavanna and Biradar (2001), Ebaid *et al.* (2007), Mukhopadhyay *et al.* (2008) and Siavoshi *et al.* (2011). The increase in grain and straw yield in NPK fertilized plots could be due to enhanced nutrient availability which improved nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to sink. Based on the experimental data, the nutrient requirement (NR) for producing one quintal of rice grain on an average was calculated to be 1.75, 0.65 and 1.83 kg N, P and K respectively.

Table 4: Effect on P and K on grain and straw yield of rice (cv. Ranjit), nutrient uptake, organic-C and available nutrient in soil under different treatments

Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Δ Yield (q ha^{-1})	Nutrient uptake (kg ha^{-1})			Apparent Recovery (%)		OC (g kg^{-1})	Available nutrient in soil (kg ha^{-1})		
				N	P	K	P	K		N	P_2O_5	K_2O
FYM (t ha^{-1})												
0	39.1	50.8	2.4 (5.8)	66.9	19.1	69.1	-	-	6.7	212.9	43.6	101.0
2.5	40.6	52.6	0.9 (2.2)	69.6	22.6	70.5	22.5	1.6	6.8	209.5	48.6	104.8
5	41.9	54.6	-0.4 (1.0)	72.7	22.2	68.8	19. 5	-0.3	7.1	224.5	55.0	109.2
10	41.5	54.4	-	72.5	21.2	69.4	13.3	0.40	7.4	215.2	46.8	103.3
SEm±	1.6	2.0		3.4	3.1	6.6	-	-	0.27	12.2	7.5	10.5
LSD5%	1.8	2.3		3.9	NS	NS	-	-	0.4	10.2	NS	NS
NPK fertilizers												
(-) NPK	36.4	47.6	12.0 (24.8)	55.0	14.8	51.5	-	-	6.5	189.9	34.9	95.4
(-)NK	38.1	49.2	10.3 (21.3)	64.7	20.2	53.7	6.1	-	6.3	199.5	57.1	101.5
(-) NP	40	51.9	8.4 (17.4)	69.1	16.6	68.5	-	14.2	6.4	201.0	47.6	100.7
(-) P	39.7	52.9	8.7 (18.0)	72.0	17.8	75.0	-	39.1	6.8	218.9	47.0	106.2
(-) K	41	53.4	7.4 (15.3)	74.7	27.4	81.3	21.3	-	7.3	225.0	49.7	107.8
(-) PK	41.8	53.9	6.6 (13.6)	69.8	16.1	59.7	-	-	7.6	218.5	40.0	97.4
(+) NPK	48.4	62.8	-	87.8	36.1	96.4	35.6	74.9	8.1	256.1	63.3	123.1
SEm±	1.6	2.0		3.4	3.1	6.6	-	-	0.5	12.2	7.5	10.5
LSD 5%	4.2	3.0		5.1	4.6	9.9	-	-	0.7	18.	11.2	14.6
CV%	4	3.8		4.9	14.5	9.6	-	-	6.8	5.7	15.5	10

Δ Yield = Yield of FYM10- yield of respective treatments for levels of FYM and Yield of NPK - yield of omitted nutrient treatment for NPK fertilizers; Data in parentheses are percent yield loss.

Nutrient Uptake

Uptake of N by rice ranged from 66.9 kg ha^{-1} in control to 72.7 kg ha^{-1} in plots receiving 5 t FYM ha^{-1} and the uptake was superior at 5% level of significant while, N uptake at 10 t FYM ha^{-1} was statistically at par with that of 5 t FYM ha^{-1} (Table 4). These results corroborate the findings of Singh and kumar *(*2014). Nitrogen uptake was decreased by 26.3 and 21.3 % with single application of P and K, respectively over combined application of N, P and K. Uptake of P and K ranged from 19.1 to 22.6 kg ha^{-1} and 68.9 to 70.5 kg ha^{-1}, respectively and were not significantly affected by FYM. On the other hand, uptake of all the major nutrients was significantly affected by NPK fertilizers alone or in combination with each other over control (Table 3). In all the cases, the highest amount of nutrients was removed by rice treated with all the NPK fertilizers. Similar results were also reported by Porpavai *et al.* (2006). The relative absorption of P was found to be significant in plots where only P was applied over that of no NPK (control). The increase in P uptake in this plot was 36.9% more over control with an apparent recovery of 6.1% (Table 3) which rose to 85.8% in plots receiving N and P together so did the apparent recovery percentage to 21.3. It is interesting to observe that the relative use efficiency of P enhanced to 35.6% by combined application of NPK fertilizers and remaining 64.4% of applied P was left in the soil either as fixed or available as residual P to the follow up crop. The absorption of applied K was the highest with application of NPK fertilizers together (96.4 kg ha^{-1}) and the effect of different combination of N, P and K was statistically significant over control (Table 4). The efficiency of K absorption evaluated as apparent recovery was 14.2 and 39.1 %, respectively with application of K alone and N and P together. Apparent recovery was enhanced to 74.9% by combined application of NPK fertilizers. In general, K uptake was considerably higher in most of the treatments receiving K fertilizer compared to N and P (Table 4). With the improved crop management practices such as use of N and P fertilizers, the yields have markedly increased resulting in higher K removal owing to higher biomass production (Sheeba and Chellamuthu 1999). Uptake of all the nutrients significantly correlated with yield (r = 0.935**, 0.825** and 0.326** for N, P and K, respectively), suggesting interdependence of nutrient uptake that influenced yield.

Organic-C and Available nutrients

The organic-C content in post harvest soil increased significantly due to application of FYM @ 5 and 10 t ha^{-1} over control. It was observed that organic carbon content was higher in the treatments where chemical fertilizers were integrated with farmyard manure (interaction effect not given here). There was an increase of 4.0, 6.7 and 13.5 % of organic carbon in soil over chemical fertilizer when the same was applied in combination with 2.5, 5 and 10 t FYM ha^{-1}, respectively. In contrary, omission of P and K tended to decrease organic carbon over control (no NPK) while other treatments significantly increased soil organic-C in post harvest soil (Table 3). The effect of FYM application in STCR experiment was found to increase significantly only in available N in soil *vis-a-vis* P_2O_5 and K_2O (Table 4). This might be due to presence of very negligible amount of P and K in FYM and in highly complexed organic form. This confronts the findings of Singh *et al.* (2001) and Kaur and Benipal (2006) who reported that use of FYM alone or with fertilizer N increased the available K status of the soil. The effect of various combination of N, P and K fertilizers on their available contents in soil was highly significant ($p<0.01$). Plots receiving P and K alone showed marked reduction in available N, P_2O_5 and K_2O (22.1 and 21.5% N, 9.8 and 24.7 % P_2O_5 and 17.5 and 18.3 % K_2O, respectively) as compared to plots receiving N along with P and K alone or in combination (Table 3). However, application of P and K individually enhanced available P_2O_5 and K_2O remarkably ($p<0.01$) over control. In all the cases, conjoint application of NPK markedly increased their available contents in soil.

From these results, it can be concluded that the integrated application of chemical fertilizers and FYM increased the grain and straw yield, and N, P and K uptake in rice as well as enhanced organic-C and available NPK in soil from strip I to IV. Application of P and K fertilizers alone could significantly increase the grain yield by 4.0 and 10.2%, respectively over control. But omission of P and K caused yield loss by 18 and 15.3 % and uptake decreased by 44.0 and 28.9 %, respectively over NPK fertilizers altogether. The respective apparent recovery of P and K was 6.1 and 14.2 % only in individual application which increased to 21.3 and 74.9% by collective application of NPK. Results suggest that combined application of N, P and K fertilizers is inevitable for better performance of rice.

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PERFORMANCE OF KHARIF ONION GENOTYPES UNDER DIFFERENT DATES OF PLANTING FOR PRODUCTIVITY AND ECONOMICS IN GANGETIC PLAINS OF WEST BENGAL

RAJIB DAS*, UMESH THAPA, NARAYAN CHATTOPADHYAY AND AMIT RANJAN MANDAL

Department of Vegetable Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia – 741252 (W.B.), India

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ABSTRACT

Two sets of experiment were conducted at Mondouri (W.B.) during 2010-11 and 2011-12 to find out the suitable varieties and to standardize the date of planting for Kharif onion production in the Gangetic plains. During first year, eight varieties namely Agrifound Dark Red, Agrifound Light Red, N-53, Baswant -780, Arka Kalyan, Pusa Red, Nasik Red and Bombay Red were evaluated. After evaluation, three best perfoming varieties namely, Baswant -780, N -53 and Agrifound Dark Red were selected and transplanted on four different dates of planting (28 July, 18 August, 8 and 29 September) to identify the most suitable planting date for Kharif onion cultivation. Results indicated that maximum yield of 152.50 q ha^{-1} was obtained from Baswant-780. In the second experiment highest plant height, neck diameter, weight of fresh bulb, diameter of bulb and maximum yield of 167.48 q ha^{-1} was also obtained from Baswant-780 where the seedlings were transplanted on 8 September. Amongst the three varieties with different dates of planting, it revealed that the variety Baswant-780 followed by Agrifound Dark were found as the most suitable Kharif onion should be planted in between the second week of August and second week of September. The maximum net returns (₹. 217975 ha-^{1}) and B:C ratio (1.56) were obtained from variety Baswant – 780 planted on 8 September.

Key Words: Date of planting, *Kharif* onion, varieties, production, economics, West Bengal

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable cum spice crop grown in India. Among the onion producing countries, India is the second largest producer of onion after China, with an area of 1087.26 thousand hectares producing 17511.10 thousand metric tons bulbs during 2011-12. In West Bengal onion is cultivated in an area of 21.68 thousand hectares producing 304.56 thousand metric tonnes of bulbs during the same year (Anon, 2012). During 2012-13, our country exported 1378545 MT of onion valued `.117223.40 lakhs (APEDA, 2013). In India, onion is predominantly grown as a rabi season crop but to overcome the problem of non availability and sky touching price of onion during October to January, one has to go for cultivation of onion during the *Kharif* season. In Maharashtra, Gujarat, Karnataka and Andhra Pradesh *Kharif* onion accounts for about 30% of the total production (Mohanty *et al.*, 2000). Rainy season onion cultivation is a new strategy in northern, eastern and central India mainly to meet the demand of fresh bulb in off season. Most onion cultivars are very sensitive to photoperiod and their range of adaptation is limited. Thus, it is imperative to assess the stability in performance of recommended varieties of onion for a specific location, especially for *Kharif* onion. Rising of *Kharif* onion crop through seedling is very difficult in northern plains because of very high temperature during June-July (Gupta *et al.*, 1999). Standardization of transplanting dates of onion seedlings means assessment of the effect of edaphic factors and environmental conditions in large scale on growth, bulb yield and bulb quality, which differ widely from one region to another. Thus, determined the optimum transplanting dates having vital role in maximizing growth, bulb yield and its quality of onion (Sharief *et al.*, 2013). Onion, being the major bulbous vegetable crop of high domestic and export demand, is assuming as an important crop of West Bengal and growing Murshidabad, Nadia and Hooghly districts. Growing onion in the Gangetic plains of West Bengal during *Kharif* season is a somewhat new strategy to be adopted, which is a very usual one in the Southern and Western part of our country. The present study was, therefore, designed to identify the most promising variety suitable for *Kharif* season and standardization of the time of planting for growing *Kharif* onion in Gangetic plains of West Bengal.

MATERIALS AND METHODS

The experiment was conducted at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India, during 2010-11 and 2011-12. The soil of experiment site was sandy loam in texture with

Corresponding author's e-mail: rajib_bckv@yahoo.co.in

5.7 g kg^{-1} organic carbon, 0.06% total nitrogen, available phosphorous 30 kg ha^{-1}, available potassium 115 kg ha^{-1} and pH 6.5. The experimental site is under subtropical humid region with range of average temperature of 36^0C (max.) to 24^0C (min.) and average R.H. of 60% (max.) to 95% (min.) during the experimental period (June to September) of both the years. In the first phase, eight varieties namely, Agrifound Dark Red, Agrifound Light Red, N-53, Baswant -780, Arka Kalyan, Pusa Red, Nasik Red and Bombay Red were planted and evaluated in randomized block design with three replications. After selection of suitable three varieties namely, Agrifound Dark Red (V_1), Baswant -780 (V_2) and N-53(V_3) were planted on 28 July (P_1), 18 August (P_2), 8 September (P_3) and 29 September (P_4) and evaluated in factorial randomized block design with three replications. The recommended fertilizer dose of 150 kg N, 40 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied in the plots (3m X 3m). Seven weeks old seedlings were planted at 30 cm between lines and 10 cm within it. All other intercultural operations were done as and when necessary. Harvesting of bulbs was done at maturity stage. Biometrical observations and yield attributing characters were recorded from randomly selected 25 sample plants from each replication. The statistical analysis was done as per methods suggested by Panse and Sukhatme (1989). Economics of onion was worked out based on the current market price of inputs and outputs.

RESULTS AND DISCUSSION

Performance of the varieties

Vegetative growth parameters: Amongst the different varieties, Agrifound Dark Red emerged with highest plant height (62.55 cm) as also reported by Mohanty *et al.* (2000). Varieties Baswant-780 (58.15 cm), N-53 (56.15cm), Agrifound Light Red (55.61 cm) and Bombay Red (56.29 cm) did not differ significantly among themselves in respect of plant height. The variety Agrifound Light Red produced the highest length of leaf (55. 61 cm) followed by N-53 (52.32 cm) and least was in Pusa Red (43.08 cm). Number of leaves per plant was recorded highest as 8.83 in variety Nasik Red and lowest as 6.53 in Pusa Red. Highest leaf diameter was measured in Baswant-780 (0.75 cm) followed by Agrifound Dark Red (0.71 cm) and Bombay Red (0.68 cm). These similarities and dissimilarities among the varieties may be attributed to the variability in their genetic configuration as well as to their differential responses with respect to phenotypic expression various valuable characters as a result of interaction between the genotypic, edaphic and environmental factors. The highest pseudostem length was noted under Agrifound Light Red (6.87cm) followed by Bombay Red (6.50cm).

Table 1: Evaluation of Kharif Onion varieties in respect of vegetative growth and of yield attributes and yields of onion

Varieties	Plant height (cm)	Foliage length (cm)	Leaves /plant	Leaf diameter (cm)	Pseudostem length (cm)	Neck diameter (cm)	Weight of fresh plant (g)	Weight of fresh bulb (g)	Diameter of bulb (cm)	Yield (q ha^{-1})
Pusa Red	48.0	43.0	6.5	0.44	4.92	0.54	88.57	40.25	5.12	134.50
N-53	56.1	52.3	8.3	0.42	5.47	0.83	102.23	41.90	5.21	142.00
Baswant-780	58.1	51.4	8.1	0.75	6.48	0.79	101.27	46.65	5.37	152.50
Agrifound Dark Red	62.5	50.7	8.8	0.71	5.96	0.81	98.60	41.40	5.30	139.30
Agrifound Light Red	55.6	55.6	8.4	0.61	6.87	0.79	93.33	39.40	4.52	133.30
Nasik Red	47.3	47.3	8.8	0.59	5.15	0.74	92.07	27.70	4.19	95.00
Arka Kalyan	50.1	45.5	7.1	0.62	6.12	0.76	85.53	28.80	4.22	96.67
Bombay Red	56.2	51.3	7.5	0.68	6.50	0.82	81.23	26.00	3.91	85.67
S. Em. (±)	2.7	2.	0.35	0.03	0.69.	0.04	3.28	1.37	0.29	5.88
CD (P=0.05)	8.2	7.1	1.07	0.11	N S	0.12	9.96	4.15	0.90	17.85

Yield attributing characters: The neck diameter of fresh bulbs showed significant variation in all the varieties. The variety Pusa Red produced the lowest neck diameter of 0.54 cm where as the neck diameter showed by other seven cultivars were statistically at par. The range of mean fresh weight of plants produced by the eight genotypes was 102.23 – 81.23, thus fresh weight of N-53 (102.23 g) and Bombay Red (81.23 g) differed significantly. Amongst the different varieties, Baswant-780 emerged as the best variety for producing the highest fresh bulb weight of 46.56 g closely followed by N-53 (41.90 g), Agrifound Dark Red (41.40 g) and Pusa Red (40.25 g) however produced significantly lower fresh bulb weight than Baswant-780. The highest measure with respect to bulb diameter was obtained in Baswant-780 (5.37 cm) followed by Agrifound Dark Red (5.30 cm), N-53 (5.21 cm) and Pusa Red (5.12 cm). Bombay Red produced the bulb having lowest bulb diameter (3.91cm.). The highest bulb yield of 152.50 q ha^{-1} was obtained from Baswant -780 followed by N-53 (142.0 q ha^{-1}) and Agrifound Dark Red (139.3 q ha^{-1}). The results are not corroborated with the findings of Bhonde *et al*. (1992) where they observed that Agrifound Dark Red is the good yielder in the Nasik situation. But the climatic situation as well the soil characteristics of the present experimental locality might have suited the most to the variety Baswant - 780 among the three varieties under study, thus, it produced the highest yield.

Table 2: Effect of date of planting and variety on vegetative and yield attributing characters on *Kharif* Onion

Treatments	Plant height (cm)	Foliage length (cm)	Leaves / plant	Leaf diameter (cm)	Pseudostem length (cm)	Neck diameter (cm)	Fresh plant weight (g)	Fresh bulb weight (g)	Diameter of bulb (cm)	Yield (q ha^{-1})
P_1V_1	50.2	43.1	6.69	0.72	6.47	0.71	100.74	50.29	5.11	145.46
P_1V_2	54.2	46.4	8.02	0.70	7.01	0.79	103.57	54.23	5.34	156.35
P_1V_3	48.6	41.7	7.98	0.49	8.05	0.76	87.01	48.66	4.18	126.79
P_2V_1	56.5	48.7	7.62	0.78	7.42	0.77	108.50	56.57	5.40	170.54
P_2V_2	55.4	48.1	7.86	0.73	8.41	0.79	109.71	55.47	5.64	176.55
P_2V_3	54.1	46.2	7.96	0.51	8.36	0.78	96.13	54.16	4.82	145.00
P_3V_1	55.4	50.0	7.33	0.78	6.76	0.76	114.82	55.48	6.19	166.21
P_3V_2	58.2	47.1	8.33	0.70	8.41	0.78	105.61	58.29	6.31	178.92
P_3V_3	52.8	47.2	8.27	0.52	8.22	0.77	100.30	52.84	4.92	157.30
P_4V_1	50.6	43.4	6.47	0.75	6.78	0.77	103.87	50.65	5.45	149.67
P_4V_2	54.9	46.5	8.31	0.70	8.12	0.80	102.91	54.91	5.48	152.9
P_4V_3	48.2	40.3	8.02	0.54	8.07	0.70	91.88	48.27	4.05	128.45
S. Em. (±)	0.71	0.73	0.16	0.11.	0.14	0.015	1.65	0.12	0.12	2.96
C.D. at 5%	2.09	2.15	0.47	N.S.	0.43	0.043	4.86	0.37	0.37	8.69

P *–date of planting,* ***V*** *–Kharif onion varieties for first phase of the experiment.* P_1 *- 28 July,* P_2 *- 18 August,* P_3 *- 8th September and* P_4 *- 29 September.* V_1 *- Agrifound Dark Red, V2 - Baswant -780 and* V_3 *- N-53*

Dates of planting

Vegetative growth parameters: The results revealed that the highest plant height of 55.54 cm was obtained from 8 September planting, very closely followed by 2nd planting date (18 August) with a plant height of 55.40 cm. The minimum plant height of 51.06 cm was recorded when the planting was done on 28 July (Table 2). As the planting was delayed gradually, the plants might have received more congenial weather condition for their growth and development. This might be an indication of suitability of late planting rather than early planting for *Kharif* onion in the Gangetic plains of West Bengal. The lower plant height in earlier planting (28 July) might be due to higher amount of rainfall occurred during this period. Baswant-780 produced the tallest plants (55.72 cm) which differed significantly from that of N-53. The differences in plant height among the three varieties might be due to interaction between their inherent genetic configuration and environmental condition prevailed during various dates of plantings. The maximum foliage length was recorded as 48.13 cm when the seedlings were transplanted on 8 September, which is pretty much alike with the findings of Singh and Singh (2002). Where as, relatively lower foliage length was noted under 28 July (41.71 cm) and 29 September (40.33 cm). The rainfall and average temperature prevailed during August to second week of September might have positive influences on the growth of higher foliage length as comparison to very early and late planting on 28 July and 29 September, respectively. The different genotypes resulted in significant variations in foliage length. Among the three genotypes the maximum foliage length of 46.96 cm was obtained from variety Baswant-780 and minimum (40.33 cm) for variety N-53. The results showed a decreasing trend in the production of number leaves/plant during very early and late plantings. The lowest number of leaves/plant (7.56) was recorded with 28 July planting and 7.60 leaves/plant with 29 September planting and these two observations were statistically at par. The July and late September planting may have received some unfavorable climatic conditions which might have attributed to the lower number of leaves production per plant. The variety Baswant-780, proved as the best, with respect of number leaves/plant (8.13), which was very closely followed the variety N-53 (8.06). Various planting dates have more or less similar effect on the character leaf diameter. The highest leaf diameter of 0.76 cm was noted in variety Agrifound Dark Red followed by 0.71 cm and 0.51 cm in variety Baswant-780 and N-53 respectively. The maximum pseudostem length of 8.06 cm was resulted when the planting was done on 18 August and this value had a significant difference the other three plantings dates. These results are very much in similarity with the findings of Sharma *et al*. (2003) and Singh and Singh (2002). This variation in the pseudostem length due to different dates of planting might be caused due to the difference in the weather condition, mainly average temperature, rainfall and R.H. as well as due to the genotype-environment interaction. The highest pseudostem length of 8.17 cm was recorded in the variety N-53. This result is more or less identical with those of Sharma *et al.* (2003).

Table 3: Economics for treatments for *Kharif* onion cultivation

Treatment combinations	Yield (q ha^{-1})	Cost of cultivation (₹.ha^{-1})	Gross return (₹.ha^{-1})	Net Return (₹.ha^{-1})	Benefit : Cost ratio
P_1V_1	145.46	139865	290920	151055	1.08
P_1V_2	156.35	139865	312700	172835	1.24
P_1V_3	126.79	139865	253580	113715	0.82
P_2V_1	170.54	139865	341080	201215	1.44
P_2V_2	176.85	139865	353700	213835	1.53
P_2V_3	145.00	139865	290000	150135	1.08
P_3V_1	166.21	139865	332420	192555	1.38
P_3V_2	178.92	139865	357840	217975	1.56
P_3V_3	157.30	139865	314600	174735	1.25
P_4V_1	149.67	139865	299340	159475	1.14
P_4V_2	152.92	139865	305840	165975	1.19
P_4V_3	128.45	139865	256900	117035	0.84

Selling price of onion bulb = ₹ 20.00 kg^{-1}, Cost of onion seed =₹ 2000.00 kg^{-1}, Cost of Urea = ₹ 7.50kg^{-1}, Cost of Single super phosphate = ₹ 16.50 kg^{-1}, Cost of muriate of potash = ₹ 24.50 kg^{-1}, Labour charge = ₹ 167.00 day^{-1}labour^{-1}

Yield attributing characters: Neck diameter was significantly influenced due to various dates of planting with different genotypes and maximum neck diameter (0.78 cm) was resulted when the planting was done on 18 August. This result has been confirmed by the findings of Singh *et al*. (2002). Among the varieties, the highest neck diameter of 0.79 cm was noted in Baswant-780. The maximum fresh plant weight of 106.01 g was obtained when transplanting was done on 8 September, followed by (104.78 g) 18 August transplanting. The lowest plant weight (97.11 g) was obtained in late July planting (28 July). Hence it is quite evident that the early and late planting both caused reduction in the weight. Among the varieties, Agrifound Dark Red produced the highest fresh plant weight of 109.98 g closely followed by Baswant-780 (105.43g). The different planting dates resulted in significant variation in weight of fresh bulb and maximum value (55.54 g) was obtained, with 8 September planting followed by second date of planting (55.40 g) indicating decreasing trend in fresh bulb weight. These results are in conformity with the findings of Sharma *et al.* (2003) in onion cultivar N-53.The different genotypes resulted in significant variation in fresh bulb and maximum bulb weight was observed in variety Baswant-780 (55.72 g) which may can be attributed to the inherent variability that exists in different genotypes or may be due to the environmental effect. The greatest bulb diameter of 5.87 cm was obtained, 8 September planting closely followed by 18 August transplanting (5.29 cm). The lowest bulb was resulted from 28 July transplanting followed by last date of planting. Bulb diameter also showed decreasing trend as planting was delayed from 8 September to 29 September. Baswant-780 proved to be the best variety with respect of bulb diameter as it produced the bulb having maximum diameter of 5.69 cm. The variety N-53 may not be considered suitable variety in comparison to Baswant-780 and Agrifound Dark Red to be grown as *Kharif* onion in the plains of West Bengal. Various dates of planting showed a considerably variable effects on yield, which ranged from 167.48 to 142.37 q ha^{-1}. The highest yield of

167.48 q ha^{-1} was recorded from the 8 September planted crop. These results corroborated with the findings of Singh *et al.* (2002) with cultivar N-53. The bulb yield of 164.03 q ha^{-1} was noted when the planting was done on 18 August followed by 143.68 and 142.37 q ha^{-1} in 29 September and 28 July planting, respectively. It was quite obvious that the decline in the bulb yield occurred due to early and late planting. The weather condition *viz.* maximum and minimum temperature, rainfall and R.H. prevailed early and late in the season might have some unfavorable influences, which caused the reduction in the total bulb yield. The variety Baswant-780 produced the maximum yield of 166.08 q ha^{-1} followed by Agrifound Dark Red (157.97 q ha^{-1}) and the lowest yield in N-53 (139.38 q ha^{-1}). The differences between yields produced by these three genotypes under this present investigation were statistically significant.

Economics: The highest benefit: cost ratio of 1.56 was obtained from variety Baswant-780, planted on 8 September and the least benefit: cost ratio (0.82) from the first date of planting (i.e. 28 July) of variety N-53. Net returns (₹. 217975 ha^{-1}) was highest with Baswant – 780 variety planted on 8 September. The minimum net return was observed from variety N-53 planted on 28 July.

It may be concluded from the present investigation that variety Baswant-780 planted on 8 September might be beneficial for achieving higher productivity and profitability in Gangetic plains of West Bengal.

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SEASONAL INCIDENCE OF RICE LEAF FOLDER CNAPHALOCROSIS MEDINALIS (GUEN.) IN AGRO CLIMATIC CONDITION OF AT BASTER PLATEAU ZONE

C.S. NETAM AND A.K. GUPTA

Shaheed Gundadhoor College of Agriculture and Research Station, IGKV, Raipur Jagdalpur
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ABSTRACT

A field experiment was conducted during kharif season of 2013 at Jagdalpur (Chhattisgarh) to study the seasonal incidence of rice leaf folder in Bastar Plateau Zone. The results revealed that infestation of rice leaf folder (15.2% seasonal mean) was observed throughout the cropping period with maximum infestation of 25.3 % during third week of September. The correlation of leaf folder with their natural enemies revealed that significantly positive correlation existed between leaf folder and spiders and leaf folder and mirid bugs with (r) values of 0.663 and 0.890, respectively. The peak activity of rice leaf folder was associated with 30.6 ^{O}C and 21.7 ^{O}C maximum and minimum temperatures and 90.5 and 45.4 % morning and evening relative humidities with the association of 57.9 mm rainfall. Correlation studies revealed a significant positive correlation between leaf infestation and maximum temperature with correlation coefficient (r) value of 0.537, whereas, significant negative correlation between leaf infestation and evening relative humidity observed with the correlation coefficient (r) value of -0.523. The regression equation for maximum temperature [$Y = 2.149x-47.42$; $R^2 = 0.288$] and evening relative humidity [$y = -0.491+42.14$; $R^2 = 0.273$].

Key words: Incidence, rice leaf folder, Bastar

INTRUDUCTION

Rice (*Oryza sativa* L.) is the most important and extensively cultivated food crop, which provides half of the daily food for one of every three persons on earth. Chhattisgarh state is popularly known as “rice bowl of India” because maximum area is covered under rice during kharif and contribute major share in national rice production. Chhattisgarh state came into existence in 2001 and having three major agro-climatic zone like Chhattisgarh plain (16 district), Bastar plateau (6 district) Northern hills (5 district). The total geographic area of Baster is 32.63 lakh ha out of which only 6.55 lakh ha. is net sown area. Rice is foremost crop, grown in about 4.63 lakh ha. area, which covers 70% of net sown area.In Bastar region, Gall midge, Leaf folder and Brown plant hopper are the most distractive pests of rice area. Farmers adopt traditional methods of ultivation with no or a little use of fertilizers and plant protection measures. Among various factors responsible for low yield, losses due to insect-pests attack are of prime importance. Among these insect-pests, leaf folder is noticed as regular insect-pest at Baster plateau zone. Leaf folder is a complex of species. Eight species of leaf folder have been recorded so for. In Chhattisgarh, severe damage due to this pest has been reported by Srivastava (1989). The population of rice leaf folder fluctuated in different periods during the seasons. The maximum number of larvae was observed during 4th week of August and 1st week of September (Ankit kumar *et al.* 2013). Chakraborty (2011) reported that leaf folder infestation was started at about 33 SMW attaining maximum peak of abundance at about 39 SMW with regular generations during single crop season. Hence, study on seasonal incidence of leaf folder is essential as this provide information on the status of leaf folder and their natural enemy fauna and also help in identifying the vulnerable stage of the crop. This information helps in developing an efficient management model for the leaf folder attacking various growth stages of the crop. Therefore, present study was undertaken.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of College of Agriculture and Research Station, IGKV, Kumhrawand, Jagdalpur, (C.G.) during karif season, 2013. Jagdalpur comes under Bastar plateau zone. It is located at 21°16' North latitude and 81^{o}36' East longitude with an altitude of 289.56 m above mean sea level. Jagdalpur comes under sub humid region. It has a seasonal rainfall of 1600 mm. Nearly, 85 % of the annual rainfall is received from 1st week of June to 3rd week of November. Climate of Jagdalpur is more suitable for growth and development of rice leaf folder.Swarna variety of rice was transplanted on 2nd week of August during *kharif* season in the plot size of 500 m^{2}. Planting was done at a distance of 15 cm from row to row and 15 cm from plant to plant. The crop was grown by adopted standard agronomical practices. Weekly observations

Corresponding author’s e-mail: avinashent@yahoo.co.in

on leaf folder infestation with their natural enemies were observed on ten randomly selected plants during the cropping season i.e. from August to November. The leaf folder infestation was recorded weekly from ten plants selected randomly by the counting of total number of leaf and the number of leaf infested by leaf folder side by side population of natural enemies was also counted. Leaf folder and natural enemies population was subjected to simple correlation, where, leaf folder infestation was as dependent factor and weather parameters, such as, temperature and humidity as independent factors. Where 'r' was found significant, linear regression equation y = a ± bx was worked out. Here, y = Dependent factor, a = Constant, b = Regression coefficient, x = Independent factor. Leaf folder damage was worked out by using following formula:

Leaf folder damage (%) =

$$\frac{\text{Total number of leaves/hill}}{\text{Number of damage leaves/hill}} \times 100$$

RESULTS AND DISCUSSION

The results revealed that occurrence of leaf folder commenced from 34 standard meteorological week (SMW). Observation of leaf folder incidence was recorded on randomly selected ten plants at weekly interval. Besides this insect pest, associated natural enemies were also recorded during the cropping period. During the course of study, leaf folder was noticed causing damage at various growth stage of the crop. Predatory population of Spider (*Lynx sp.*), Mirid bug (*Cyrtorhinus lividipennis*) Damselfly (*Enallagma cyathigerum*) and a parasitic wasp (*Cotesia glomerata*) were observed preying on larvae of leaf folder.

Leaf folder Cnaphalocrosis medinalis (Guen.)

First incidence of leaf folder was recorded at tillering stage of the crop in the third week of August with 7.4 % leaf infestation. The level of infestation was gradually increased up to 21.8% leaf infestation recorded in first week of September. Two peak periods were recorded during third week of September and third week of October where leaf infestation reached maximum with 25.3 and 22.4%, respectively.Thereafter, the activity of leaf folder decreased gradually up to last week of November with a seasonal mean of 15.16 % (Table1).

Table 1: Seasonal incidence of leaf folder of rice on variety Swarna

Date of observation	SMW	Total Leaf	Damage Leaf	% Damage Leaf
22-08-13	34	14.7	1.1	7.4
29-08-13	35	15.8	1.7	10.7
05-09-13	36	17.4	3.8	21.8
12-09-13	37	19.0	3.2	16.8
19-09-13	38	38.2	9.7	25.3
26-09-13	39	31.9	5.2	16.3
03-10-13	40	41.4	76	18.3
10-10-13	41	44.7	9.6	21.4
17-10-13	42	54.4	12.2	22.4
24-10-13	43	54.1	8.0	14.7
31-10-13	44	51.3	5.9	11.5
07-11-13	45	395	3.1	7.8
14-11-13	46	57.9	9.0	15.5
21-11-13	47	35.2	3.7	10.5
28-11-13	48	35.0	2.2	6.2
Seasonal Mean of % Damage Leaf				15.16

Leaf folder was noticed as major leaf feeder insect active throughout the cropping season especially at tillering and panicle initiation stage during third week of September and October. Patnaik (2001) also recorded the peak incidence of leaf folder occurred in the month of September and October in Kendujhar, Orissa which is in confirmity with the present finding. Present investigation was also in accordance with the findings of Balasubramani *et al*. (2000), who reported significantly higher leaf folder incidence during the month of September in Tamilnadu. Kumar *et al.* (2003) indicated that the peak activity of leaf folder occurred in the first fortnight of October while, in present investigation, second peak activity was noticed during third fortnight of October. Kumar *et al.* (1996) revealed that minimum level of infestation was recorded during the month of July and reached maximum during the month of September with 33.2 per cent leaf infestation. The present investigation also revealed maximum leaf infestation during September with 25.3 % infestation. Patel *et al* (2001) reported that leaf folder infestation initiated from 36 SMW during Kharif season and reached its peak level during 43 SMW while, in present findings, infestation started from 34 SMW and reached its peak infestation during 38 SMW followed by 42 SMW. Present findings were contradictory with those of Chakraborty (2011) who reported that leaf folder infestation was initiated during 33 SMW and peak abundance during 39 SMW in Navsari (Gujarat).

Natural enemy fauna on leaf folder of rice

The predatory fauna on leaf folder are given in Table 2.

Spider: Species of spider (Lynx sp.) was recorded as major bio agent. They made their first appearance on the crop in the last week of August with 0.10 spider/ plant. They were observed feeding on the larval and adult stages of leaf folder. Their activity continued till last week of October. Maximum population of 0.90 spider/ plant was observed during second week of October.

Table 2: Seasonal incidence of leaf folder and associated predators on rice variety Swarna

Date of Observation	SMW	Mean Population per Plant			
		Leaf folder	Spider	Mirid bug	Damselfly
22-08-13	34	0.10	0.10	0.00	0.10
29-08-13	35	0.20	0.10	0.10	0.10
05-09-13	36	0.40	0.10	0.30	0.10
12-09-13	37	0.30	0.10	0.10	0.20
19-09-13	38	0.50	0.40	0.30	0.00
26-09-13	39	0.20	0.10	0.10	0.10
03-10-13	40	0.30	0.00	0.10	0.10
10-10-13	41	0.50	0.90	0.40	0.00
17-10-13	42	0.40	0.10	0.30	0.20
24-10-13	43	0.10	0.00	0.10	0.00
31-10-13	44	0.20	0.16	0.00	0.00
07-11-13	45	0.10	0.00	0.10	0.00
14-11-13	46	0.30	0.00	0.20	0.10
21-11-13	47	0.10	0.00	0.00	0.00
28-11-13	48	0.20	0.00	0.10	0.10
Seasonal mean		0.26	0.14	0.14	0.07
Correlation coefficient(r)		Leaf folder	0.663*	0.890*	0.173

** Significant at 5% level*

Mirid bug: Besides the spider, mirid bug (*Cyrtorhinus lividipennis*) was observed feeding on every larval stage of leaf folder. Bug was active from last week of August to second week of November. Peak activity of mirid bug was recorded during second week of October with 0.40 bug/ plant. Besides the above predators damselfly (*Enallagma cyathigerum*) was also observed from last week of August with two peaks of their population recorded during second week of September and third week of October. A parasitic wasp (*Cotesia glomerata*) was noticed parasitizing the larval stage of leaf folder also. In the present investigation, three predators were observed preying upon leaf folder of rice. Spider was observed as a major bio-agent against leaf folder followed by mirid bug and damselfly. Besides these predators, *Cotesia sp.* was observed as larval parasitoid. Ankit Kumar *et al.* (2013) reported *Cotesia sp.* as dominating larval parasitoid. A spider (*Lycosa sp.*) also predated upon larvae of pest, whereas, in the present studies spider (Lynx *sp.*) was recorded as major bio-agent against the pest.

Correlation studies

To observe the effect of predator population on the activity of leaf folder, the population of leaf folder was correlated with the population of spider and mirid bug. It revealed that leaf folder was significantly positively influenced with spider and mirid bug population with correlation coefficient (r) of 0.663 and 0.890, respectively. From the correlation it is clear that as the population of leaf folder increases population of spider and mired bud are also increases. However, non significant positive relationship existed between leaf folder and damselfly.

Effect of ambient weather parameters on seasonal incidence of rice leaf folder

Table 3 indicated seasonal incidence of leaf folder and effect of various weather parameters. During the period of observation, weekly fluctuation of maximum and minimum temperatures ranged from 26.1 to 30.6 ^{O}C and 12.1 to 23.1 ^{O}C, respectively. Similarly morning and evening relative humidity ranged from 88.4 to 94. 1% and 45.4 to 73.2 %, respectively. Vapour pressure (morning and evening) varied from 12.4 to 21.9 % and 12.5 to 20.2 %, respectively. Rainfall varied from 3.8 to 76.5 mm during whole cropping season. Leaf folder infestation was first observed on the crop in the last week of August with 7.4 % leaf infestation, which was associated with 30.1 ^{O}C and 23.1 ^{O}C maximum and minimum temperatures and 89.0 and 53.7 % morning and evening relative humidity with the seasonal rainfall of 36.4 mm. The insect gradually increased its density and exhibited peak activity in the third week of September with 25.3 % leaf infestation. It was associated with 30.6 ^{O}C and 21.7 ^{O}C maximum and minimum temperatures and 90.5 and 45.4 % morning and evening relative humidity with the association of 57.9 mm rainfall. The second peak activity was

Table 3: Effect of weather parameters on the seasonal fluctuation of leaf folder on rice variety Swarna

Date of Observation	SMW	Leaf folder infestation (%)	Temperature (^{O}C)		Rainfall (mms)	Relative Humidity (%)		Vapour Pressure		Wind Velocity (kmph)	Evaporation (mms)	Sunshine hours
			Maximum	Minimum		I	II	I	II			
22/08/2013	34	7.4	30.1	23.1	36.4	89.0	53.7	21.7	18.4	3.2	2.6	4.5
29/08/2013	35	10.7	27.6	21.9	33.3	89.5	61.2	21.3	18.9	9.0	2.0	2.8
05/09/2013	36	21.8	29.1	22.1	20.1	88.4	51.2	21.3	17.9	4.1	3.7	3.7
12/09/2013	37	16.8	30.2	21.7	26.6	91.7	55.0	21.9	19.2	3.1	4.1	3.3
19/09/2013	38	25.3	30.6	21.7	57.9	90.5	45.4	21.7	17.4	1.7	4.6	7.3
26/09/2013	39	16.3	29.1	21.9	11.3	91.0	55.0	21.5	18.5	3.5	5.5	3.1
03/10/2013	40	18.3	30.4	21.3	38.0	89.7	49.5	21.3	17.6	2.7	4.1	5.4
10/10/2013	41	21.4	29.8	21.1	53.8	89.8	54.8	21.2	19.0	3.8	2.1	3.7
17/10/2013	42	22.4	29.6	21.2	20.2	90.4	50.7	21.3	17.8	4.7	2.1	3.5
24/10/2013	43	14.7	30.0	19.6	30.0	92.7	50.2	20.3	17.8	1.4	3.0	7.1
31/10/2013	44	11.5	26.1	20.5	76.5	94.1	73.2	20.8	20.2	5.4	1.6	1.4
07/11/2013	45	7.8	28.7	19.0	0.0	91.0	58.7	19.6	19.2	3.1	2.2	5.1
14/11/2013	46	15.5	30.6	21.0	0.0	89.5	54.2	21.1	17.5	2.7	2.1	4.3
21/11/2013	47	10.5	26.2	12.1	0.0	89.8	55.8	12.4	12.5	2.2	2.0	6.7
28/11/2013	48	6.2	27.9	16.2	3.8	89.8	54.1	16.0	17.3	4.3	2.2	4.1
Correlation Coefficient (r)		Leaf folder Infestation	0.537*	0.426	0.332	-0.093	-0.523*	0.479	0.049	-0.216	0.482	0.126

** Significant at 5% level*

exhibited during third week of October with 22.4 % leaf damage which was associated with 29.6 ^{O}C and 21.2 ^{O}C maximum and minimum temperatures, 90.4 and 50.7 % morning and evening relative humidity and 20.2 mm rainfall. There was a significant positive correlation (r= 0.537) between leaf infestation and maximum temperature (regression equation being y = 2.149x- 47.42), whereas, significant negative correlation (r= -0.523) existed between leaf infestation and evening relative humidity (regression equation being y = -0.491x+42.14). The maximum temperature varied from 29 to 30 ^{O}C and minimum from 20 to 21 ^{O}C. The morning relative humidity was around 90 % and evening relative humidity from 44 to 45 % with less rainfall which was found congenial for pest multiplication on the crop. Almost similar findings were reported by Ankit kumar *et al.* (2013) at Haryana. They observed a significant positive correlation between maximum temperature and leaf infestation and negative correlation between rainfall and leaf infestation. In the present study, leaf infestation was significant positively correlated with maximum temperature with r values of 0.537 and significant negatively correlated with evening relative humidity with r values of -0.523. Present findings are in agreement with those of Mukherjee *et al.* (2008) who found significant negative correlation with evening relative humidity and rainfall at Sambalpur. Khan *et al.* (2004) on the other hand, observed a significant negative relationship between maximum temperature and per cent leaf infestation. In the present studies, leaf folder made its first infestation on the crop in the last week of August with peak activity in the third week of September, whereas, Patel *et al.* (2001) reported the first leaf infestation of the pest in the first week of September with peak activity in the last week of October.

On the basis of present investigation, it was concluded that peak activity of rice leaf folder was observed in the third week of September. Leaf infestation had significant positive correlation with maximum temperature and significant negative with evening relative humidity. The correlation of leaf folder with their natural enemies concluded that significantly positive correlation existed between leaf folder and spiders and leaf folder and mirid bugs.

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EFFECT OF SULPHUR ON PRODUCTIVITY, ECONOMICS AND NUTRIENT UPTAKE IN SPINACH

DINESH PRATAP SINGH, V.K. GULPADIYA, R.S. CHAUHAN AND S.P. SINGH

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra-283 105 (U.P.)
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ABSTRACT

A field experiment was conducted during rabi season of 2009-10 and 2010-11 on a sandy loam soil at Raja Balwant Singh College, Bichpuri, Agra (U.P.) to study the effect of suphur levels (0, 15, 30, 45 and 60 kg S ha^{-1}) on productivity, profitability and uptake of nutrients by spinach (Spinach oleracea) crop. The results revealed that spinach crop responded significantly to sulphur application up to 45 kg S ha^{-1}. The sulphur application significantly increased spinach green foliage yield by 22.7, 67.0, 89.8 and 95.5 % at 15, 30, 45 and 60 kg S ha^{-1}, respectively over control. The highest dry matter yield (3.11t ha$^{-1)}$ was recorded with 60.kg S ha^{-1} which was slightly higher than that of 45 kg S ha-^{1} .The uptake of N, P, K and S by spinach crop increased with sulphur application to the soil but Zn uptake decreased at higher levels of sulphur. The protein content and yield of spinach increased significantly with sulphur application over control.The maximum gross returns, net returns (₹.40547 ha^{-1}) and benefit: cost ratios (176) were obtained with 60 kg S ha^{-1}. The S – use efficiency and apparent S recovery decreased at higher levels of sulphur.

Keywords: Sulphur, nutrient uptake economics, yield, spinach.

INTRODUCTION

Spinach, a leafy vegetable, is an excellent source of vitamin K, vitamin A (in the form of carotenoids), manganese, folate, magnesium, iron, copper, vitamin B2, vitamin B6, vitamin E, calcium, potassium and vitamin C. It is a very good source of dietary fibre, phosphorus, vitamin B1, zinc, protein and choline. Additionally, spinach is a good source of omega-3 fatty acids, niacin, pantothenic acid and selenium. The yield of spinach is influenced by application of sulphur. To sustain high yield of spinach, the application of sulphur is required in optimum amount. Sulphur (S) has been recognized as the fourth important plant nutrient after nitrogen, phosphorus and potassium. It is gaining considerable importance in quality crop production in the context of Indian agriculture, particularly when there is more and more use of non sulphur containing fertilizers and lesser use of organic manures. Sulphur has been known for its role in the synthesis of carbohydrates, proteins, vitamins and flavor compounds. It plays an important role in the formation of S-containing amino acids like cystine (27% S), cysteine (26% S), methionine (21% S), which act as building blocks in the synthesis of proteins. It has a role to play in increasing chlorophyll formation and aiding photosynthesis (Marschner. 1986). Sulphur also plays a role in the activation of enzymes, nucleic acids and forms a part of biotin and thiamine.Removal of S by crops in India is about 1.26 million tonne (mt), whereas its replenishment through fertilizers is only about 0.76 mt (Tiwari and Gupta, 2006). Furthermore, the use efficiency of added S through external sources is also very low, being only 8-10% (Hegde and Murthy 2005). In recent years an increased frequency of sulphur deficiency has been observed in crops and sulphur may become a factor limiting yield and quality of crops. Different crops require a considerable amount of sulphur for proper growth and there was no recommendation of sulphur fertilizer for spinach crop. Therefore, keeping the above facts in view, a field study was conducted to study the sulphur response and to find out the optimum dose of S fertilizer in spinach.

MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2009-10 and 2010-11 at R.B.S. College, Research Farm, Bichpuri, Agra. The experiment was laid out in randomized block design with three replications. There were five levesl of sulphur i.e. 0, 15, 30, 45 and 60 kg ha^{-1}. The soil of the experimental field was sandy loam in texture, alkaline in reaction (pH 7.8), EC (0.17 dS m^{-1}), low in organic carbon (3.1 g kg^{-1}), available N (145 kg ha^{-1}) available P (9.5 kg ha^{-1}), K (108 kg ha^{-1}) and S (8.5 mg kg^{-1}). The spinach crop was sown using 5 kg of seed ha^{-1} during the month of October in both the years. The sulphur treatments were applied before sowing as per treatments through elemental sulphur. As per recommendation, a uniform basal dose of 100 kg N, 60 kg P_2O_5 and 60 kg K_2O were applied at showing through urea, di ammonium phosphate and muriate potash respectively. Entire dose of phosphorus and potassium and half dose of N were applied at the time of sowing and remaining half nitrogen was applied one month after sowing. Rest of the management practices were in accordance with the recommended package of practices for the crop. Green foliage yields was recorded at harvest. Random chopped samples of green foliage were sun dried and placed in the oven at 65° C for 72 hours to estimate dry matter percentage and then it was multiplied with respective green foliage yield to calculate dry matter yield. Plant samples were analyzed for N by Kjeldahl method. Phosphorus was determined in di acid digest by vanado molybdate yellow colour method, K by flame photometer, sulphur by turbidi metric method (Chesnin and Yien, 1951) and Zn on atomic absorptions pectrophotometer (Jackson 1973). The uptake of nutrients was calculated from the data on concentration of the given nutrient multiplied by yields. Sulphur use efficiency was computed with the formula given below:

Sulphur use efficiency (kg produce/kg S applied) = $(Y_1\text{-}Y_0)/Sa$, Where Y_1 = yield (kg ha^{-1}) in test treatment, Y_0= yield (kg ha^{-1}) in the control plot, Sa=Sulphur applied in test treatment (kg ha^{-1}), The apparent S recovery was worked out as follows: Apparent S recovery (%) =

$$\frac{\text{Uptake in treated plot} - \text{Uptake in control plot}}{\text{Fertilizer dose}} \times 100$$

Economics of different treatments was worked out on the basis of input and output on the prevailing market price.

RESULTS AND DISCUSSION

Yield

The data (Table 1) indicated that the spinach mean yield in control plot was 8.53 t ha^{-1}. The mean green foliage yield increased from 8.53 to 16.20 t ha^{-1} and mean dry matter yield from 1.52 to 3.11 t ha^{-1} with application of different rates of sulphur application. On an average, the increase in mean spinach green foliage yield over control was 22.7, 67.0, 89.8 and 95.5% with 15, 30, 45 and 60 kg S ha^{-1}, respectively. The response of sulphur application of spinach was found significant upto 45 kg S ha^{-1} and increase with application of 60kg S ha^{-1} was statistically non-significant over 45 kg S ha^{-1}. The increased yield with S application might be due to increased availability, absorption and translocation of S nutrient by and in to the spinach plant, increased enzyme activity, photosynthesis, transport of sugars, protein synthesis and ultimately increased crop yield. Singh and Singh (2003), Sriramachandrasekhran (2009), Sriramachandrasekharan and Shukla (2010) Ali *et al.* (2013) and Verma *et al.* (2014) also observed significant effect of sulphur application in onion, Okra, radish and fababean, respectively.

Table 1: Effect of Sulphur levels on yields of spinach

Sulphur (kg ha^{-1})	Green foliage yield (t ha^{-1})			Yield response (%)	Dry matter yield (t ha^{-1})		
	2008-09	2009-10	Mean		2008-09	2009-10	Mean
0	8.82	8.25	8.53	-	1.55	1.49	1.52
15	10.50	10.44	10.47	22.7	1.82	1.81	1.81
30	14.58	13.90	14.24	67.0	2.80	2.67	2.73
45	16.65	15.73	16.19	89.8	3.11	2.93	3.02
60	17.17	16.20	16.68	95.5	3.20	3.03	3.11
CD (P=0.05)	1.14	0.96	0.95		0.28	0.22	0.24

Protein

Application of sulphur gradually increased the protein content and its yield in spinach crop (Table 3). The protein content in spinach leaves ranged from 4.7 to 5.3%. The results of the present investigation find support from Ali *et al.* (2013) who observed a significant increase in protein content of fababean up to 60 kg S ha^{-1}. The increase in protein content with S could be due to the fact that N is an integral part of protein and the protein of vegetable crop contains relatively large quantity of S containing amino acids. The increase in protein yield in spinach due to S application was from 71.4 kg ha^{-1} in control to 164.8kg ha^{-1} with 60 kg S ha^{-1}. The results indicated a beneficial effect of S on protein percentage in spinach crop. Protein yield is a function of protein content and dry matter yield of spinach leaves and both the parameters increased with sulphur application thus resulting in a significant increase in protein yield. Omprakash et al. (1997) and Ali *et al.* (2013) observed that the protein yield of spinach crop was significantly increased with S application.

Nutrient uptake

The nitrogen uptake by spinach leaves increased significantly with increasing levels of sulphur (Table 2) over control. The increases in N uptake by spinach leaves increased from 11.7 kg ha^{-1} at control to 26.0 kg ha^{-1} with 60 kg S ha^{-1}. The higher values of N uptake with S addition could be attributed to enhanced vigour of crop growth with increased N utilization and translocation into the plant resulting in the enhancement of the yield. Similar results were reported by Singh and Singh (2003) and Ali *et al.* (2013). The data (Table 2) indicate that the application of S significantly increased the phosphorus uptake in spinach from 3.8 kg ha^{-1} in control to 9.9 kg ha^{-1} at 60 kg S ha^{-1}. The changes in P uptake brought about by sulphur fertilization were pronounced and significant in spinach crop. These results are in agreement with the findings of Singh and Singh (2003).

Table 2: Effect of sulphur levels on uptake of N, P, K, S (kg ha^{-1}) and Zn (g ha^{-1}) by spinach

Sulphur (kg ha^{-1})	**Nitrogen**	**P**	**K**	**S**	**Zn**	**Apparent S recovery (%)**	**S use efficiency (kg produce/kg S)**
0	11.7	3.8	12.3	9.7	102.0	-	-
15	14.3	5.1	15.3	12.8	105.1	20.6	129.0
30	22.1	8.2	23.6	20.8	104.0	37.6	190.0
45	25.0	9.6	26.3	24.7	100.0	33.3	170.2
60	26.0	9.9	27.7	26.1	96.4	278	135.8
CD (P=0.05)	2.41	1.27	1.21	1.78	5.57	-	-

A progressive increase in sulphur levels gradually increased the uptake of potassium by spinach crop. Highest uptake of potassium was recorded with 60 kg S ha^{-1}, which might be due to higher yield of spinach crop. In the crop, the uptake of potassium under 15, 30, 45 and 60 kg S ha^{-1} was significantly more than the control. Similar results were obtained by Singh and Singh (2003) and Ali *et al.* (2013). Application of sulphur significantly increased the S uptake upto 60 kg S ha^{-1} by spinach crop (Table 2). The increased S uptake following sulphur application might have been contributed by increased sulphur concentration and yield of the crop (Singh and Singh, 2003). The minimum value of Zn uptake in spinach crop was recorded with 60 kg S ha^{-1}. Thus, the results indicate an antagonistic effect of S on Zn utilization by the crop. Ali *et al.* (2013) reported similar results.

Table 3: Effect of Sulphur on quality and economics of spinach

Sulphur (kg ha^{-1})	**Protein content (%)**	**Protein yield (kg ha^{-1})**	**Gross returns (₹.ha^{-1})**	**Net returns (₹.ha^{-1})**	**B:C ratio**
0	4.7	71.4	34120	8990	0.35
15	4.9	88.6	41880	16735	0.66
30	5.1	139.2	56960	31800	1.26
45	5.2	157.0	64760	36976	1.46
60	5.3	164.8	66720	40547	1.76
CD (P=0.05)	0.09	12.5			

Economics

The data (Table 3) indicate that the highest gross profit (₹. 66720 ha^{-1}) and net returns (₹.40547 ha^{-1}) were obtained from 60 kg S ha^{-1} in spinach. The 45 kg S ha^{-1} proved as second best fetching the net returns of ₹. 36947 ha^{-1}. In the light of this, it can be argued that more green foliage (leaves) production with 60 kg S ha^{-1} may be the reason for the resultant profits. The income per rupee spent (B/C ratio) was highest (1.76) with 60 kg S ha^{-1} from the spinach. It is due to more net profit than cost of cultivation involved with this treatment. The second best treatment was 45 kg S ha^{-1} followed by 30 kg S ha^{-1}. The B/C ratio was minimum due to no sulphur application (control).

Efficiency indices

Apparent recovery (%) of sulphur was influenced by S levels with maximum recovery being at 30 kg S ha^{-1} (Table 2). Reduction in apparent recovery of S by spinach was noted at 45 and 60 kg S ha^{-1}. The range of apparent recovery by spinach was from 20.6 to 37.6 %. The response in kg produce/kg sulphur showed an increase upto the level of 30 kg S ha^{-1}. Further increase in the level of sulphur (45 and 60 kg S ha^{-1}) tended to decrease the sulphur use efficiency over 30 kg S ha^{-1}. Better S use efficiency was obtained with S addition upto 30 kg S ha^{-1} recording 190 kg green foliage of spinach/kg sulphur applied., in spinach crop. Similar increase in SUE with increasing levels of S application was reported by Ali *et al.* (2013).

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NUTRIENT MANAGEMENT IN CABBAGE FOR HIGHER PRODUCTION IN BUNDELKHAND REGION OF UTTAR PRADESH

AMIT KUMAR AND ARCHANA KHARE

Department of Horticulture, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.)-284 128
Received: October, 2014; Revised accepted: January, 2015

ABSTRACT

A field experiment was conducted at Research farm, Bundelkhand University, Jhansi (U.P.) to study the effect of inorganic (NPK) fertilizer and boron spray on cabbage (Brassica oleracea L. var. capitata) production and quality. Application of 180 kg N + 80 Kg P_2O_5 + 60 Kg K_2O ha^{-1} + 0.25% borax spray recorded significantly taller plants at all the stages of growth, greater number of leaves (open and folded) per cabbage head (28.6 and 60.9) ,head diameter (cross sectional and vertical) of cabbage (18.2 and 18.0) dry weight of cabbage per head (10.3%) fresh weight (2.6 kg). The crop responded significantly upto highest level of NPK (180 + kg N + 80 kg P_2O_5 + 60 kg K_2O ha-^{1}) + 0.25% borax spray and increased the head yield by 116.5 % over control. Boron spray (0.25%) proved superior to the control with respect to head yield of cabbage. The maximum protein content (1.7 %) and yield (162.4 q ha^{-1}) were recorded with 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha-^{1} + 0.25% B spray.Maximum total soluble solid (6.8%) was also recorded under 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha^{-1} + 0.25 foliar spray of borax. The lowest values of all the parameters were recorded under control.

Keywords: Nutrient, management, cabbage, quality, yield

INTRODUCTION

Cabbage (*Brassica oleracea* L. var. Capitata) is one of the most important cole crops of India. It is a good source of vitamin A, C and minerals like iodine, copper, potassium and sulphur etc. It is used in salad, cooked vegetable, curries pickles as well as dehydrated forms. Cabbage juice is used to be a remedy against poisonous mushrooms and is also used as a gargle against hoarseness. The leaves are used to cover wounds and ulcers and are also recommended against hangover (Chatterjee 1990).Nitrogen encourages the vegetative development of plants by imparting a healthy green colour to the leaves. It also controls to some extent the efficient utilization of phosphorus and potassium. Its deficiency retards growth and root development, turns the foliage yellowish or pale green, hastens maturity and causes lower crop yield. Phosphorus influences the vigour of plants and improves the quality of crops. It encourages the formation of new cells, promotes root growth and hastens leaf development, the emergence of buds and the formation of heads. Potassium enhances the ability of the plants to resist disease, insect attack and cold and other adverse conditions. It plays an essential part in the formation of starch and in the production and translocation of sugars.Modern agriculture over the years has resulted in greater depletion of boron (B) in soil, so its deficiencies have emerged as a serious obstacle in sustaining higher production f food as well as vegetable crops in all parts of the country. Boron is directly and indirectly involved with many plant metabolic functions. Boron acts as new cell developer in meristematic tissue, fruit and seed setting, is involved in the regulation of the carbohydrate metabolism and its transport within the plant, DNA synthesis in meristems, synthesis of amino acids and proteins and nitrogen fixing bacteria. Boron has marked effect on plant from the stand point of both nutrition as well as toxicity. The application of boron through different sources either through soil or foliar spray was found to be beneficial in stimulating plant growth and in increasing yield of crops. However; research on the performance of cabbage with nutrient management practices especially in Bundelkhand region of Uttar Pradesh is very meager. Keeping in view, an attempt was made to find out through field experiment the effect of integrated use of major (NPK) and micronutrient (B) on growth, yield and quality of cabbage.

MATERIALS AND METHODS

A field experiment was conducted at experimental farm, Institute of Agricultural Sciences, Bundelkhand University, Jhansi during rabi season of 2007-08. Bundelkhand region is located along the Vindhyan tract between 24° 26' N latitute, 78° 81' E longitude at 251m above mean sea level. The soil was clay loam in texture with alkaline in reaction (pH 7.5), organic carbon 3.7 g kg^{-1}, available N 160 kg ha^{-1}, available P 16 kg ha^{-1}, K 150 kg ha^{-1} and hot water soluble boron 0.18 mg kg^{-1}. The experiment was conducted in a randomized block design replicated thrice. The treatments were: T_1, control, T_2, 0.25% boron spray, T_3, 150 kg N ha^{-1}, T_4, 150 kg N ha^{-1} + 0.25% boron spray, T_5, 150 kg N + 60 kg P_2O_5 ha^{-1}, T_6, 150 kg N + 60 kg P_2O_5 + 0.25% boron spray, T_7, 150 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}, T_8, 150 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} + 0.25% B spray, T_9, 180 kg N ha^{-1}, T_{10}, 180 kg N + 0.25% B spray, T_{11}, 180 kg N + 80 kg P_2O_5 ha^{-1}, T_{12}, 180 kg N + 80 kg P_2O_5 + 0.25% B spray.$T_{13,}$ 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha-^{1} and $T_{14,}$ 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha-^{1} + 0.25% B spray. The sources of N, P and K were urea, diammonium phosphate and muriate of potash, respectively. Half dose of N and full dose of P_2O_5 and K_2O were applied at the time of transplanting. Remaining dose of N was applied in two splits and boron was applied as foliar spray after 20 days of transplanting. Cabbage variety Golden Acre seedlings (25 days old) were transplanted on 15 November 2007. Rest of the management practices were in accordance with the recommended package of practices for the crop. The height of plant at one month interval was recorded. Number of leaves (open and folded), cross sectional area, vertical length, fresh weight of head and yield were recorded at maturity. Dry matter was determined by sun drying of head and then oven dried at 40° C till the constant weight. Finally the dry matter yield was calculated. Total soluble solids were determined with hand refractometer. Nitrogen content in head was determined by Kjeldahl method and protein content was obtained by multiplying N content with 6.25.

RESULTS AND DISCUSSION

Growth and Yield attributes

Plant height increased consistently with advanced age of the crop irrespective of various treatments. Application of 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha^{-1} + 0.25% foliar spray of borax proved most effective in improving the plant height of cabbage at all the stages of growth followed by 180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha^{-1} + no borax. These treatments, being at par, proved significantly superior to most of the treatments in respect of plant height. The increase in plant height may be attributed to balanced supply of nutrients through chemical fertilizers resulting in higher plant canopy which in turn increased photosynthetic processes during development, Kumar and Choudhary (2002) and Kumar *et al.* (2013) reported similar results.The plants under control showed poorest height at all the stage of growth. Nitrogen was more effective in improving the plant height followed by P and K. Boron proved less effective in increasing the height of plants. Kumar and Singh (2009) and Kumar *et al.* (2013) reported similar results.

Table 1: Effect of various treatments on plant height (cm) of cabbage

Treatment	Days after planting			
	25	55	85	Harvest
T_1 Control	14.1	17.1	20.0	21.0
T_2 0.25% borax spray	14.4	17.5	20.4	21.5
T_3 150 kg N ha^{-1}	17.1	20.1	23.0	24.0
T_4 150 kg N + 0.25% B spray	17.4	20.4	23.3	24.4
T_5 150 kg N + 60 kg P_2O_5 ha^{-1}	18.2	21.4	24.4	25.7
T_6 150kg N + 60kg P_2O_5 + 0.25% B stray	19.0	21.7	24.7	25.9
T_7 150 kg N + 60kg P_2O_5 + 40kg K_2O ha^{-1}	20.0	22.0	25.1	26.3
T_8 150kg N+60kg P_2O_5 +40kg K_2O ha^{-1} +0.25% B spray	20.4	22.4	25.4	26.7
T_9 180 kg N ha^{-1}	21.0	24.0	27.0	27.7
T_{10} 180 kg N ha^{-1} + 0.25% B spray	21.2	24.4	27.4	27.9
T_{11} 180 kg N + 80 kg P_2O_5 ha^{-1}	22.0	25.1	28.4	28.0
T_{12} 180kg N + 80kg P_2O_5 + 0.25% B spray	22.3	25.4	28.9	29.3
T_{13} 180 kg N + 80kg P_2O_5 + 60 kg K_2O ha^{-1}	23.0	26.0	29.9	30.0
T_{14} 180 kg N + 80kg P_2O_5 + 60 kg P_2O_5 + 0.25% B spray	23.2	26.4	30.0	30.3
CD (P=0.05)	1.02	1.21	1.41	1.49

The number of leaves per plant is one of the most important parameter in cabbage as it is the leaves, which are consumed in one or the other form. The number of leaves, both open and folded, were produced maximum with180 kg N + 80 Kg P_2O_5 + 60 kg K_2O ha^{-1} + 0.25% foliar application of borax. The lowest numbers of leaves were produced in control. Thus, it is clear from the results that the maximum numbers of leaves were produced with combined use of nutrients (Panday *et al.*, 2007). The degree of boron response on number of leaves was quite low as reported by Kumar *et al.* (2013) in cauliflower. Boron is associated with the rate of water absorbance and translocation of sugar in plant. Hence, the increase in number of leaves per head (Kumar *et al.* 2013). The size of heads, as noted by cross sectional and vertical length, increased significantly by most of the treatments over control. The most effective treatment in producing heads of greater size was180 kg N + 80 kg P_2O_5 + 60 kg K_2O ha + 0.25% B spray. The plants under control exhibited smallest and lightest heads. Beneficial effect of N, P and K was reported by Singh et al. (2010) and Singh et al. (2011) in cauliflower and cabbage, respectively but when N was applied with P and K, there was a significant improvement in size of cabbage heads (Singh et al. 2011). Foliar application of boron also improved the size of heads as compared to control but the magnitude of improvement was of low order. The crop grown with higher doses of N (180 kg ha^{-1}) and P_2O_5 (80 kg ha^{-1}) with and without K_2O and borax produced significantly higher fresh weight and proved significantly superior to control. However, the magnitude of response to boron was lower than those of N, P and K.The highest percentage of dry matter (10.3) was recorded with 180 kg N + 80 kg P_2O_5 + 60 kg K_2O + 0.25% B spray followed by 180 kg N + 80 kg P_2O_5 + 60 kg K2O and no B spray. Boron spray alone did not improve dry matter accumumilation significantly over control but rest of the treatments proved significantly superior to control. The probable reason for improving growth and yield parameters with the use of NPK + 0.25% boron spray could be due to increased availability of nutrients to plants, resulting better growth (Kumar *et al.* 2013).

Yield

The yield of cabbage heads improved significantly by most of the treatments over control.The head yield of cabbage ranged from 75.0 to 16204 q ha^{-1}. Among the treatments, 180 kg N + 80 kg P_2O_5 + 60 kg K_2O + 0.25% B spray proved most effective in improving the head yield of cabbage (Table 2). The increase in head yield due to this treatment was 116.5% over control. Higher productivity of vegetable crops as a result of integrated use of major nutrients and boron could be explained on the grounds that addition of NPK in balanced and adequate amounts increased nutrient uptake which leads higher yield of cabbage heads (Parmar, 2014). Integration of NPK and B could therefore be considered as a better option in increasing fertilizer use efficieny and providing a more balanced supply of nutrients.The lower yield of cabbage heads was recorded under control.

Table 2: Effect of various treatments on growth, quality and yield of cabbage

Treatment	Open leaves/plant	Folded leaves/plant	Cross sectional diameter (cm)	Vertical length (cm)	Fresh wt. (kg)	Dry wt. %	Protein (%)	TSS (%)	Yield (q/ha^{-1})
T_1	16.0	48.0	12.9	12.2	1.2	6.7	1.2	4.8	75.0
T_2	16.3	48.2	13.3	13.0	1.3	7.1	1.2	5.3	81.2
T_3	19.0	52.7	15.0	14.6	1.4	7.7	1.3	5.4	90.6
T_4	19.6	53.0	15.3	14.8	1.6	7.9	1.3	5.5	100.0
T_5	21.0	53.3	15.5	15.2	1.7	8.0	1.3	5.6	109.3
T_6	22.0	54.0	15.6	15.3	1.9	8.3	1.5	5.8	118.7
T_7	23.6	54.5	16.0	15.4	2.0	8.7	1.5	5.9	125.0
T_8	24.0	55.3	16.2	16.0	2.1	9.0	1.5	6.1	129.1
T_9	24.6	56.7	16.3	16.2	2.1	7.7	1.6	6.3	134.3
T_{10}	25.0	58.0	16.6	16.5	2.2	7.9	1.6	6.4	137.5
T_{11}	26.0	59.0	16.7	16.6	2.3	9.5	1.6	6.6	143.7
T_{12}	26.3	59.0	17.3	17.2	2.3	9.6	1.6	6.6	146.8
T_{13}	17.0	60.0	17.7	17.5	2.4	10.0	1.7	6.8	153.1
T_{14}	28.6	60.9	18.2	18.0	2.6	10.3	1.7	6.8	162.4
CD (P=0.05)	2.08	1.08	1.26	1.76	0.27	0.78	0.35	0.62	17.96

Quality

Data (Table 2) indicated that application of NPK levels improved the protein percentage in cabbage head significantly over control. The maximum protein percentage in cabbage heads was noticed with 180 kg N + 80 kg P_2O_5 + 60 kg K_2O + 0.25% B spray and lowest in control. Foliar application of B also improved the protein percentage over control.The maximum percentage of TSS (6.83%) was recorded with 180 kg N + 80 kg P_2O_5 + 60 kg K_2O + 0.25% B sprays. However, the lowest value (4.80%) was recorded under control. Improvement in quality parameters such as protein and TSS due to integrated use of major (NPK) and B could be attributed to synthesis of amino acids, which might have collectively lead to improvement in quality parameters. Similar observations have also been reported by Varghese and Duraisama (2005).

It is concluded from the results that application of higher level of NPK alongwith 0.25% boron spray proved to be playing a synergistic role in sustaining the productivity of cabbage. This is reflected in terms of enhancement of biometric characters, yield and quality of cabbage heads. Hence, application of magor nutrients along with boron would likely to improve the yield and quality of cabbage.

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EFFECT OF HERBICIDES WITH AND WITHOUT SURFACTANT AGAINST GRASSY AND BROAD LEAF WEEDS IN WHEAT

K.S. YADAV, NISHA BHADAURIA, R.L RAJPUT AND AJAY BHADAURIA

RVSKVV, College of Agriculture, Gwalior (M.P.)
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ABSTRACT

Field experiment was carried out during rabi season of 2009-10 at Reseach farm, College of Agriculture, Gwalior (M.P.) to study the effect of herbicides on growth and yield of wheat. Unchecked weeds growth caused 61.5% reduction in grain yield of wheat. The results showed that yield attributing character and grain yield significantly by differed due to weed control treatments, where highest number of effective ears (85.69)/m row length and grain yield (5312kg ha^{-1}) were recorded with two hand weeding at 25 and 50 DAS. It was on par with Pinoxaden at 40 g ha^{-1}fb carfentrazone (AS 1%) at 25 g ha^{-1}. Among the herbicidal treatments, Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) resulted highest weed control efficiency (78.7%) and lowest grassy (0.63) and broad leaves weeds (0.59) weed dry weight (4.43) and weed index (6.27) followed by Sulfosulfuron (25 g/ha PoE). Hand weeding twice at 25 and 50 DAS fetched the highest net income of ₹ 58260 ha^{-1} while *B:C ratio was maximum (4.54) under Pinoxaden at 40 g ha^{-1}fb carfentrazone at 25 g ha^{-1} (AS 1%).*

Key words: Integrated weed management, weed control efficiency, herbicides, wheat, weed flora.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in India. There has been tremendous increase in area, production and productivity of this crop during the green revolution phase of Indian agriculture. It occupies second position both in terms of area and production. In India, it is cultivated in 29.07 million hectares of land with annual production of 86.87 million tonnes and productivity of 2989 kg ha^{-1}, whereas in Madhya Pradesh, it is cultivated in an area of 37.85 lakh hectares with an annual production of 68.38 lakh tonnes and productivity of 1885 kg ha^{-1}. Weed infestation during the crop period causes more than 53 % reduction in grain yield depending on the weed densities and type of weed flora present (Singh *et al.*, 2002). Commonly used herbicide isoproturon controls grassy weeds only but had little effect on trouble some broad leaf weeds. Further, continuous use of isoproturon may lead to development of resistant bio-types of *Phalaris minor* (Walia *et al.*, 1997). Hence, it is essential to identify alternative herbicide molecules with broad spectrum activity for sustainable weed management in wheat .Conventional methods of weed control being weather dependent, laborious, time consuming and costly due to high cost of labour and mechanical means being less efficient in controlling weeds compare to use of herbicides. Under such conditions it is important to find out the economic feasibility of wheat cultivation with herbicides.Keeping these facts in view; the present study was carried out.

MATERIALS AND METHODS

An experiment was conducted at the Research farm College of Agriculture, Gwalior (M.P.) during Rabi season of 2009-10. The soil of experimental field was sandy clay loam in texture with low available nitrogen (218 kg ha^{-1}) medium in phosphorus (17.5 kg ha^{-1}) and high in potassium (285 kg ha^{-1}) content and neutral in soil reaction (pH 7.6). Experiment was conducted in randomized block design having twelve treatments with three replications.Weed management practices comprised of viz., T_1, Carfentrazone at 15 g ha^{-1} fb pinoxaden at 30 g ha^{-1} (PoE), T_2 ,Carfentrazone at 20 g ha^{-1} fb pinoxaden at 35 g ha^{-1} (PoE), $T_{3,}$ Carfentrazone at 25 g ha^{-1} fb pinoxaden at 40 g ha^{-1} (PoE), $T_{4,}$ Pinoxaden at 30 g ha^{-1} fb carfentrazone (AS 1%) at 15 g ha^{-1} (PoE), $T_{5,}$ Pinoxaden at 35 g ha^{-1} fb carfentrazone (AS 1%) at 20 g ha^{-1}, T_6, Pinoxaden at 40 g ha^{-1}fb carfentrazone (AS 1%) at 25 g ha^{-1} (PoE),T_7, Carfentrazone (25 g ha^{-1} PoE), T_8, Pinoxaden (40 g ha^{-1}PoE), T_9, Isoproturon at 1000 g ha^{-1} + 2, 4-D at 500 g ha^{-1} (PoE), T_{10}, Sulfosulfuron (25 g ha^{-1}PoE), $T_{11,}$ two hand weeding at 25 and 50 DAS, and T_{12} weedy check . Application of 120 kg N, 60 kg P_2O_5, 40 kg K_2O and 25 kg $ZnSO_4$ ha^{-1} was made as urea, diammonium posphate and muriate of potash repectively. The half dose of nitrogen with full dose of P_2O_5, K_2O and Zn were applied at the time of sowing as a basal dose. Seed was sown @ 120 kg ha^{-1}at row to row distance of 22.5 cm. The sowing was done on 28 November 2009. Herbicides were sprayed with a knap sack sprayer fitted with a flat fan nozzle

Corresponding author's e-mail: *bhadauria.snisha2011@gmail.com*

using 500 litres of water per hectare. Hand weeding was done using a *khurpa.* Harvesting was done on 25 March, 2010. The growth and yield attributes were recorded from five selected plants in each plot. Observations were recorded with the help of a quadrant 0.5 m x 0.5 m weeds placed randomly at two spots in each plot at 60DAS. The data on weeds were subjected to log transformation (log1+x) to normalize their distribution. Weeds were cut at ground level, washed with tap water, sun dried for a few days and then oven dried at 65°C for 48 hours and then weighed. Total dry matter was determined by the summing up the dry weight of each plant. Weed control efficiency was calculated using weed dry weight data at 60 DAS which was maximum during weed growth period irrespective of treatments. Economics of different weed control treatments was worked out on prevailing market prices of inputs and outputs.

RESULTS AND DISCUSION

Maximum weed infestation was observed in weedy check and the dominant weeds were Chenopodium album (42.8%) and Phalaris minor (26.7%). The contribution of other weeds like Cyperus rotundus, Cynodon dactylon, Anagallis arvensis, Melilotus indica, Spargula arvensis, Fumaria parviflora and Convolvulus arvensis was less than 31% to total weed infestation. All the herbicidal treatments including weed free recorded a significant reduction in population of narrow and broad leaf weeds compared to weedy check at 60DAS. Two hand weeding at 25 and 50 DAS significantly controlled the narrow leaf weeds at 60 DAS which was at par with Pinoxaden at 40 g/ha fb carfentrazone at 25 g ha^{-1} (AS 1%) and Sulfosulfuron (25 g ha^{-1}). The lowest count of broad leaf weeds throughout the crop growth cycle was under hand weeding twice followed by Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) and Sulfosulfuron (25 g ha^{-1}). Among the herbicidal treatments, post-emergence application of Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) recorded significantly lowest population of broad leaf weeds. However, this was found at par with Pinoxaden fb carfentrazone (AS 1%) (35 + 20 g ha^{-1}), Isoproturon at 1000 g ha^{-1} + 2, 4-D at 500 g ha^{-1} and Sulfosulfuron (25 g ha^{-1}) at 60 DAS. The superiority of new herbicides like carfentrazone-ethyl in respect of controlling the weeds especially broad-leaf weeds was reported by Walia and Singh (2006), Pandey *et al.* (2007), Shukla *et al.* (2008),Verma *et al.* (2008), Saini *et al.* (2010) and Chauhan (2014).

Table 1: Effect of different treatments on No. of narrow and broad leaf weeds /m^2, weed dry weight g/m^2, weed control efficiency and weed index

	Treatment	No.of narrow weeds at 60 DAS	No. of Broadleaf weeds at 60 DAS	Weed dry weight at 60 DAS	Weed control efficiency (%)	Weed index (%)
T_1	T_1 Carfentrazone at 15g/ha fb Pinoxaden at 30g/ha (PoE)	0.85 (6.00)	0.95 (8.00)	12.53	51.61	35.20
T_2	Carfentrazone at 20 g/ha fb pinoxaden at 35 g/ha (PoE)	0.82 (5.67)	0.90 (7.33)	11.30	51.93	33.18
T_3	Carfentrazone at 25 g/ha fb pinoxaden at 40 g/ha (PoE)	0.77 (5.00)	0.88 (6.67)	10.80	55.48	31.68
T_4	Pinoxaden at 30 g/ha fb carfentrazone (AS 1%) at 15 g/ha (PoE)	0.75 (4.67)	0.84 (6.00)	8.13	58.06	26.93
T_5	Pinoxaden at 35 g/ha fb carfentrazone (AS 1%) at 20 g/ha (PoE)	0.69 (4.00)	0.75 (4.67)	6.17	65.16	24.26
T_6	Pinoxaden at 40 g/ha fb carfentrazone (AS 1%) at 25 g/ha (PoE)	0.63 (3.33)	0.59 (3.33)	4.43	78.71	6.27
T_7	Carfentrazone (25 g/ha PoE)	1.09 (11.33)	1.03 (9.67)	22.60	17.74	42.38
T_8	Pinoxaden (40 g/ha PoE)	0.90 (7.00)	0.98 (8.67)	17.27	32.25	40.26
T_9	Isoproturon at 1000 g/ha + 2, 4-D at 500 g/ha (PoE)	0.77 (5.00)	0.74 (4.67)	6.73	61.61	24.40
T_{10}	Sulfosulfuron (25 g/ha PoE)	0.66 (3.67)	0.70 (4.00)	5.93	73.87	14.12
T_{11}	Weed free (2 H.W. at 25 and 50 DAS)	0.55 (2.67)	0.26 (1.00)	3.50	82.90	-
T_{12}	Weedy check	1.95 (89.67)	2.20 (156.33)	202.53	-	61.51
Transformation		**Log (1+x)**	**Log (1+x)**		**-**	
C.D. (P=0.05)		**0.13**	**0.22**	**23.98**		

Note: *DAS – Days after sowing, PoE – Post emergence, Figures in parentheses indicate original values*

All weed control treatments at 60 DAS gave significantly lower weed dry weight than weedy check at each growth stage. At early stage of weed growth (60 days), all weed control treatments were at par to each other. This may be mainly attributed to lower narrow and broad-leaf weed population per unit area recorded under the effect of above treatments. (Singh *et al.* 2002).Weed control efficiency ranged from 17.74 to 82.90%. The highest weed control efficiency was estimated in two hand weeding at 25 and 50 DAS (82.9%) followed by Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) (78.71%). Verma *et al.* (2008) also reported reduced dry weight and increased weed control efficiency due to application of Carfentrazone and Sulfosulfuron. Post-emergence application of Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) recorded lowest weed index (6.27%) followed by Sulfosulfuron at 25 g ha^{-1} (14.12%). Similarly weedy check observed in maximum weed index (61.51). Similar resuts were reported by Walia and Singh (2006).

Number of effective ears/m row length and grain yield showed significant differences due to weed control treatments where, highest number of effective ears 85.69/m row length and grain yield were recorded with two hand weeding at 25 and 50 DAS treatment and it was on par with Pinoxaden at 40 g ha^{-1} fb carfentrazone (AS 1%) at 25 g ha^{-1}. All the weed control treatments except Carfentrazone at 15 g/ha fb pinoxaden at 30 g/ha, Carfentrazone at 20 g/ha fb pinoxaden at 35 g/ha, Carfentrazone at 25 g/ha fb pinoxaden at 40 g/ha, Carfentrazone (25 g/ha) and Pinoxaden (40 g/ha) were significantly superior to weedy check with respect to yield parameter. All the herbicidal treatments (Pinoxaden at 40 g ha^{-1} fb carfentrazone (AS 1%) at 25 g ha^{-1}) recorded highest number of effective ears /m row length and grain yield. It was on par with Sulfosulfuron (25 g ha^{-1} PoE). Two hand weeding at 25 and 50 DAS treatment resulted in significantly highest number of grains per ear, however it was at par with the application of Pinoxaden at 40 g ha^{-1} fb carfentrazone (AS 1%) at 25 g ha^{-1}, Sulfosulfuron (25 g ha^{-1}), Isoproturon at 1000 g ha^{-1} + 2, 4-D at 500 g ha^{-1} and Pinoxaden at 35 g ha^{-1} fb carfentrazone (AS 1%) at 20 g ha^{-1}. Among weed control treatments, two hand weeding at 25 and 50 DAS treatment resulted in significantly highest test weight (40.00 g). This might be due to less population of weeds especially broad-leaf weeds in the plots treated with these herbicides and in two hand weeding at 25 and 50 DAS plots where there was less competition between crop and weed plants for moisture, light, space and nutrients utilized provided congenial condition to the crop for proper development of its reproductive phase which resulted in the enhancement of all these yield contributing characters. The highest grain yield was due to effective suppression of weeds in the early stages, which was evidenced from maximum yield attributes recorded. Sharma and Singh (2011), Shukla *et al.* (2008), Singh *et al.* (2011) and Verma *et al.* (2008) also reported similar results.

Table 2: Effect of different treatments on yield attributing characters, yield and economics of wheat

	Treatment	**Effective ear/m row length**	**Ear length (cm)**	**No. of grains /ear**	**Test weight (g)**	**Grain yield (kg ha^{-1})**	**Net income (₹.ha^{-1})**	**B:C ratio**
T_1	Carfentrazone at 15 g/ha fb pinoxaden at 30 g/ha (PoE)	80.58	8.71	32.47	31.00	3442	34699	3.21
T_2	Carfentrazone at 20 g/ha fb pinoxaden at 35 g/ha (PoE)	81.02	8.77	32.90	32.67	3550	36106	3.29
T_3	Carfentrazone at 25 g/ha fb pinoxaden at 40 g/ha (PoE)	81.37	8.97	33.70	33.33	3629	37259	3.35
T_4	Pinoxaden at 30 g/ha fb carfentrazone (AS 1%) at 15 g/ha (PoE)	81.91	9.47	34.17	34.00	3882	41517	3.64
T_5	Pinoxaden at 35 g/ha fb carfentrazone (AS 1%) at 20 g/ha (PoE)	82.76	9.57	35.07	36.00	4024	44443	3.82
T_6	Pinoxaden at 40 g/ha fb carfentrazone (AS 1%) at 25 g/ha (PoE)	84.72	9.67	36.63	38.33	4979	56218	4.54
T_7	Carfentrazone (25 g/ha PoE)	76.99	8.27	31.10	29.33	3061	30100	2.99
T_8	Pinoxaden (40 g/ha PoE)	78.47	8.40	31.50	29.33	3173	31321	3.01
T_9	Isoproturon at 1000 g/ha + 2, 4-D at 500 g/ha (PoE)	82.22	9.53	34.67	35.33	4016	43537	3.74
T_{10}	Sulfosulfuron (25 g/ha PoE)	82.87	9.63	35.77	37.33	4562	51743	4.44
T_{11}	Weed free (2 H.W. at 25 and 50 DAS)	85.69	9.87	37.60	40.00	5312	58260	4.10
T_{12}	Weedy check	69.93	8.93	29.92	28.00	2044	16586	2.12
	C.D. (P=0.05)	**2.29**	**0.94**	**3.14**	**4.92**	**587**		

Herbicides cost : *(i) Carfentrazone – 800 ₹/1.00 kg, (ii) Pinoxaden – 650 ₹/1.00 kg, (iii) Sulfosulfuron – 600 ₹/13.00g (iv) Isoproturon – 150/500g, (v) 2,4 D – 280 ₹/kg*

Economics

Hand weeding twice at 25 and 50 DAS fetched the highest net income (₹.58260 ha^{-1}) followed by Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) and Sulfosulfuron (25 g ha^{-1}) treatments recording net income of ₹. 58260 ha^{-1} ₹. 56218 ha^{-1} and ₹. 51743 ha^{-1}, respectively. The B:C ratio was maximum (₹. 3.54) under Pinoxaden at 40 g ha^{-1} fb carfentrazone at 25 g ha^{-1} (AS 1%) followed by Sulfosulfuron at 25 g ha^{-1}. (₹. 4.44) and two hand weeding at 25 and 50 DAS (₹. 4.10) due to the high labour cost in case of hand weeding at 25 and 50 DAS as compared to herbicides. These results also corroborate with the findings of Jat *et al.* (2003). It is concluded that among the herbicides Pinoxaden at 40 g/ha fb carfentrazone (AS 1%) at 25 g ha^{-1} and sulfulfuron (25 g ha^{-1}) were found more effective to control the grassy and broad leaves weeds in wheat. Weed incurred a loss of 61.51% in terms of grain yield of wheat. Amongst different weed control treatments, weed free was the best treatment for improving the growth, yield attributes and yield of wheat followed by Pinoxaden at 40 g ha^{-1} fb carfentrazone (AS 1%) at 25 g ha^{-1} and Sulfosulfuron (25 g ha^{-1}).Weed free treatment gave the highest monetary return closely followed by Pinoxaden at 40 g ha^{-1} fb carfentrazone (AS 1%) at 25 g ha^{-1} and Sulfosulfuron (25 g ha^{-1}). The highest B:C ratio was registered with Pinoxaden at 40 g/ha fb carfentrazone (AS 1%) at 25 g ha^{-1} followed by Sulfosulfuron (25 g ha^{-1}).

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INFLUENCE OF GROWTH REGULATORS ON GROWTH, YIELD AND ECONOMICS OF CABBAGE VARIETIES

BIRENDRA VIKRAM SINGH

Department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior – 474 002 (M.P.), India

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ABSTRACT

A field experiment was conducted at Gwalior during rabi season of 2012-13 to study the effect of mixture of GA and NAA with four concentrations i.e. 0, 10, 15 and 20 ppm on growth, yield attributes and yield on cabbage varieties, namely Krishna (Hybrid), Kranti (Hybrid), Golden acre and Pride of India. Results revealed that 15 ppm GA_3 + NAA was found most effective growth regulator in increasing the growth, yield attributes and head yield (688.50 q ha^{-1}) and net returns (₹. 1,05,792 ha^{-1}) of cabbage varieties. Among varieties, Krishna (Hybrid) produced the maximum growth, yield (625.35 q ha^{-1}) and net return (₹.93893 ha^{-1}) as compared to the other varieties. Pride of India proved inferior in respect of growth, yield and net returns.

Key words: Growth regulators, cabbage varieties, productivity, economics

INTRODUCTION

Cabbage (*Brassica oleraceae* var. Capitata Linn.) belongs to family Cruciferae is an important vegetable of cole group. It is one of the important vegetable crops cultivated throughout India. It is very nutritional and a rich source of vitamin A, B, C also contains protein upto 1.4 g/100 g. Cabbage is used as vegetables in curries, salad and pickling. It is used alone or mixed with potatoes for vegetable purpose. It covers about 6% of total area under vegetables. India comes next to China in cabbage production occupying an area of 0.28 million hectares with the production of 6.20 million tonnes. In the recent years, the use of growth regulators in improvement of quality and yield of vegetable has been emphasized. Gibberellic acid (GA) is a very potent plant growth substance and its application at very low concentrations can have a profound effect. Application of NAA induces higher physiological efficiency including photosynthetic ability of plants. It leads to better growth and yield of several vegetable crops without substantial increase in the cot of production (Shivran and Jat 2013; Verma and Maurya 2013). Information regarding the use of plant growth regulators on cabbage is not available. Hence, an attempt was therefore made to identify the growth regulators and their varying concentration for obtaining the maximum significant results of cabbage varieties.

MATERIALS AND METHODS

The field experiment was conducted at the Horticulture nursery, College of Agriculture, Gwalior (M.P.) during the *rabi* seasons of 2012-13. Gwalior is situated in the northern tract of M.P., enjoying sub-tropical climate with extreme hot about 46^0 C in summer and minimum temperature 1^0 C in the winter season. It is located at the latitude of $26^013'$ N longitude $74^0 4'$E and altitude of 208 m above the sea level. The field soil was sandy-loam having soil pH 7.9, electrical conductivity 0.13 dSm^{-1}, organic carbon 4.7 g kg^{-1}, available N, P_2O_5 and K_2O 214, 15 and 283 kg ha^{-1}, respectively. Mixtures of GA and NAA with their four concentrations (0, 10, 15 and 20 ppm) were tested in randomized block design (factorial) with three replication and four varieties namely Krishna (Hybrid), Kranti (Hybrid), Golden acre and Pride of India. The seeds of different varieties of cabbage were treated treatmentwise by hormonal powder of GA_3+NAA at their varying concentrations before sowing in nursery bed. The recommended doses of fertilizers nitrogen 150 kg ha^{-1}, P_2O_5 80 kg ha^{-1} and 75 kg K_2O ha^{-1} were applied through urea, single superphosphate and muriate of potash, respectively as basal dressing two days prior to transplanting. In addition to these fertilizers, a basal dose of 200 q ha^{-1} of FYM was also incorporated at the time of field preparation and plant protection measures were adopted for optimum crop growth. Observations were recorded on plant height (cm), number of open leaves/plant, length and width of leaves, circumference of head, weight of untrimmed and trimmed head, stalk length, diameter of head and yield of head. The observations on the characters of growth and development of plants were recorded at 75 DAT on five randomly selected plants from each treatment in each replication. The data were analysed by adopting the standard procedures. Several economics indices are available to evaluate the profitability of cropping system. No single index is capable of giving good comparison of different treatment and so a number of index of indices are used together to assess the economic viability of the system. Since, the price of the farm products changes from year to year, season to season and place to place, the profitability of the system also changes accordingly. Gross income, net return and B:C ratio for the treatments were calculated by using standard basic formulae of economics.

RESULTS AND DISCUSSION

Growth parameters

Growth parameters as affected by various treatments are presented in Table 1. Results revealed that Krishna (Hybrid) recorded maximum plant height (22.06 cm) and length of leaves upto 31.04 cm, whereas Golden acre resulted in the highest number of open leaves (19.02/plant). Krishna (Hybrid), Golden acre and Pride of India recorded more or less equally higher leaf width (27.08 - 27.14 cm), whereas the lowest leaf width (23.28 cm) was measured in Kranti (Hybrid). The Pride of India recorded the significantly lowest leaf length (23.48 cm) over other three varieties (Table 1). Thus, there appeared to be very wide differences among these four cabbage varieties with respect to vegetative growth characters. This may be due to variation in the genetical variability among the varieties against growth characters as well as due to changes in the agro-climatic conditions. The similar variations in growth characters among the cabbage varieties have also been reported by Patil and Patil (1997) and Shaikh *et al.* (2002). This reason may be due to the fact that the increased vegetative growth of the plant gives more opportunity for photosynthesis area resulted higher rate of photosynthesis and accumulation of food material sink. Increasing the concentrations of plant growth substances only upto 15 ppm increased all the growth characters almost significantly (Table 1). Further increase in concentration upto 20 ppm did not increase these parameters over 15 ppm concentrations. Enhancement in morphological parameters by the mixture of GA3 and NAA may be due to their affect on cell enlargement, cell growth, physico-chemical properties of protoplasm, respiration, nitrogen and nucleic acid metabolism etc. NAA promoted cell division in pericycle and cortical tissues, the pattern was similar as occurring during lateral root development. The evidence finds support of the mechanism of auxin action in terms of master reaction theory of Thiamann (1936) as quoted by Khamparia (1998) that auxin is held responsible for initiating a fundamental change in the enzyme system of cytoplasm. The beneficial influence of plant growth regulators on growth parameters of horticultural crops have also been reported by Singh *et al.* (2001) and Kanaujia et al. (2002).This is possibly due to the fact that plant growth regulators encourages the cell division and elongation with the modification of physiological processes resulted in enhancement of growth characters in cabbage varieties.

Table 1: Growth and yield-attributes of cabbage varieties as influenced with mixture of GA3 + NAA concentration

Treaments	Plant height (cm)	No. of open leaves /plant	Length of leaves (cm)	Width of leaves (cm)	Circumference of curds (cm)	Weight of untrimmed curds (kg)	Weight of trimmed curds (kg)	Stalk length (cm)	Diameter of curd (cm)
Varieties									
Krishna (Hybrid)	22.06	17.51	31.04	27.08	26.47	2.44	1.85	10.95	5.20
Kranti (Hybrid)	18.32	17.13	26.06	23.38	23.22	2.35	1.75	10.35	4.68
Golden acre	18.86	19.02	24.73	27.00	33.56	1.54	1.08	10.28	6.29
Pride of India	18.43	17.49	23.48	27.14	14.26	1.16	0.76	10.15	2.32
CD(P=0.05)	0.65	0.43	0.60	0.70	1.27	0.15	0.13	0.22	0.21
GA3 + NAA (ppm)									
0	18.53	16.87	25.07	24.33	21.43	1.48	1.02	9.67	3.39
10	19.05	17.38	26.02	26.59	23.42	1.98	1.46	9.73	3.72
15	19.77	18.07	26.85	27.11	25.86	2.50	1.55	9.93	4.12
20	19.25	17.91	26.41	26.68	25.61	1.92	1.50	9.85	4.07
CD(P=0.05)	0.65	0.43	0.60	0.70	1.27	0.15	0.13	0.22	0.21
Interactions	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Sig. - Significant

Yield-attributes

The productivity of any crop is totally based on the yield-attributing parameters. In case of cabbage, the yield attributes were circumference, diameter, weight of untrimmed and trimmed head. The head of Golden acre attained significantly higher circumference (33.56 cm) as well as diameter (6.29 cm) over the varieties taken in the treatments. So far, whatever the weight of untrimmed and trimmed heads was concerned it was found lowest i.e. 1.54 and 1.08 kg respectively. However, Krishna (Hybrid) variety, all the above mentioned yield-attributes were found in the higher range. On the other hand, the variety Pride of India recorded all the four yield-attributes in the significantly lowest range (Table-1). The significant variations among the varieties with respect to yield-attributes may be due to similar positive variations recorded in case of the growth attributes of cabbage varieties. These variations may be due to the effect of prevailing environmental conditions. The photosynthesis, respiration and other metabolic processes vary due to the environmental fluctuations from variety to variety. Some varieties respond positively while other negatively. The differences noted in the four varieties viz. Krishna (Hybrid), Kranti (Hybrid), Golden acre and Pride of India may be due to these reasons under the agro-climatic conditions of Kymore plateau. Abu Grab and Ebrahim (2010) also reported similar results. In regards to plant growth substances only 15 ppm enhanced the yield-attributes significantly (Table-1). The significant increase in yield-attributes due to PGS mixture may be due to the significant increase in plant height, number of open leaves/plants, length and width of leaf. Considerably, PGS can only modify the attributes corroborating to the findings of researchers (Anand Bahadur, 2001 and Singh et al., 2003). The probable reason may be due to application of PGS mixture in minute quantities for growth and development of plants. GA3 + NAA accelerate the development of growth and reproductive phases thus, promoting yield attributing characters.

Table 2: Yield and net returns from cabbage varieties as influenced with mixture of GA3 + NAA concentration

Treatments	**Yield of untrimmed curds (q ha^{-1})**	**Yield of trimmed curds (q ha^{-1})**	**Gross income (₹. ha^{-1})**	**Net returns (₹. ha^{-1})**	**B:C ratio**
Varieties					
Krishna (Hybrid)	885.73	625.35	137700	93893	4.31
Kranti (Hybrid)	887.00	598.91	136000	89340	4.12
Golden acre	584.16	370.66	130534	43345	2.55
Pride of India	402.75	281.97	125800	26333	1.94
CD(P=0.05)	58.20	43.28	--	--	--
GA3 + NAA (ppm)					
0	593.23	388.06	96050	48624	2.67
10	691.58	475.58	102632	65221	3.27
15	743.83	688.50	105792	70714	3.51
20	731.00	503.50	100086	68352	3.46
CD(P=0.05)	58.20	43.28	--	--	--
Interactions	Sig.	Sig.	--	--	--

Sig. - Significant

Yield and net returns

The data (Table 2) indicate that the variety, Krishna (Hybrid) proved the best giving maximum yield of trimmed heads (625.35 q ha^{-1}) followed by Kranti (Hybrid) producing 598.91 q ha^{-1} trimmed heads. The differences in cabbage yield from different varieties are exactly in accordance with the yield-attributes obtained in these varieties as a result of attainment of genetically governed yielding potentiality. These findings are in conformity with the findings of Patil and Patil (1997); Abu Grab and Ebrahim (2010) and Singh *et al.* (2003) who reported that yield attributes were significantly influenced due to curtailed vegetative growth with the encouragement of reproductive phase. The increasing concentration of plant growth regulators mixture only up to 15 ppm proved highly beneficial which enhanced the maximum yield of the cabbage varieties. Accordingly, at 15 ppm concentration of GA3 + NAA mixture, the highest yield of untrimmed and trimmed heads was 743.83 and 688.50 q ha^{-1}, respectively (Table 2). So much increase in yield due to 15 ppm plant growth substances concentration may be due to similar increases in growth and yield-attributes of cabbage by the applied dose of PGS concentration. The present findings are in accordance with those of Singh *et al.* (2001) and Singh *et al.* (2003).

Economics

The data (Table 2) revealed that Krishna (Hybrid) gave maximum net return (₹. 93893 ha^{-1}) with B:C ratio (4.31) followed by Kranti (Hybrid) giving net return (₹. 89340 ha^{-1}) with B:C ratio of 4.12. The net return was in accordance with the gross income obtained from cabbage yield of the varieties. Accordingly, the hybrid varieties viz. Krishna and Kranti treated with 15 ppm concentration of GA3 + NAA mixture augmented the net returns. Thus, Krishna (Hybrid) with 15 ppm concentration recorded the maximum net return (₹. 1,05,792 ha^{-1}). The second best interaction Kranti (Hybrid) treated with 15 ppm concentration achieving net return (₹. 1,02,632 ha^{-1}). It may be concluded that Krishna (Hybrid) with GA3 + NAA, 15 ppm concentration recorded maximum growth parameters, yield and net returns.

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EFFECT OF SULPHUR ON GROWTH, YIELD AND ECONOMICS OF POTATO CULTIVARS

D.K. SHARMA, S.S. KUSHWAH* AND K.S. VERMA

College of Horticulture, R.V.S. Krishi Vishwa Vidyalaya, Mandsaur- 474 002 (MP)
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ABSTRACT

An experiment was conducted at College of Horticulture, Mandsaur (M.P.) during rabi season of 2008-09 to evaluate the four potato cultivars (Kufri Chipsona-1, Kufri Chipsona-2, Kufri Jyoti, Kufri Pushkar) under five sulphur (0, 15, 30, 45, and 60 kgha^{-1}) levels. Twenty treatment combinations were replicated thrice in factorial randomized block design. Significant variations were observed in different varieties of potato for growth parameters, yield attributes, and tuber yield. Maximum number of sprouts was recorded in Kufri Pushkar followed by Kufri Chipsona-1 and lowest in Kufri Jyoti. Kufri Chipsona-2 produced tallest plants and higher number of leaves per plant. Fresh weight of shoot per plant number of tuber per plant (8.33), average tuber weight (167.3g) and total tuber yield (41.90t ha^{-1}) was recorded maximum with Kufri Pushkar. There was an increase in these parameters with increasing dose of sulphur upto 45 kg ha^{-1}. Further increase in sulphur dose either reduced the values or showed non significant improvement. Highest number of sprout per tuber (7.5), plant height (41.7, 47.9, 59.2cm), number of leaves per plant (29.6, 52.0, 76.5), fresh weight of shoot per plant (50.3, 64.2, 76.5 g), tuber per plant (8.58), tuber weight (166.56g) as well as total tuber yield (37.74 t ha^{-1}) were recorded with 45 kg S ha^{-1}. Highest net return (₹.188890.2ha^{-1}) as well as B:C ratio (3.02) were recorded with Kufri Pushkar. Among the sulphur levels, maximum net return (₹.163100.5ha^{-1}) and B:C ratio (2.57) was obtained with 45 kg S ha^{-1}.

Key words: Potato, sulphur, growth, yield, economics

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most popular food crop of the world. It ranks fourth in importance after rice, wheat and maize. Potato is a nutritious, easily digestible, wholesome food. It is one of the widely grown crops in India. The country produced 12.42% of the world's potatoes from 10.32% of the total global potato growing area with productivity level (22.8tha^{-1}) higher than the world's average (18.9t ha^{-1}) during the year 2012-13. India stands second in world potato production (NHB, 2014). Genetic architecture has great influence on yield and quality of potato. Various varieties of potato having wide variation in their yield potential and quality attributes have been evolved. These varieties further show variation in their attributes under different agro climatic conditions. Kufri Jyoti is widely adopted potato variety grown for table potato as well as processing purpose. Kufri Chipsona-1 and Kufri Chipsona-2 are processing potato varieties. While Kufri Pushkar has a good keeping and cooking quality, low dry matter content with medium size tuber. It is a high yielding potato variety (Kang *et al.*, 2007).Sulphur is fourth major nutrient after NPK, required by plants. Its application is less expensive but can give higher profits than other nutrients (Tandon and Messick, 2007). Sulphur plays an essential role in chlorophyll formation and therefore helps to give plants their green colour. It is the key component of balanced nutrition required to potato. Intensive cropping and use of high-grade fertilizers have resulted in depletion of sulphur in soils. Various workers have reported the need of application of sulphur fertilizers along with its beneficial effects on yield and quality (Chettri *et al.*, 2002, Jaga and Sharma, 2013 and Choudhary *et al.*, 2013). Keeping these facts in view an experiment was conducted to see the response of potato cultivars to sulphur levels under agroclimatic conditions of Mandsaur, Madhya Pradesh.

MATERIALS AND METHODS

The experiment was conducted during Rabi season of 2008-09 at "Bahadari farm", College of Horticulture, Mandsaur, Madhya Pradesh. Mandsaur is situated in western part of Madhya Pradesh, between latitude of 23o 45' to 24^{o}13' North, longitude of 74^{o} 44' to 75^{o}18' East and at an altitude of 435.20 m above sea level. This region lies under Malwa Plateau Agro climatic zone of the state. Mandsaur is having sub-tropical and semi-arid climatic conditions with a temperature range of 5oC minimum and 44oC maximum in winter and summer respectively. In this region maximum rainfall is received during mid June to September. The average annual rainfall is 544.05 mm. South - West monsoon is responsible for major part of annual precipitation. The soil of the experimental field was Clay in texture with uniform topography. The soil pH was 7.1 having

Corresponding author's e-mail: kushwahhort@rediffmail.com

available N, P, K and S content in soil 140, 27, 390 and 27kgha^{-1}, respectively. The experiment was laid out in factorial randomised block design with three replications, taking four potato varieties Kufri Chipsona-1, Kufri Chipsona-2, Kufri Jyoti, Kufri Pushkar and five sulphur doses (0,15, 30, 45 and 60 kgha^{-1}). A uniform dose of nutrients was applied @ N 120, P_2O_5 80 and K_2O 100 kg ha^{-1} in all the plots. Full dose of P, K, S and half dose of N was given as basal application. Remaining half dose of N was applied in two equal splits i.e. 1st at 25 days after planting and 2nd at 45 DAP. The N, P, K and S were supplied through urea, di ammonium phosphate, muriate of potash (MOP) and elemental sulphur, respectively. Healthy and uniform size tubers were planted on 16 October at spacing of 60 cm row to row and 25 cm plant to plant. Observations were recorded on growth parameters viz., number of sprout per tuber (at 45 DAP), plant height (at 30, 60, 90 DAP), number of leaves (at 30, 60, 90 DAP), fresh and dry weight of shoot (at 30, 60, 90 DAP), yield parameters viz., number of tuber per plant, tuber weight (g) and tuber yield per hectare. Economics of different treatments was worked out on the basis of prevailing prices of inputs and output. The prices of inputs at the time of experiments were DAP @ ` 980/q, urea @ ` 504/q, MOP @ ` 550/q, elemental sulphur @ ` 60/kg, potato seed tuber @ `1750/q. The potato tuber sale rate was @ ` 600/q. Sulphur use efficiency (SUE) was calculated as per procedure (Sud *et al*., 1996).

RESULTS AND DISCUSSION

Growth parameters

Results (Table 1) showed that varieties had exerted significant effect on growth parameters. There was linear increase in plant height, number of leaves, fresh and dry weight of shoot per plant upto 90 days after planting in all the varieties. Though, the fresh and dry weight of shoot per plant at 45 DAP showed non significant effect. Maximum number of sprouts was recorded in Kufri Pushkar followed by Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Jyoti. Maximum plant height was recorded with Kufri Chipsona-2, which was significantly superior over other varieties. It was followed by Kufri Chipsona-1, Kufri Pushkar and lowest plant height was recorded with Kufri Jyoti. Maximum number of leaves was observed with Kufri Chipsona-2, which was significantly superior over other varieties. Kufri Pushkar recorded maximum fresh weight of shoot per plant followed by Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Jyoti in descending order. Different genetic makeup might have resulted in varied potential for sprouting as well as photosynthesis, which resulted in more food material accumulation and ultimately high fresh and dry weight of shoot in Kufri Pushkar. Kumar *et al.* (2008) also reported significant difference in growth parameters under different variety of potato.

Table 1: Growth parameters in potato as influenced by varieties and sulphur levels at different stages

Treatment	Sprouts per tuber	Plant height (cm)			Leaves per plant			Fresh weight of shoot/plant (g)			Dry weight of shoot/plant (g)		
		45 DAP	60 DAP	90 DAP	45 DAP	60 DAP	90 DAP	45 DAP	60 DAP	90 DAP	45 DAP	60 DAP	90 DAP
Varieties (V)													
(Kufri Chipsona-1)	6.5	38.0	41.3	54.3	26.1	46.4	67.5	41.3	54.4	60.3	4.3	7.5	10.1
(Kufri Chipsona-2)	5.7	49.7	56.0	67.5	32.0	51.0	97.7	38.9	51.4	59.6	4.2	7.0	9.9
(Kufri Jyoti)	5.5	32.4	37.6	48.6	20.8	41.3	54.3	37.3	46.7	53.8	3.8	6.5	9.7
(Kufri Pushkar)	7.7	35.2	40.6	51.7	21.8	46.2	64.7	42.1	59.5	65.3	5.0	8.1	11.2
SE m±	0.27	1.08	1.29	1.45	1.29	2.27	2.36	1.96	2.08	2.19	0.30	0.34	0.39
CD (P=0.05)	0.77	3.11	3.69	4.14	3.70	6.52	6.76	NS	5.97	6.02	NS	0.97	1.11
Sulphur l (kg ha^{-1})													
0	5.5	36.2	40.7	52.3	21.7	38.8	65.1	29.4	42.2	45.4	3.2	5.9	8.0
15	5.7	37.0	42.1	53.6	22.4	42.7	69.9	38.3	47.2	52.8	3.8	6.6	9.5
30	6.2	39.0	42.8	55.3	25.5	46.9	70.6	40.0	54.1	59.3	4.4	7.1	10.5
45	7.5	41.7	47.9	59.2	29.6	52.0	76.5	50.3	64.2	76.5	5.5	9.0	12.0
60	6.9	40.3	45.9	57.2	26.7	50.7	73.2	41.5	57.5	66.0	4.7	8.0	11.2
SE m±	0.30	1.21	1.44	1.62	1.44	2.54	2.64	2.19	2.33	3.01	0.34	0.38	0.43
CD (P=0.05)	0.87	3.48	4.12	4.64	4.14	7.28	7.55	6.27	6.68	8.62	0.99	1.09	1.24

The findings (Table1) revealed significant influence of sulphur application on all the growth parameters at all the stages of growth. Among the sulphur doses, highest number of sprout per tuber was found with the application of 45 kg S ha^{-1}. Further increase in sulphur level did not show any remarkable influence. Similarly, plant height, number of leaves per plant and fresh and dry weight of shoot per plant also showed increase up to 45 kgha^{-1} sulphur application. Further increase in sulphur level i.e. 60 kgha^{-1} had no significant improvement in these growth parameters. The increase in growth parameters under sulphur application might be due to improved sulphur availability, which in turn enhanced the plant metabolism and photosynthetic activity resulting into better growth. These findings are in agreement with Singh and Shrivastava (1995) and Jat *et al.* (2013).

Yield attributes and yield

Different varieties as well as sulphur levels had significant influence on number of tuber per plant, average tuber weight and tuber yield. Maximum number of tuber per plant was recorded with Kufri Pushkar followed by Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Jyoti in descending order. Kufri Pushkar recorded significantly higher number of tuber per plant as compared to Kufri Jyoti and Kufri Chipsona-2. Highest average tuber weight was recorded with Kufri Pushkar, which was significantly superior over other varieties. Rest of the varieties followed the order as Kufri Chipsona-1 > Kufri Chipsona-2 > Kufri Jyoti. There was no remarkable difference between tuber weight of Kufri Chipsona-1 and Kufri Chipsona-2 and between Kufri Chipsona-2 and Kufri Jyoti. Genetic background of the varieties might be responsible for these differences in yield attributes. Tuber yield was recorded highest with Kufri Pushkar, which was significantly superior over other varieties. Rest of the varieties followed the order of Kufri Chipsona-1 > Kufri Chipsona-2 and > Kufri Jyoti for tuber yield of potato. The difference between tuber yield of Kufri Chipsona-1 and Kufri Chipsona-2 was not significant. Kufri Jyoti yielded at par to Kufri Chipsona-2. Higher growth parameters along with greater tuberisation and bulking capacity due to genetic makeup might have resulted in greater number of tuber, average tuber weight, maximum total tuber yield in Kufri Pushkar. Jaiswal *et al.* (2008) and Kumar *et al.* (2008) also reported significant variation in yield parameters and total tuber yield of different potato varieties. Sulphur levels showed significant influence on yield parameters and yield in potato. Highest number of tuber per plant was recorded at 45 kg ha^{-1} sulphur, which was significantly superior over control and 15 kg ha^{-1} sulphur levels. Application of sulphur at the rate of 30 kg ha^{-1} and 60 kg ha^{-1} showed non-significant difference in number of tuber per plant as compared to 45 kg ha^{-1} sulphur level. Average tuber weight was recorded highest with application of 45 kg ha^{-1} sulphur which was significantly superior over all lower levels of sulphur. Further increase in sulphur level showed no significant response. The improvement in yield attributes with the application of sulphur could be ascribed to its pivotal role in regulating physiological and metabolic system in plant. Sulphur enhances cell multiplication, elongation and expansion, chlorophyll synthesis resulting in higher dry matter accumulation consequently higher yield attributes. These results are corroborated with those reported by Singh *et al.*(2012).Total tuber yield was found maximum with 45 kg S ha^{-1} which was significantly higher than control, 15 kg ha^{-1} and 30 kgha^{-1} sulphur levels. While the differences in tuber yield at 45 kg ha^{-1} and 60 kg ha^{-1} sulphur were not remarkable. These results showed that there was enhancement in yield parameters and yield up to 45 kg ha^{-1} sulphur and further increase in sulphur level had no significant positive improvement.

Table 2: Yield and economics of potato cultivars as affected by sulphur

Treatments	Number of tuber per plant	Tuber weight (g)	Tuber (t ha^{-1})	Net income (₹. ha^{-1})	B:C Ratio	SUE (q kg^{-1})
Varieties (V)						
(Kufri Chipsona-1)	8.00	138.02	32.70	133731.0	2.14	1.03
(Kufri Chipsona-2)	7.27	133.60	30.01	118103.4	1.88	1.05
(Kufri Jyoti)	6.47	117.88	27.11	100196.6	1.60	1.59
(Kufri Pushkar)	8.33	167.30	41.90	188890.2	3.02	0.74
SEm±	0.37	7.02	1.12	6749.5	0.11	-
CD (P=0.05)	1.06	20.13	3.23	19338.7	0.31	-
Sulphur (S) kg/ha						
0	6.67	119.48	28.73	111683.5	1.84	0
15	7.00	129.16	30.40	120850.5	1.96	1.12
30	7.50	131.55	32.75	134017.0	2.14	1.34
45	8.58	166.56	37.74	163100.5	2.57	2.01
60	7.83	149.25	35.13	146500.0	2.28	1.07
SE m±	0.42	7.85	1.26	7546.2	0.12	-
CD (P=0.05)	1.20	22.50	3.60	21621.3	0.35	-

More availability of sulphur which is an important component in plant nutrition might have increased the growth parameters, yield parameters and finally yield in potato due to increased metabolic activities, photosynthesis, assimilation and bulking rate. These findings are in line with those of Lalitha *et al.* (2002) and Sud and Sharma (2002).

Sulphur use efficiency (SUE)

The data (Table 2) showed variation among potato varieties for Sulphur use efficiency. Highest SUE (1.59 q kg^{-1}) was recorded with Kufri Jyoti which was followed by Kufri Chipsona-2, Kufri Chipsona-1. Kufri Pushkar had lowest SUE (0.74 q kg^{-1}). The efficient cultivars give higher tuber yield under nutrient stress than less efficient cultivar. Jatav *et al.* (2013) reported significant variation in potato varieties for N use efficiency.Application of sulphur had registered remarkable influence on SUE in potato. There was increase in sulphur use efficiency with increasing dose of sulphur application upto 45 kg ha^{-1}. Further increase in sulphur levels resulted in lower SUE. This may be due to the fact that input-output relationship follows the law of diminishing return as far as the relationship between sulphur and yield is concerned. Similar findings have been reported by Sud *et al*. (1996) and Jatav *et al*. (2013).

Economics

Economic evaluation of treatments showed that cost of cultivation increased with increasing level of sulphur. Gross income was recorded highest with variety Kufri Pushkar under 45 kg ha^{-1} sulphur. It was followed by Kufri Pushkar under 60 kg ha^{-1}, Kufri Pushkar under 30 $kgha^{-1}$, Kufri Pushkar under 15 kg S ha^{-1}, Kufri Pushkar without sulphur, Kufri Chipsona-1 under 45 kg ha^{-1}, Kufri Chipsona-2 under 45 kg ha^{-1} and Kufri Chipsona-1 under 60 kg S ha^{-1} in descending order. Minimum gross income was recorded with variety Kufri Jyoti without sulphur application. Highest net income was obtained with variety Kufri Pushkar under 45 kg ha^{-1} sulphur followed by 60, 30, 15 kg ha^{-1} and without sulphur application with same variety. Minimum net income was received with Kufri Jyoti without sulphur application. Highest cost: benefit ratio was noted with Kufri Pushkar with 45 kg S ha^{-1} followed by 60 and 30 kg sulphur application with same variety. Lowest cost: benefit ratio was realized with Kufri Jyoti under control. The increase in yield with sulphur application under different varieties might be the reason for these results. Lalitha *et al.* (2000) also reported higher net return and cost: benefit ratio with sulphur application.

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STATUS OF AVAILABLE NUTRIENTS AND POTASSIUM FRACTION IN SOILS OF DIMAPUR, NAGALAND IN RELATION TO LAND USE SYSTEMS

Y.K. SHARMA, S.K. SHARMA AND ANAMIKA SHARMA*

Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland, 797106
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ABSTRACT

Seventy two surface (0-20cm) soil samples were collected from different locations of Dimapur district of Nagaland under cereal, orchard and forest land use systems and analyzed for status of available nutrients and forms of potassium. Soils of the district were strong to moderate acidic (4.40 to 5.80) in reaction. Sand, silt and clay content of the soils ranged from 30.8 to 55.0, 24.1 to 40.2 and 18.2 to 36.3 % with mean values of 40.0, 32.0 and 27.7 %, respectively. The CEC of the soils was quite low and irrespective of land use systems, varied from 9.5 to 17.2 cmol (p^+) kg^{-1}. The soils under forest land use were recorded to be high in CEC than other land use systems. Soils of the district were high in organic carbon, medium in available nitrogen and low in available phosphorus contents. Available sulphur in the soils varied from 14.8 to 35.0 kg ha^{-1}. DTPA extractable Zn varied from 0.20 to 3.50 mg kg^{-1} with a mean value of 1.52 mg kg^{-1}. Higher amounts of organic carbon, available N, P, S and Zn were recorded in the soils under forest land use followed by orchard and cereal land use. Total K, 1N NH_4OAc K, water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K of the soils ranged between 1720 and 3450, 67.7 and 120.0, 5.5 and 9.2, 62.1 and 110.8, 797 and 1477 and 721.1 and 1357 mg kg^{-1}, respectively. Available, water soluble, exchangeable, 1N HNO_3 K and non-exchangeable K constituted 3.7, 0.3, 3.4, 42.9 and 39.3 % of the total K. Soils under cereal land use system were deficient to the extent of 4.2, 66.7, 12.5, 62,5 and 41.7% in available N, P, K, S and Zn, respectively. In orchard land use system, extent of deficiency was 50.0, 20.8 and 29.2% for P, S and Zn, respectively soils were medium to high in N and medium in K under this land use system. In forest land use system, 29.2 and 8.3% soils were deficient in P and S, respectively. Highly significant and positive relationship amongst different forms of K indicated existence of dynamics equilibrium among various forms of K. Various fractions of potassium had positive and significant correlation with organic carbon and clay content of the soils.

Keywords: Available nutrients, potassium forms, land use systems, Dimapur

INTRODUCTION

Knowledge about physical, chemical properties and soil fertility status of an area is very much relevant for identifying problems and constraints in crop production for enhancing crop productivity in sustained manner. Nutrients status of soil play a vital role in the growth, development and yield of plants and information of available nutrient status of an area can go a long way in planning in judicious use of nutrient sources and soil management practices. Knowledge about nutrients status of the soil is helpful in understanding the inherent capacity of soil to supply essential plant nutrients for utilization to crops. Potassium is released in soluble and exchangeable form during weathering of potassium bearing minerals at widely differing rates. Soil potassium exists in dynamic equilibrium between its forms. The availability of K to plants is not only controlled by solution K, rather it is manifested by exchangeable and non- exchangeable K. Potassium dynamics refer to renewal of K at any point of time as controlled by the climatic variables, soil and hydrological conditions, cultural practices, crops and cropping pattern of the area in question (Baruah et al., 2002). Major portion of soil K exists as constituent of mineral structure and in fixed or non-exchangeable forms with minor portion as water soluble and exchangeable K (Pasricha, 2002). Besides the soil characteristics, land use pattern also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh et al., 2003). Soils under particular land use system may affect physico- chemical properties which may modify fertility status and nutrient availability to plants. Scanty information is available on physicochemical properties, nutrient status and different forms of potassium of soils of Dimapur district of Nagaland. Therefore, survey investigation was carried out to study the fertility status and forms of potassium in relation to land use systems and soil properties.

MATERIALS AND METHODS

For present investigation, seventy two (three samples from each ecosystem of each village) soil samples (0-20cm), representing leading land use ecosystems viz., cereal ecosystem, orchard ecosystem, and forest ecosystem were collected from

*Corresponding author: *Programme Coordinator, KVK, Dimapur, ICAR Research Complex, Jharnapani, Nagaland*

different locations of Dimapur district of Nagaland. Large area of the Dimapur district is in the plains with an average elevation of 260 m above sea level excepting the Medziphema sub-division and a few villages of Niuland sub-division, which are located in the foothills. Dimapur is situated at 25° 54' 45" N Latitude and 93° 44' 30" E Longitude. Climate of the district is hot and humid in the plains during summer (reaching a maximum of 36ºC, with humidity up to 93%) while the winter months are cool and pleasant. The average annual rainfall of the district is 1504.7 mm. Major crops of the district are paddy, maize, soybean, cucurbits, pineapple, banana, litchi and jackfruit. Collected soil samples were analysed for pH, mechanical composition, porosity, CEC, organic carbon, available N, P and K using standard methods (Jackson, 1973). Available phosphorus was extracted with NH_4F (Bray and Kurtz, 1945). Available sulphur was extracted with 0.15% $CaCl_2$ solution (Williams and Steinbergs, 1959) and subsequently estimated by turbidimetric method (Chesnin and Yien, 1951). Total K was extracted by digestion of the soil samples with perchloric and hydrofluoric acid. Water soluble K was extracted by shaking the soil with distilled water (1:5 soil -water suspension). The 1N boiling HNO_3 K was extracted adopting the method advocated by Wood and Deturk (1941). Different forms of potassium in extracts were determined flame photometrically. Zinc was extracted with DTPA (Lindsay and Norvell, 1978) and analyzed by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Physicochemical properties

Irrespective of land use systems, the pH of soils varied from 4.40 to 5.80, indicating that the soils are acidic in reaction (Table 1). The soils under orchard land use system showed slightly high pH as compared to other land use system. Excess leaching of bases from the soil profile due to heavy rainfall might be caused acidity in these soils (Sharma and Singh, 2002). Similar findings have also been reported by Amenla *et al.*, (2010). Irrespective of land use systems, the sand, silt and clay contents of the soils varied from 30.8 to 55.0, 24.1 to 40.2 and 18.2 to 36.3 %, respectively. The CEC of the soils of cereal, orchard and forest land use patterns varied from 9.5 to 13.5, 9.8 to 15.0 and 12.3 to 17.2 cmol (p^+) kg^{-1} with an average of 11.1, 12.2 and 14.5 cmol (p^+) kg^{-1}, respectively. The soils under forest ecosystem indicated higher CEC value than other ecosystems which might be due to high amount of organic carbon in the soils under forest ecosystem. Irrespective of land use system, the porosity of the soils ranged from 44.7 to 59.4 % with an average of 53.9 %. Higher porosity was recorded in the soils of forest land use system, while low porosity was found in the soils under cereal land use. Possible reason of this trend of porosity might be variation in organic carbon content of the soils of different land use systems. Irrespective of land use systems, organic carbon content in soils of Dimapur district ranged from 6.5 to 20.4 g kg^{-1} with an average of 12.5 g kg^{-1}. Average organic carbon content of the soils under cereal, orchard and forest ecosystems was 8.5, 11.4 and 17.4 g kg^{-1}, respectively indicating higher amount in forest ecosystem. All the soil samples contained high amount of organic carbon except soils of Medziphema village under cereal land use. Wide variation in organic carbon accumulation under different land use systems has also been reported by Sharma *et al.*, (2013).

Fertility Status

Available N content of the soils under cereal, orchard and forest land use patterns ranged from 293.4 to 442.5, 364.8 to 494.0 and 467.0 to 562.1 kg ha^{-1} with an average of 362.0, 416.4 and 518.6 kg ha^{-1}, respectively. The corresponding ranges of available P in these soils were from 7.5 to 10.6, 8.0 to 13.5 and 10.1 to 15.7 kg ha^{-1} with average of 9.1, 11.1 and 12.4 kg ha^{-1}. Except soils of Piphema village under forest land use, soils of rest villages under all land use systems fell under medium category of nitrogen. Medium class of available N indicated that the mineralizable nitrogen fraction under prevailed climatic condition and acidic environment is rather low. Variation in available N and P status of the soils under different land use systems within village might be due to variation in organic carbon status of the soils. These results are in agreement with those of Somasundaram *et al.* (2009). Available sulphur content in the soils under cereal, orchard and forest ecosystems varied from 14.8 to 25.0, 18.0 to 27.0 and 24.2 to 35.0 kg ha^{-1} with an average of 17.9, 23.0 and 29.3 kg ha^{-1}, respectively. Soils under forest land use system had high amount of sulphur as compared to soils of other land use systems which might be due to high amount of organic carbon. Irrespective of land use systems, the DTPA extractable Zn content varied from 0.20 to 3.50 mg kg^{-1} with a mean value of 1.52 mg kg^{-1} which clearly indicates that soils were deficient to sufficient in Zn. On the basis of average Zn content, soils under cereal land use were marginal and soils under orchard and forest use were sufficient. However, soils of six villages under cereal and orchard use showed deficient amount of Zn.

Table 1: Physicochemical properties and available nutrient status of soils under various land use system

Land use ecosystem & location of sampling	pH	Mechanical composition (%)			CEC cmol (p^+) kg^{-1}	Porosity (%)	Organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})			DTPA Zn (mg kg^{-1})
		Sand	Silt	Clay				N	P	S	
Cereal Ecosystem											
Maova	4.92	34.2	40.2	25.5	10.7	44.7	7.6	320.2	9.5	16.0	0.30
Rajuphema	4.61	36.8	29.4	33.7	13.5	54.6	10.0	388.3	7.5	14.8	0.75
Piphema	4.88	30.8	37.9	31.1	9.7	52.0	8.4	293.4	9.8	20.0	1.22
Pherema	5.50	35.7	37.8	26.4	11.0	54.5	10.0	442.5	8.0	25.0	2.00
Socunema	4.98	43.0	31.3	25.6	11.8	52.0	9.2	338.3	10.5	19.0	2.00
Medziphema	5.56	33.8	33.8	32.3	10.6	45.4	6.5	386.1	8.0	17.5	0.20
Sirhima	4.90	45.7	31.2	23.0	9.5	50.1	7.8	331.1	9.5	14.8	1.10
Jharnapani	5.70	50.9	27.7	21.3	12.4	44.7	9.0	396.3	10.6	16.5	0.50
	(5.13)	(38.8)	(33.6)	(27.3)	(11.1)	(49.7)	(8.5)	(362.0)	(9.1)	(17.9)	(1.00)
Orchard Ecosystem											
Maova	5.38	45.3	34.4	20.2	13.0	55.0	11.2	420.1	11.8	24.4	3.00
Rajuphema	5.05	34.1	37.7	28.1	11.3	50.4	10.0	402.1	10.8	24.0	1.20
Piphema	4.59	38.2	32.2	29.5	15.0	55.0	12.3	392.1	10.9	23.0	2.05
Pherema	4.96	36.0	34.8	29.2	12.0	53.0	10.5	394.1	10.7	18.0	2.15
Socunema	4.97	41.2	29.9	28.8	12.8	55.0	12.6	494.0	8.0	21.0	0.50
Medziphema	5.66	35.8	35.4	28.6	9.8	57.2	11.6	364.8	13.5	24.3	0.50
Sirhima	5.66	34.6	29.7	35.6	12.8	52.0	11.7	414.0	10.3	22.4	1.10
Jharnapani	5.36	55.0	23.1	21.2	11.2	58.6	12.0	450.1	12.8	27.0	0.20
	(5.20)	(40.1)	(32.1)	(27.6)	(12.2)	(54.5)	(11.4)	(416.4)	(11.1)	(23.0)	(1.33)
Forest Ecosystem											
Maova	5.18	55.0	24.1	20.8	14.8	57.0	15.4	551.9	11.4	24.8	3.04
Rajuphema	5.80	47.2	34.5	18.2	12.3	55.9	16.8	467.0	14.2	24.2	2.20
Piphema	5.32	38.3	34.3	27.3	13.2	59.4	20.0	562.1	15.6	28.0	0.92
Pherema	4.99	35.8	38.2	26.0	16.6	55.0	17.0	511.0	10.3	30.0	2.80
Socunema	5.44	42.0	29.2	28.7	17.2	59.0	20.4	496.8	15.7	35.0	1.53
Medziphema	4.90	35.3	28.2	36.3	14.8	57.6	12.7	529.4	11.1	30.6	1.15
Sirhima	5.00	34.6	30.0	35.4	13.1	59.0	19.6	478.0	10.8	29.9	3.50
Jharnapani	4.40	41.8	24.2	33.8	14.0	58.2	17.9	552.7	10.1	32.2	2.85
	(5.13)	(41.2)	(30.3)	(28.3)	(14.5)	(57.6)	(17.4)	(518.6)	(12.4)	(29.3)	(2.24)
Overall average	(5.15)	(40.0)	(32.0)	(27.7)	(12.6)	(53.9)	(12.5)	(432.3)	(10.8)	(23.4)	(1.52)

Figure in parenthesis indicates mean value

Extent of deficient, marginal and sufficient soil samples was 41.7, 29.2 and nil, 33.3, 20.8 and 12.5 and 25.0, 50.0 and 87.5% under cereal, orchard and forest land use system, respectively. Higher amount of Zn in soils of forest land use system might be due to high organic carbon content of the soils which provides more surface area for ion exchange and cation adsorption and contributed to higher values of Zn in soils. Since DTPA is an organic chelating agent, extracts Zn from different pools and higher amount of organic carbon and severe soil acidity enhanced Zn concentration in soil solution. Similar findings were also noted by Talukdar *et al.*, (2009). Low amount of NPS and Zn under cereal and orchard ecosystem might be ascribed to regular mining and poor recycling of nutrients, which tended to deplete nutrient status of the soils.

Potassium Fractions

Total potassium content under cereal, orchard and forest ecosystems ranged from 1720 to 2710, 1930 to 2700 and 2670 to 3450 mg kg^{-1} with an average of 2253.6, 2226.4 and 3019.0 mg kg^{-1}, respectively (Table 2). Available K, water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K constituted 3.7, 0.3, 3.4, 42.9 and 39.3 % of the total K. Total K had positive significant correlation with organic carbon, clay content and other potassium forms and negative significant correlation (r= -0.34) with soil pH (Table 3). Irrespective of land use systems the available potassium content of the soils varied from 67.7 to 120.8 mg kg^{-1} with a mean value of 91.9 mg kg^{-1}. Available K content in the soils under cereal, orchard and forest ecosystem was 85.6, 88.6 and 101.5 mg kg^{-1}, respectively. 12.5% samples in cereal land use and 4.2% samples in forest land use were low and high in available K, respectively. While rest samples in each land use system were medium in available K. Extent of soil samples to medium class of K was 87.5, 100 and 95.8% in cereal, orchard and forest land use system, respectively. The water soluble K and exchangeable K contributed about 7.3 and 92.6 % towards available K. High amount of

Table 2: Forms of potassium of the soils under various land use system

Land use ecosystem & location of sampling	Total K (mg kg $^{-1}$)	Av K (1N NH_4OAc) (mg kg^{-1})	WS K (mg kg $^{-1}$)	Ex K (Av K - WS K) (mg kg^{-1})	1N HNO_3 K (mg kg $^{-1}$)	NE K (1N HNO_3 K - Av K) (mg kg^{-1})
Cereal Ecosystem						
Maova	2600	94.4	6.1	88.3	1203	1108.6
Rajuphema	2216	84.4	5.6	78.8	973	888.6
Piphema	2170	81.0	5.6	75.4	960	879.0
Pherema	1895	67.7	5.6	62.1	882	814.3
Socunema	2710	102.9	7.4	95.5	1216	1113.1
Medziphema	2218	88.4	6.1	82.3	1046	957.6
Sirhima	2500	90.6	6.0	84.6	1124	1033.4
Jharnapani	1720	75.9	5.5	70.4	797	721.1
	(2253.6)	(85.6)	(5.9)	(79.6)	(1025.1)	(939.4)
Orchard Ecosystem						
Maova	2411	91.4	6.5	84.9	1127	1035.6
Rajuphema	1930	92.2	5.6	86.6	910	817.8
Piphema	2080	77.7	5.9	71.8	959	881.3
Pherema	2130	80.0	6.7	73.3	983	903.0
Socunema	2010	85.4	7.1	78.3	1012	926.6
Medziphema	2220	85.4	5.7	79.7	972	886.6
Sirhima	2700	109.5	7.3	102.2	1107	997.5
Jharnapani	2330	87.9	6.9	81.0	1019	931.1
	(2226.4)	(88.6)	(6.4)	(82.2)	(1011.1)	(922.4)
Forest Ecosystem						
Maova	3251	91.3	6.8	84.5	865	773.7
Rajuphema	2807	87.2	7.0	80.2	995	907.8
Piphema	3450	120.0	9.2	110.8	1477	1357.0
Pherema	2670	86.8	6.2	80.6	901	814.2
Socunema	3010	112.2	8.2	104.0	1359	1246.8
Medziphema	3042	106.0	7.7	98.3	1264	1158.0
Sirhima	2992	101.3	8.8	92.5	1348	1246.7
Jharnapani	2930	107.0	8.5	98.5	1269	1162.0
	(3019.0)	(101.5)	(7.8)	(93.6)	(1184.7)	(1083.2)
Overall average	(2499.7)	(91.9)	(6.7)	(85.1)	(1073.6)	(981.7)

Av = available, WS = water soluble, Ex = exchangeable, NE = non-exchangeable
Figure in parenthesis indicates mean value

available K in the soils under forest ecosystem might be due to high organic carbon content. It had highly positive correlation with water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K. Water soluble K ranged from 5.5 to 7.4, 5.6 to 7.3 and 6.2 to 9.2 mg kg^{-1} with an average of 5.9, 6.4 and 7.8 mg kg^{-1} in the soils under cereal, orchard and forest land use, respectively. Water soluble K was found to be more in the soils of forest land use system. Water soluble K had significant and positive correlation with other forms of potassium (Table-3). Irrespective of land use systems, exchangeable K ranged between 62.1 and 110.8 mg kg^{-1} with a mean of 85.1 mg kg^{-1}. The HNO_3 soluble K in the soils under cereal, orchard and forest land use systems varied from 797 to 1216, 910 to 1127 and 901 to 1477 mg kg^{-1} with an average of 1025.1, 1011.1 and 1184.7 mg kg^{-1}, respectively. The HNO_3 soluble K constituted, on an average 42.9% of the total K. Significant positive correlation was reported among the various forms of K indicated the existence of equilibrium among the potassium forms. Further, significant positive correlation between HNO_3 K and CEC (r=0.24) indicated that some K might be absorbed in the inner side of the lattice, which could not be exchanged by exchangeable NH_4^+ but could be extracted with HNO_3, was a part of exchange complex which is slowly exchangeable (Prasad, 2010). The non- exchangeable K content of the soils of the district ranged from 721.1 to 1357.0 mg kg^{-1} with an average of 981.7 mg kg^{-1}. The non- exchangeable K constituted 39.3 % towards total K. The non-exchangeable K have positive and significant relationship with other forms of K. These results are fairly comparable to the results reported by Sharma (2013) for acidic soils of Nagaland.

Table 3: Correlation coefficient between different forms of potassium and soil properties

Soil properties	Total K	Available K	Water soluble K	Exchangeable K	1N HNO_3 K	Non Exchangeable K
pH	-0.34**	-0.15	-0.25*	-0.23*	-0.32**	-0.23*
CEC	-0.06	0.16	0.15	0.15	0.24*	0.18
Porosity	0.06	0.10	0.11	0.08	0.08	0.07
SOC	0.35**	0.36**	0.38**	0.36**	0.35**	0.22*
Clay	0.33**	0.30**	0.21*	0.31**	0.33**	0.35**
Total K	-	0.89**	0.88**	0.79**	0.87**	0.86**
Available K	-	-	0.86**	0.89**	0.75**	0.67**
Water soluble K	-	-	-	0.92**	0.89**	0.82**
Exchangeable K	-	-	-	-	0.54**	0.73**
1N HNO_3 K	-	-	-	-	-	0.82**

* *Significance at 5%,* ** *Significance at 1%*

The above results lead to a conclusion that the soils are rich in organic matter, medium in available N, adequate in available sulphur and DTPA Zn but deficient in available phosphorus. Available nutrients are relatively low in soils under cereals and orchard ecosystems than soils of forest ecosystems. Higher amounts of different forms of K were noticed in the soils of forest land use system. Organic carbon and clay content of soils showed significant and positive correlation with all forms of potassium. Highly significant and positive relationship was observed amongst different forms of K.

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ASSOSCIATION BETWEEN YIELD AND ITS COMPONENT TRAITS UNDER IRRIGATED AND DROUGHT CONDITIONS IN CHICKPEA

M.S. SHIVAKUMAR*, P.M.SALIMATH, SUMA S. BIRADAR AND PRAKASH I. GANGASHETTY

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad – 580 005, Karnataka, India.
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ABSTRACT

Five hundred and seventy five selected chickpea genotypes of F_2 population and F_2derived F_3 progeniesof cross between ICC 13124 and WR 315 was carried out under drought and irrigated conditions to determine the nature of association between grain yield and yield components by partitioning the correlation coefficients into direct and indirect effects.Considering the correlation and path analysis, under drought and irrigated situation,seed yield per plant had highly significant phenotypic relationship withtraits like number of pods per plant (0.91 and 0.79) and number of seeds per plant(0.31 and 0.88). When correlation coefficient was portioned into direct and indirect effect, the number of seeds per plant (0.97 and 0.95) and number of pods per plant(0.08 and 0.04)have shown high direct effect on seed yield per plant under drought and irrigated situation, respectively. These results suggested that improvement of grain yield in chickpea is linked with these traits.

Key words: Chickpea, correlation, path coefficient analysis, drought, segregating generations.

INTRODUCTION

Chickpea (*Cicerarietinum*L.) is the third leading grain legume in the world and first in the South Asia. Ninety two % of the area and eighty nine % of the production of grain are concentrated in semi-arid tropical countries. Research into the plant response to water stress is becoming increasingly important, as most climate change scenarios suggest an increase in aridity in many areas of the globe. Breeding efforts for improvement of drought tolerance in crop plants is primarily based on selection for grain yield under drought stress. Because of the variability in drought pattern from year to year, further progress may not be achieved by selecting solely for grain yield. However, the progress in breeding for drought resistance is generally considered to be slow due to the quantitative and temporal variability of available moisture across years, the low genotypic variance in yield under these conditions and inherent methodological difficulties in evaluating component traits (Ludlow and Muchow, 1990) together with the highly complex genetic basis of this character (Turner *et al*., 2001).The correlation studies are helpful in formulating efficient breeding programme for multiple trait selection. Correlation coefficient measures the mutual relationship between various plant characters and gives reasonable indication for plant breeders to face selection on characters to improve economic yield and also for planning more efficient breeding programmes. In crop like chickpea, where production of hybrid is out of question and hybridization followed by selection is the main procedure for improvement, the knowledge on correlation is an obligate necessity for achieving genetic improvement. The importance of correlation study in selection programme is appreciable when highly heritable characters are associated with important characters like yield which have low heritability. Selection for yield to improve productivity most often will not be fruitful, since it is a highly complex trait. However, improvement in productivity can be brought about by affecting selection for its closely associated component traits. In order to plan such selection strategy, information on the nature and magnitude of association of the component traits with productivity is a basic pre-requisite. In the present study correlations, were worked out using F_2 population and $F_{2\text{-}3}$ progenies under irrigated and drought condition separately.

MATERIALS AND METHODS

The experimental material consisted of two parents, one check, F_2 population and F_2 derived F_3 progenies of the cross between ICC13124 and WR 315. Till now breeding for drought resistance in chickpea is done using either ICC 4958 or Annigeri 1. Where as in our study we have used a new source ICC 13124 which was identified as one of the best drought tolerant line by Parameshwarappa and Salimath (2010) in Dharwad after screening mini core collections obtained from ICRISAT, Hyderabad. F_2 populations were evaluated during rabi 2009-10. F_2 derived F_3 progenies were evaluated during *rabi* 2010-2011 in both irrigated and drought condition. Each F_2 derived F_3 progenies along with parents and

Corresponding author e-mail: shivakumarms.gpb@gmail.com ICAR Research Complex, Jharnapani, Nagaland

check at regular interval were grown in augmented design with 8 blocks and 3 checks. Individual progeny row was sown in single row of 2. meter length, spaced 30 cm apart and 20 cm between plants. The moisture stress was created by taking up sowing 30 days later than normal sowing and withholding irrigation after germination and seedling establishment. The last irrigation given to stress plot was on 14th day after sowing while for non-stress condition, irrigation was given at regular intervals up to physiological maturity. All other recommended package of practices were adopted for raising the good crop.From 575 F_{2-3} plants, observation was made on nine quantitative characters., *viz.* days to 50% flowering (DFF), plant height (PH), primary branches per plant (PB), secondary branches per plant (SB), number of pods per plant (N0P), seeds per pod (SPP), number of seeds per plant (NOS), test weight (TW) and seed yield per plant (SY) were recorded.In both the segregating populations, the simple correlation coefficients were calculated to determine the direction and magnitude of associations among different characters and tested against table 'r' values (Fisher and Yates, 1963) at (n-2) degree of freedom both at 0.05 and 0.01 probability levels for their significance. Simple correlations were calculated by using the formula as given Weber and Moorthy (1952). Path coefficient analysis suggested by Wright (1921), Dewey and Lu (1959) was carried out to know the direct and indirect effect of the morphological traits on plant yield.

RESULTS AND DISCUSSION

The phenotypic correlations of seed yield per plant with other quantitative characters in both F_2 population, F_{2-3} progenies under irrigated and drought conditions are presented in Table 1. It is observed that in F_2 and F_3 generations, seed yield was significantly and positively correlated with all the character like primary branches, secondary branches, number of pods per plant,, seeds per pod, number of seeds per plant and test weight (Meena., 2010). Whereas in $F_{2,}$ plant height is negatively correlated with seed yield (Salimath and Patil 1990 and Ali *et al*. 2011).

Table 1: Phenotypic correlation coefficient among yield components in F_2 population, F_{2-3} progenies under irrigated and drought condition

		PH	PB	SB	NOP	SPP	NOS	TW
	F_2	1						
PH	F_3I	1						
	F_3D	1						
	F_2	0.049	1					
PB	F_3I	0.27**	1					
	F_3D	0.38**	1					
	F_2	0.071	0.488**	1				
SB	F_3I	0.400**	0.460**	1				
	F_3D	0.310**	0.360**	1				
	F_2	-0.046	0.360**	0.340**	1			
NOP	F_3I	0.380**	0.170**	0.390**	1			
	F_3D	0.340**	0.480**	0.390**	1			
	F_2	-0.081	0.360**	0.340**	0.910**	1		
SPP	F_3I	0.430**	0.190**	0.430**	0.860**	1		
	F_3D	0.350**	0.480**	0.390**	0.970**	1		
	F_2	-0..037	0.04	0.027	0.068	0.258**	1	
NOS	F_3I	0.120**	0.08	0.060	-0.080	0.240**	1	
	F_3D	0.120**	0.170**	0.100*	0.250**	0.410**	1	
	F_2	0.134**	0.003	-0.034	-0.191**	-0.250**	-0.160**	1
TW	F_3I	0.140**	-0.090	-0.07	-0.170**	-0.260**	-0.200**	1
	F_3D	0.160**	-0.080	-0.030	-0.390**	-0.420**	-0.270**	1
	F_2	-0.024	0.385**	0.349**	0.865**	0.914**	0.180**	0.068
SY	F_3I	0.480**	0.150**	0.400**	0.790**	0.880**	0.880**	0.20**
	F_3D	0.436**	0.500**	0.420**	0.910**	0.920**	0.310**	0.08

**- Significance at 5%, **- Significance at 1%*

Plant height in F_2, was negatively correlated with traits like number of pods per plant, seeds per pod, seeds per plant and test weight (Ali *et al.*, 2011 and Padmavathi *et al.*, 2013). In F_3, plant height was positively correlated with these traits. Linkage between genes contributing to most of the character would have broken due to segregation.The primary and secondary branches per plant were positively and significantly correlated with grain yield per plant in both F_2 and F_3 (Vijayalakshmi*et al.*,2000, Jeena and Arora., 2001). Hundred seed weight is negatively correlated with number of seeds per plant, pods per plant which were in contrast (Abhishek*et al.,* 2012). Number of pods per plant and seeds per plant showed significant and positive correlation with each other (Malik *et al.,* 2010, Yucel and Anlarsal 2010 and Sarker *et al.,* 2014). Hence, number of seeds per plant should be used as selection for yield improvement in chickpea (Ali *et al*. 2011). As expected seeds per pod were positively and significantly correlated with seeds per plant but negatively with number of pods per plant.Seed yield per plant had highly significant phenotypic relationship with pods per plant, seeds per plant (Sharma and Saini 2010). Under drought condition, the seed yield exhibited a highly positive correlation with seed number. The plant height had significant correlation with all characteristics except the unfilled pod per plant in both cultivars and high positive correlation was observed between height and seed per plant.These results suggested that improvement of grain yield in chickpea is linked with these traits and selection of these characters might have good impact on seed yield per plant.

Table 2: Direct (diagonal) and indirect effects of different characters on seed yield per plant in F_2 population

	PH	**PB**	**SB**	**NOP**	**SSP**	**NOS**	**TW**
PH	**0.008**	0.001	0.001	-0.001	-0.0003	-0.001	0.001
PB	0.001	**0.019**	0.009	0.007	0.001	0.007	0.0001
SB	0.001	0.004	**0.080**	0.003	0.0002	0.003	-0.0003
NOP	-0.009	0.073	0.069	**0.200**	-0.014	0.181	-0.038
SPP	-0.002	0.002	0.001	-0.003	**0.044**	0.012	-0.007
NOS	-0.064	0.286	0.272	0.718	0.204	**0.790**	-0.198
TW	0.042	0.001	-0.011	-0.059	-0.051	-0.078	**0.310**
SY	-0.024	0.385	0.349	0.865	0.185	0.914	0.067
R^2	-0.001	0.007	0.003	0.172	0.008	0.722	0.0209

Residual effect: 0.26

The estimation of correlation coefficient revealed only the relationship between yield and yield components but did not show any direct and indirect effects on different yield components on yield *per se*. There was correspondence between direct effect and phenotypic correlation for most of the component characters with seed yield per plant in the F_2 population and $F_{2\text{-}3}$ progenies. Further, it revealed high direct effect of seeds per plant and pods per plant on seed yield per plant. Hence, desirable improvement may be brought about by selecting genotypes with more number of pods and seeds per plant.Plant height had a positive direct effect on seed yield per plant (except F_2). It is mainly due to its indirect effect via major characters which affect the seed yield per plant, like number of seeds per plant and number of pods per plant which were positive and of higher magnitude (Yucel *et al*., 2006). Primary and secondary branches exerted positive direct effect on seed yield per plant in both F_2 and F_3 population and high indirect effect through number of seeds per plant.This indicates that selection of plants with more branches will help in increasing seed per plant and simultaneously increased yield (Kumar *et al*., 2003, Abhishek *et al.,* 2012).

Table 3: Direct (diagonal) and indirect effects of different characters on seed yield per plant in $F_{2\text{-}3}$ progenies under irrigated condition

	DFF	**PH**	**PB**	**SB**	**NOP**	**NOS**	**SPP**	**TW**
DFF	**0.0013**	-0.0003	-0.0001	-0.0001	-0.0002	-0.0002	0	0
PH	0.0017	**-0.0072**	-0.0019	-0.0029	-0.0027	-0.0031	-0.0009	-0.001
PB	0.0001	-0.0005	**-0.0019**	-0.0009	-0.0003	-0.0004	-0.0001	0.0002
SB	-0.001	0.0059	0.0068	**0.0147**	0.0057	0.0063	0.0008	-0.001
NOP	-0.006	0.0167	0.0074	0.0173	**0.0443**	0.038	-0.0032	-0.0074
NOS	-0.1117	0.4074	0.1857	0.4064	0.8178	**0.9549**	0.2283	-0.2447
SPP	0	0.0001	0	0	0	0.0001	**0.0004**	-0.0001
TW	-0.0143	0.0636	-0.0403	-0.0308	-0.0754	-0.1156	-0.0918	**0.4512**
SY	-0.13	0.4856	0.1557	0.4038	0.7892	0.88	0.1335	0.1971
R^2	-0.0002	-0.0035	-0.0003	0.006	0.035	0.8403	0.0001	0.0889

Residual effect = 0.2018

It was observed that a higher indirect contribution was exhibited on number of pods per plant and seeds per plant by most of the yield components; thus, these traits related to seed yield per plant should be given emphasis in selection (Padmathi *et al.*, 2013 and Sarke *et al.*, 2014). Low residual effect indicated that the selection of traits for path coefficient analysis is appropriate and no characters were neglected. The pods per plant, seeds per plant, plant height and branches per plant were important components characters which must be given due weightage when a plant breeder practices selection.

Table 4: Direct (diagonal) and indirect effects of different characters on seed yield per plant in $F_{2\text{-}3}$ progenies under drought condition

Characters	DFF	PH	PB	SB	NOP	NOS	SPP	TW
DFF	**0.0013**	0	0	0	0	0	-0.0001	0
PH	0	**-0.0101**	-0.0039	-0.0032	-0.0035	-0.0036	-0.0012	-0.0016
PB	-0.0008	0.0084	**0.0222**	0.0079	0.0106	0.0106	0.0037	-0.0018
SB	-0.0001	0.0047	0.0053	**0.015**	0.0058	0.0058	0.0015	-0.0005
NOP	-0.0018	0.0303	0.0423	0.0344	**0.0888**	0.0863	0.0225	-0.0346
NOS	-0.0359	0.347	0.4662	0.3773	0.9509	**0.979**	0.398	-0.4108
SPP	0.0011	-0.0018	-0.0026	-0.0015	-0.0039	-0.0062	**-0.0152**	0.0041
TW	-0.0028	0.0577	-0.0296	-0.0132	-0.1406	-0.1515	-0.0976	**0.3612**
SY	-0.0389	0.4361	0.5	0.4167	0.9081	0.9202	0.3118	0.0841
R^2	-0.0001	-0.0044	0.0111	0.0062	0.0807	0.9009	-0.0047	-0.0304

Residual effect = 0.1837

Days to 50% flowering had a negative and low direct effect on seed yield per plant, but a high indirect effect via number of pods and seeds per plant, hundred seed weight, and plant height. These results suggested that the selection of shorter flowering lines contribute to increasing seed yield per plant with an indirect effect via these traits. Number of seeds and pods are the two important traits which have positive association with seed yield under drought situation (Yadav *et al.*, 2005). Further, it revealed high direct effect of seeds per plant and pods per plant on seed yield per plant even under drought condition also. Hence, desirable improvement may be brought about by selecting genotypes with more number of pods and seeds per plant for breeding genotypes with drought tolerance.

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EFFECT OF NITROGEN AND POTASSIUM ON GROWTH YIELD AND NUTRIENT UPTAKE OF TURMERIC GENOTYPES

KAMLESH AHIRWAR, S.B. SINGH, MANOJ KUMAR ARHIRWAR, KAMODILAL AHIRWAR AND K.N. NAMDEO*

Department of Botany, Government Post Graduate, Science College, Rewa-486001 (M.P.), India
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ABSTRACT

A field experiment was conducted during rainy-cum-winter seasons of 2011-12 and 2012-13 to study the effect of nitrogen and potassium on growth, yield and nutrients uptake of turmeric genotypes. Roma recorded the maximum plant height, leaves/plant, length and breadth of leaves, number and length of clumps/plant and length of mother rhizome and fresh rhizome yield (101.72 q ha^{-1}) with net income of ₹.474564 ha^{-1}. Fertility level upto $N_{200}K_{200}$ resulted in maximum growth, yield attributes and rhizome yield (100.90 q ha^{-1}) with net income of `₹. 468560 ha^{-1}. Thus, Roma may be grown with $N_{200}K_{200}$ to achieve maximum profit under the existing agro-climatic conditions. Roma producing 101.72 q ha^{-1} fresh rhizomes took up the maximum nutrients (162.0 kg N, 53.6 kg P and 109.9 kg K ha^{-1}). Application of $N_{200}K_{200}$ resulted in highest uptake of N, P and K (158.6 kg N, 51.9 kg P and 107.8 kg K ha^{-1}). The findings suggest that due to heavy withdrawal of nutrients by turmeric genotypes, the succeeding crop must be nourished properly based on soil test values.

Key words: Nitrogen, potassium, turmeric genotypes, nutrients uptake

INTRODUCTION

India accounts for 80% of the world output of turmeric, though major part of its produce is being utilized within the country. Despite its excellent 45% export potential, the output of turmeric has not kept pace with increasing domestic and export demand for one or the other reasons *viz.*, marginal farming, unscientific techniques of cultivation and incomplete nourishment with the essential plant nutrients. Turmeric is a long-duration and fertilizer responsive crop. Nitrogen is considered as one of the key elements in deciding the yield potential of high-yielding varieties. Importance of N and K fertilization in turmeric has been reported by various research workers in relation to quality and productivity of the crop (Haque *et al.*, 2007 and Ahirwar *et al.*, 2010). Turmeric is a long-duration and fertilizer responsive crop. Nitrogen and potassium are considered as one of the key elements in deciding the yield potential and quality of high-yielding varieties. The importance of nitrogen and potassium fertilizers for higher productivity of turmeric has been reported by many researchers (Haque *et al.*, 2007 and Ahirwar *et al.*, 2010). However, there exist wide differences between addition and uptake of such fertilizers by the crops. The general tendency is that the total crop removal of nutrients is never replenished. That is why soil health and sustainable productivity of crops are becoming great threat. Due to fertility variations in different soil types, the response of a certain turmeric genotype to direct fertilizer application is highly inconsistent, location and even site specific. Hence, fertilizer recommendation for a particular soil type and crop variety should be made based on soil test values. Many turmeric genotypes have been developed in India possessing a high genetic diversity towards production potential and medicinal qualities under a given set of agro-climatic and environmental conditions. Consequently, their nutritional requirement towards major nutrients is also varied. Therefore, the scrutiny of newly developed genotypes for their actual N and K requirement is essential for securing higher productivity and quality of turmeric. So far no such work has been done under the soil and climatic conditions of Rewa region, the present research was therefore, initiated.

MATERIALS AND METHODS

The field experiment was conducted at the Private Research Farm, Beena-Semaria Road, Rewa (M.P.) during 2011-12 and 2012-13. The soil was silty clay-loam having pH 7.5, electrical conductivity 0.34 dS m^{-1}, organic carbon 6.40 g kg^{-1}, available N, P_2O_5 and K_2O 228, 24 and 381 kg ha^{-1}, respectively. The rainfall received during June to March was 760 and 795 mm in both the years. The treatments comprised three genotypes (Roma, PCT-8 and Suroma) in the main plots and nine fertility levels (N_{100} K_{100}, N_{100} K_{150}, N_{100} K_{200}, N_{150} K_{100}, N_{150} K_{150}, N_{150} K_{200}, N_{200} K_{100}, N_{200} K_{150}, $N_{200}K_{200}$) in the sub-plots. The experiment was laid out in split plot design replicated three times. Mother rhizomes of turmeric genotypes were planted during 16 and 19 July in both the years keeping 30 cm row distance and 15 cm plant distance. Urea, diammonium phosphate and muriate

Corresponding author e-mail: drknnamdeo@gmail.com, College of Agriculture, Rewa 486001 (M.P.) India

of potash were used to maintain the fertility levels for N, P and K, respectively. As per treatments, half of the N and K were applied as basal, ¼ N at 45 DAS and the remaining ¼ N and ½ doses were applied at 90 DAS. Application of 60 kg P_2O_5 ha^{-1} was done as basal in all the treatments. Light and frequent irrigations were ensured throughout the growth period. Other cultural practices of turmeric cultivation were adopted as per recommendation. The digging of rhizomes was done during the last week of March in both the years. The N, P and K contents in rhizomes were determined by adopting standard procedures (Jackson 1973). The nutrients uptake was calculated by multiplying the turmeric yield with the percentage of nutrient content in turmeric. The economics of treatments was computed on the basis of prevailing market price of inputs and prduce.

RESULTS AND DISCUSSION

Growth and yield attributes

Data (Table 1) reveal that out of three genotypes, Roma enhanced the growth parameters as well as yield attributes upto the maximum extent. The second and third position was attained by PCT-8 and Suroma, respectively. The maximum growth parameters in Roma were 102 cm plant height, 10.43 leaves / plant, 37.59 cm leaves length, 14.41 cm leaves breadth, 6.81 clumps/plant and 35.36 cm clumps length. Suroma genotype recorded significantly lowest all these parameters. The significant differences in growth parameters and yield attributes in different genotypes might be owing to their genetic variability. The best performance of Roma over others might be ascribed to its physiological role in synthesis and partitioning of the biomass (Harinkhede, 2005 and Patel *et al.*, 2012). The different fertility levels did not influence the growth parameters and yield attributes upto significant extent except number and length of clumps/plant and length of mother rhizome which were found significant. However, the highest $N_{200}K_{200}$ level recorded the highest whereas $N_{100}K_{100}$ level recorded the lowest values of these parameters. The increased supply of nitrogen and potassium resulted in enhanced photosynthesis process. In fact, leaf is the factory for the conversion of solar energy into chemical energy by the process of photosynthesis. The beneficial influence of applied N and K on these parameters may be due to increased translocation of more photosynthates towards the sink as a result of increased availability of N and K nutrients for the actively growing plants (Haque *et al.*, 2007, Ahirwar *et al.*, 2010 and Pandey *et al.*, 2012).

Table 1: Growth, yield attributes of turmeric as influenced by genotypes and fertility levels (Pooled for two years)

Treatment	Plant height (cm) 150 DAS	Leaves /plant 150 DAS	Length of leaves (cm) 150 DAS	Breadth of leaves (cm) 150 DAS	Number of clumps/ plant 150 DAS	Length of clumps/ plant (cm) 150 DAS	Length of mother rhizome (cm)
Genotypes							
Roma	102.00	10.43	37.59	14.41	6.81	35.36	6.93
PCT-8	98.24	9.42	36.37	13.39	6.77	34.40	6.79
Suroma	93.90	8.69	35.49	11.89	6.13	33.49	6.51
CD (P=0.05)	**0.78**	**0.27**	**NS**	**0.26**	**NS**	**0.17**	**NS**
Fertility levels							
$N_{100}K_{100}$	97.53	9.34	36.38	13.08	**6.57**	34.25	6.50
$N_{100}K_{150}$	98.04	9.45	36.51	13.17	6.70	34.35	6.75
$N_{100}K_{200}$	98.03	9.53	36.65	13.26	6.82	34.43	6.85
$N_{150}K_{100}$	98.14	9.44	36.45	13.12	6.59	34.42	6.64
$N_{150}K_{150}$	97.92	9.41	36.50	13.20	6.69	34.48	6.68
$N_{150}K_{200}$	98.06	9.53	36.72	13.35	6.80	34.48	6.89
$N_{200}K_{100}$	97.82	9.42	36.38	13.21	6.59	34.32	6.59
$N_{200}K_{150}$	98.16	9.57	36.53	13.29	6.78	34.38	6.80
$N_{200}K_{200}$	98.65	9.64	36.77	13.44	6.92	34.57	7.00
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**0.21**	**0.17**	**0.23**

NS= Non -significant

Yield of turmeric

The fresh yield of turmeric rhizomes (101.72 q ha^{-1}) and dry matter recovery (37.39%) were significantly higher in case of Roma genotype compared to PCT-8 and Suroma. The Suroma genotype produced the significantly lowest turmeric yield (96.13 q ha^{-1}) being less than 5.59 q ha^{-1} than Roma. The dry matter recovery was lowest (35.24%) in Suroma. The increased yield and dry matter recovery from Roma over others might be owing to its maximum yield `rhizomes (100.90 q ha^{-1}) against all the remaining fertility levels. The dry matter recovery was not changed significantly, however $N_{200}K_{200}$ gave the maximum dry matter recovery (36.53%), whereas the minimum recovery (36.14%) was noted from $N_{100}K_{100}$ fertility level. These results are in accordance with the findings of Ahirwar *et al.*, (2010) and Pandey *et al.*, (2012).

Table 2: Yield, economics and uptake of nutrients by turmeric as influenced by genotypes and fertility levels (Pooled for two years)

Treatments	Fresh yield of rhizomes (q ha^{-1})	Dry matter recovery (%)	Net income (₹. ha^{-1})	B:C ratio	Nutrients uptake (kg ha^{-1})		
					N	P	K
Genotypes							
Roma	101.72	37.39	474564	4.50	162.0	53.6	109.9
PCT-8	99.51	36.33	461350	4.40	155.7	49.3	101.7
Suroma	96.13	35.24	441094	4.25	147.1	44.4	95.1
CD (P=0.05)	0.39	0.73	--	--	4.90	4.18	3.82
Fertility levels							
$N_{100}K_{100}$	97.30	36.14	449210	4.34	151.5	46.3	96.9
$N_{100}K_{150}$	98.00	36.20	452880	4.35	152.5	47.2	98.2
$N_{100}K_{200}$	98.14	36.31	453210	4.34	153.7	47.6	100.5
$N_{150}K_{100}$	99.09	36.26	459320	4.40	154.0	48.7	100.9
$N_{150}K_{150}$	99.16	36.31	459230	4.39	155.1	49.0	102.5
$N_{150}K_{200}$	99.33	36.46	459760	4.38	155.9	50.0	104.1
$N_{200}K_{100}$	99.94	36.28	463770	4.42	155.8	50.3	104.0
$N_{200}K_{150}$	100.24	36.40	465080	4.42	157.4	51.0	105.5
$N_{200}K_{200}$	100.90	36.53	468560	4.43	158.6	51.9	107.8
CD (P=0.05)	0.39	NS	-	-	4.90	4.18	3.82

NS= Non -significant

Economics

Amongst the three genotypes, Roma gave the maximum net income (₹.474564 ha^{-1}) and B:C ratio (4.50). The second best genotype was PCT-8 giving a net profit of ₹. 461350 ha^{-1} with B:C ratio 4.40. Suroma stood the third best genotype. Thus Roma and PCT-8 gave extra net income of ₹. 33470 and ₹. 20256 ha^{-1}, respectively over Suroma. The difference in net income amongst the genotypes was in accordance with the variation in their rhizome yield. Amongst the fertility levels, $N_{200}K_{200}$ resulted in highest net income of ₹.468560/ha, whereas it was only ₹.449210 ha^{-1} from the lowest $N_{100}K_{100}$ fertility level. The extra net income from $N_{200}K_{200}$ against $N_{100}K_{100}$ was upto ₹.19350 ha^{-1}. Similarly, the net income was ₹. 15870 ha^{-1} from $N_{200}K_{150}$ as against $N_{100}K_{100}$. The net income was further augmented by ₹.483860 ha^{-1} when Roma was fertilized with $N_{200}K_{200}$ fertility level.

Uptake of nutrients

The N, P and K uptake by rhizomes was found to deviate significantly due to different genotypes. Roma producing 101-72 q ha^{-1} rhizomes recorded significantly higher N, P and K uptake over the other two genotypes. The maximum N, P and K uptake was 162.0, 53.6 and 109.9 kg ha^{-1}, respectively (Table 2). The significant increase in the uptake of NPK in Roma might be due to similar increases in NPK contents in rhizomes as well as increased rhizome yields. The similar trend was also followed in PCT-8 and Suroma genotypes which ranked in the second and third positions, respectively. The fertility levels did not affect the N uptake upto significant extent, whereas P and K uptake were influenced significantly due to fertility levels. The highest fertility level ($N_{200}K_{200}$) resulted in maximum uptake of N (158.6 kg ha^{-1}), P (51.9 kg ha^{-1}) and K (107.8 kg ha^{-1}). In case of P and K uptake by rhizomes, higher fertility levels ($N_{200}K_{100}$, $N_{200}K_{150}$ and $N_{200}K_{200}$) proved significantly superior to the lower fertility levels ($N_{100}K_{100}$, $N_{100}K_{150}$ and $N_{100}K_{200}$). The increased uptake of NPK due to increased levels of applied N and K was due to increase in the NPK contents in rhizomes as well as increased rhizome yield. The positive influence of N and K fertilizers on root-shoot growth, yield attributes, yield and nutrients uptake might be due to increased number of leaves and their size development, increased photosynthates and their effective translocation towards developing reproductive organs (rhizomes). The present findings corroborate with those of other workers (Reddy *et al.* 2008), Chaurasa *et al.* (2009) and Pandey *et al.* (2012).

From the results, it can be concluded that Roma genotype may be grown with N_{200} K_{200} to achieve maximum yield and income from turmeric.

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EFFECT OF VARIETIES AND NUTRIENT LEVELS ON JUTE IN EASTERN UTTAR PRADESH

M.V.SINGH, BHAGWAN SINGH, VED PRAKASH AND NEERAJ KUMAR

Crop Research Station, Bahraich - 271801 (U.P.)
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ABSTRACT

A field experiment was conducted at Crop Research Station, Bahraich (U.P.) during name the season of 2012 and 2013 to study the effect of varieties and nutrients levels on jute (Carchorus capsularis). The three jute varieties viz. JRC-9057, JRC-321, JRC-698 and 3 nutrient levels viz. 60:13:25, 80:17.5:33.3 and 100: 21.8:41.7 kg NPK ha^{-1} were evaluated in randomized block design with three replications. The results revealed that the jute variety JRC-321 produced higher plant height, (314.6) basal diameter (1.62 cm) and fibre yield (27.13 q ha^{-1}) along with net profit of ₹. 32200 ha^{-1}. Increasing levels of nutrients increased all the growth attributes as well as fibre yield of jute varieties. The highest plant height (314.5 cm), basal diameter (1.58 cm) and fibre yield (27.93 q ha^{-1}) were recorded with the application of 100:21.8:41.7 kg NPK ha^{-1} which was significantly superior to other levels of nutrients. Net returns (₹. 32900 ha^{-1}) and B:C ratio (2.93) were the highest at 100: 21.8: 41.7 kg NPK ha^{-1} level. Highest values of N (77.6 kg ha^{-1}) P (33.0 kg ha^{-1}) and K (103.5 kg ha^{-1}) uptake were recorded with 100: 21.8: 41.7 kg NPK ha^{-1}.

Keywords: Variety, nutrient levels, yield, economics, nutrient uptake, jute.

INTRODUCTION

Jute is one of the most important commercial crop of our country particularly of eastern and north eastern India. India has the largest area under jute cultivation (1.0 million ha) with the production of nearly 100 lakh bales (Sen, 2007). The productivity of jute has increased from 1138 kg ha^{-1} in 1947-48 to around 2300 kg ha^{-1} in 2004-05 More than 0.25 million industrial workers and 0.05 million traders get employment in jute sector and occupied only 0.15 percent of the cropped area in the country (Chaudhary and Sinha, 2004). The jute quality improvement is a continuous process employing various techniques such as development of new varieties with plant breeding and biotechnology.The varieties play an important role in growth as well as fibre production of jute. Genetical variability of varieties reflected the growth and yield attributes and yield. Alternatively, agronomic methods such as fertilizing crop through fertilizers can be used for enhancing the yield. Imbalanced use of fertilizers also affect the crop growth that leads to decline the fibre yield. Information on the effect of nutrients on jute varieties is meagre Therefore an experiment was laid out in the field to evaluate the effect of varieties and levels of nutrients on growth, yield uptake of nutrients by jute.

MATERIALS AND METHOD

A field experiment was undertaken at the Crop Research Station, Bahraich (U.P.) during zaid season of 2012 and 2013 in sandy loam soil having pH 7.5, organic carbon 3.5 g kg^{-1} and available N,P and K 240, 13.5, 250 kg ha^{-1}, respectively. The experiment consisted of three jute varieties (JRC-9057, JRC-321, JRC-698) and three fertility levels (60:13:25, 80:17.5:33.3, 21.8, 91.7 kg ha^{-1}) was conducted in randomized block design with 3 replications. The crop was sown on 15 April in both the years. The spacing of 30 cm row to row and plant to plant spacing was maintained 10 cm after two thinning of crop. The 5 kg seeds ha^{-1} was used for sowing. Entire amount of P and K and 1/3 dose of N was applied at the time of sowing as basal dressing through urea, single superphosphate and muriate of potash and remaining 2/3 dose of nitrogen was applied of 45 and 75 days of sowing of the crop. All agronomical practices like weeding, intercultural operations, and irrigation and plant protection measures were followed time to time. The crop was harvested at 120 days after sowing. The growth and yield attributes were recorded at full growth stage of crop and yield was estimated after harvesting and retting of crop. Economics of each treatment was calculated considering the nearest market price of input and output. Nitrogen, P and K content in plants were estimated as per procedures described by Jackson (1973). The uptake of N, P and K was calculated by multiplying yield data with corresponding values of their concentrations and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Varieties

The data (Table 1) revealed that the highest plant height (314.6 cm) and basal diameter (1.62 cm) were recorded under jute variety JRC-321 which was found significantly superior over variety JRC-9057 and JRC-698. This might be due to better genetical character in that variety. The variety JRC-9057 was

Corresponding author e-mail: mvsinghbrh2013@gmail.com

found at second place and JRC-698 at third place in respect of plant height and basal diameter. Results indicated that the maximum fibre yield (27.13 q ha^{-1}) was noted under jute variety JRC-321 which was found 4.12, 10.28 % higher over jute variety JRC-9057 and JRC-698, respectively. This might be due to highest plant height and basal diameter of plant under the same variety. Higher net income of (` 32200 ha^{-1}) was noted under variety JRC-321 which was found 5.2 and 12.9 % more over variety JRC-9057 and JRC-698, respectively. This might be due to higher fibre yield recorded under jute variety JRC-321 and B:C ratio was also found in same manner. Nutrient uptake data (Table 1) indicated that higher nutrients uptake of N (77.0 kg ha^{-1}), P (31.8 kg ha-^{1}) and K (105.2 kg ha-^{1}) was recorded under variety JRC-321 followed by variety JRC-9057. The minimum uptake of nutrients was recorded in JRC-698 variety of jute which may be attributed to lower yield produced by JRC-698.Similar results were also reported by Kumar *et al.* (2010), Singh *et al.* (2011) and Anonymous (2014).

Table 1: Effect of treatments on growth, characters of jute (mean of two years)

Treatments	Plant population (m^2)	Plant Height (cm)	Basal diameter (cm)
Varieties			
JRC-9057	4.7	310.7	1.55
JRC-321	4.6	314.6	1.62
JRC-698	4.6	308.8	1.44
CD (P= 0.05)	N.S.	0.9	0.06
Fertility Levels (kg ha^{-1})			
60:13:25	44.7	308.7	1.49
80:17.5:33.3	45.9	311.0	1.55
100:21.8:41.7	44.5	314.5	1.58
CD (P= 0.05)	N.S.	0.9	0.06

Nutrient

The pooled data (Table 1) indicated that the growth characters and fibre yield increased significantly with increasing levels of NPK over control. The highest plant height (314.5 cm), basal diameter (1.58 cm) and fibre yield (27.93 q ha^{-1}) were recorded with application of nutrients (100:21.8:41.7 kg NPK ha^{-1}) which was 1.8 and 1.1 % higher in plant height; 5.6 and 1.8 % in basal diameter and 14.4 and 8.1 % in fibre yield over the application of 60:13:25 and 80:17.5:33.3 kg NPK ha^{-1}, respectively. The higher growth and yield under N, P and K levels might be due to increased growth and chlorophyll content in leaves as a result of favourable environment and improved fertility status of soil. All these favourable situations eventually brought about greater fibre yield of jute. Similar results were reported by Singh *et al.* (2011) Saha *et al.* (2008) and Ray and Chaudhary (2000). Data (Table 2) reveal that the hightest net returns (₹. 32900 $ha^{-1)}$ was noted with higher fertility level (100: 21.8: 41.7 kg NPK ha-^{1}) followed by 80: 17.5: 33.3: kg NPK ha^{-1} (₹. 30000 ha^{-1}). The lowest net returns (₹.27885 ha^{-1}) was noted at control. Similar results were reported by Kumar et al. (2010).) The higher B:C ratio (2.93) was noted with100:21.8:41.7 kg NPK ha^{-1} which was superior over other two doses of nutrients. All the combinations of nitrogen, phosphorus and potassium had significantly beneficial effect on the uptake of nutrients by the crop over control (Table 2). The highest uptake of N (77.6 kg ha^{-1}), P (33.0 kg ha^{-1}) and K (103.5 kg ha^{-1}) was recorded with 100: 21.8: 41.7 kg NPK ha^{-1} and lowest under control. Since uptake of a nutrient is the result of concentration of that particular nutrient and yield. So, N, P and K uptake was also highest in the crop. The uptake of nutrients increased significantly with increasing levels of N, P and K over control.

Table 2: Effect of treatments on yield, economics and uptake of nutrients by jute crop

Treatments	Fibre yield (q ha^{-1})	Net profit (₹. ha^{-1})	B:C ratio	Total nutrient uptake (kg ha^{-1})		
				N	P	K
Varieties						
JRC-9057	26.01	30508	2.84	75.4	31.3	100.3
JRC-321	27.13	32200	2.95	77.0	31.8	105.2
JRC-698	24.34	28016	2.69	71.3	29.6	91.3
CD (P= 0.05)	0.21	1250	0.25	0.47	0.33	0.72
Fertility Levels (kg ha^{-1})						
60:13:25	23.89	27885	2.74	71.5	28.7	94.5
80:17.5:33.3	25.66	30000	2.82	74.6	31.0	98.7
100:21.8:41.7	27.93	32900	2.93	77.6s	33.0	103.5
CD (P= 0.05)	0.21	1150	0.25	0.47	0.33	0.72

On the basis of the data it could be concluded that the jute variety JRC-321 with application 100:21.8:41.7 kg NPK ha^{-1} produced highest fibre yields, and profit. It is recommended to the farmers of eastern U.P. to adopt the variety JRC-321 with 100:21.8:41.7 kg NPK ha^{-1} for obtaining higher fibre yield and net return.

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GENETIC VARIABILITY IN DRUMSTICK GENOTYPES

SHEETAL TAK[1*] AND I.B. MAURYA[2]

College of Horticulture and Forestry, Jhalrapatan city, Jhalawar - 326023 (Raj.)
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ABSTRACT

Drumstick (Moringa oleifera Lam.) is one of the important perennial vegetable grown in India. Every part of plant valued for food, but it's also enriched with more nutrition and high minerals and vitamins at cheaper inputs. Leaves, flowers and immature pods are used as a highly nutritive vegetable and for medicinal purpose. In experiment 36 genotypes were evaluated with three replications in complete randomized design during 2011-2012.The results revealed a significant difference in all the characters like pod weight (26.37-66.43 g), pod length (24.43 to 59.47 cm), pod girth (7.33 to 23.67 mm), number of leaflets/leaf (8.00 to 13.33), and leaf length (28.63 to 66.37 cm). Similarly, a wide variation was recorded for nutrients in drumstick leaves. It was 22.07 to 37.47 % for dry matter; 5.33 to 7.87 % for TSS; 0.72 to 1.43 mg/g for chlorophyll. The GCV was greater than PCV for all the characters but the differences were low. High GCV and heritability estimates coupled with greater genetic advance was recorded for pod weight and indicated that these characters had additive gene effects and therefore, they are more reliable for effective selection.

Keywords: Drumstick, food plant, medicinal uses, evaluation, genotypes.

INTRODUCTION

Drumstick [*Moringa oleifera* Lam. (Syn. *M. pterygosperma Gaertn.*)] is one of the best known and most widely distributed and naturalized species of a monogeneric family Moringaceae. The genus *Moringa* has more than 13 species of which two species viz., *M. oleifera* Lam. (syn. *M. pterygosperma* Gaertn.) and *M. concanensis* Nimmo occur in India and the former being the vegetable type (Panday *et al.*, 2011). Drumstick is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics. *Moringa* has many medicinal properties. Almost all parts viz., root, bark, gum, leaf, fruit (pod), flower, seed and seed oil have been used for treatment of various inflammation and infectious diseases along with cardiovascular, gastrointestinal, haematological and hepatorenal, disorders (Singh *et al*., 2011). Flowers are used as stimulant, tonic and diuretic. They are useful in increasing the flow of bile. The seeds of *Moringa* are considered to be antipyretic, acrid, bitter (Oliveira *et al.*, 1999) and reported to show antimicrobial activity. The seeds of *Moringa* are used as water purifier. The oil extracted from the seed, known as "*Ben*", is used as lubricant in watches, for edible purpose and in cosmetics. The kernel of the seed is rich in crude protein, fatty oil and fiber. Leaves contain 4.0% moisture, 38.4% crude protein, 34.17% fatty oil, 3.5% fibre and 3.2% mineral matter. India is the largest producer of *Moringa* with an annual production of 1.1-1.3 million tonnes of tender fruits from an area of 38,000 ha. Much variability has also been reported by Reshmi (2004) in drumstick with respect to morphological characters which are helpful in selection of elite tree for combination breeding programme. In a systematic breeding programme, collection, evaluation and characterization of the germplasm is the first important step for gathering the basic information about variability exists in a particular crop plant. Hence, the present study was initiated.

MATERIALS AND METHODS

The present investigation was conducted during the year 2011-12 at the College of Horticulture and Forestry, Jhalawar. The location of the experimental site is comprised of four districts of the Rajasthan namely Jhalawar, Kota, Ajmer and Udaipur. Jhalawar district falls under sub-humid South Eastern Plains under agro-climatic zone V. The climate of Jhalawar is typically sub-humid and characterized by extremes of temperature both in summer and winter with high rainfall and moderate relative humidity. Udaipur has a sub tropical climate characterized by mild winter and summer. Ajmer and Kota both have hot semi arid climate, with high temperature throughout the year.The experimental material comprised of 36 genotypes of drumstick collected from four districts of the Rajasthan namely Ajmer, Jhalawar, Kota and Udaipur through a survey made during February - March, 2012 with the help of local people. Initially, 15-20 trees of drumstick, growing naturally on road side or planted in open field/ boundary wall or grown in kitchen garden, were identified from each district but finally 9 bearing trees

Corresponding author e-mail: tak.sheetal10@gmail.com, ibmaurya@rediffmail.com

showing variability for morphological characteristics were selected for the present investigation .The observations were recorded on 10 different morphological pod, seed and leaf characters *viz.,* pod weight, pod length, pod girth, seeds/pod, 10-seed weight, leaflets/leaf, leaf length, dry matter, TSS, and chlorophyll ,vitamin C, protein, nitrogen, phosphorus, potassium, calcium, iron, magnesium from randomly selected plants and the average was subjected to statistical analysis of variance (Panse and Sukhatme,1978).

RESULTS AND DISCUSSION

A healthy vegetative growth is an ideal indicator of the plant ability to survive under moisture stress condition. In the present study, among the eighteen morphometric and nutrient parameters studied, all the characters showed significant variation indicating they being influenced by the genotype. The extent of variabilitypresent in the drumstick genotypes was measured in term of mean, coefficient of variance, critical difference, and genetic coefficient of variance(GCV), phenotypic coefficient of variance(PCV),genetic advance (GA) and heritability(broad sense) (table 1 and table 2). Among the vegetative parameters a wide range of variation was observed in plant height. The genotypes used for present study were of 6 yrs (JWRM-2) to 35 yrs (JWRM- 29) of age and height and girth of the tree varied from 6.5 m to 12.5 m and 30 to 78 cm, respectively. Bitterness (Bitter/Non Bitter) is a quality attribute and recorded by tasting the immature pods of 36 genotypes. Wide variations with respect to bitterness of pods were noted during the survey of the genotypes. On the basis of taste, the genotypes were grouped into three categories i.e. non-bitter, slightly bitter and bitter.

Table 1: Range and mean values of pods and leaves characteristics in drumstick

Characters	Range	Mean
Pods		
Pod weight (g)	26.3-66.4	46.5±1.5
Pod length (cm)	26.7-59.4	41.5±2.0
Pod girth (mm)	7.3-23.6	15.3±1.4
Seeds/pod	10.0-23.0	17.0±1.4
10 seed weight (g)	2.1-6.4	4.0±0.1
Leaves		
Leaflets/ leaf	8.0-13.3	10.8±0.8
Leaf length (cm)	28.6-66.3	48.3±1.8
Dry matter content (%)	22.0-37.4	31.3±0.6
T.S.S.(%)	5.3-7.8	6.5±0.29
Chlorophyll (mg/g)	0.7-1.4	1.06±0.05
Vitamin –C (mg/100g)	155.4-220.2	188.6±1.8
Protein (%)	22.5-26.6	24.4±0.19

Analysis of variation revealed that the genotypes JWRM-6, JWRM-7 were superior in respect of pod weight as compared to other genotypes and ranged from 26.37 to 66.43 g. The genotypes showed variation in fruit characters as they were selected from different geographical locations. As far as drumstick is concerned, fruit length is an important character, which decides the consumer attraction. The medium fruit length (<60cm) is preferred in the local market, where the fruit (>1.0m) is suitable for processing industry. The maximum pod length was found in JWRM-4 (59.47 cm) followed by JWRM-10 (52.37 cm) it's ranged from 26.70 to 59.47 cm. Results are in agreement with the findings of Varalakshmi and Devaraju (2007) in drumstick. The pod girth varied from 7.33 to 23.67 mm. Kernal oil of drumstick seeds is used as a lubricant in precision equipments. This shows the economic and industrial importance of drumstick seeds. Additionally, the oil cake has been used as water purifier in industry. Therefore, industry prefers fruits with more seeds while culinary preference was directed to selection of fruits with less seeds. The number of seeds per pod in the present study ranged from 10.00 (JWRM-17) to 23.00 (JWRM-31). It was noted that large sized fruit had more number of seeds. 10-seed weight of 36 genotypes varied from 2.14 g (JWRM- 23) to 6.48 g (JWRM- 28). Raja *et al.* (2011) recorded the highest seed weight i.e. 12.8 g along with 23.5 seeds per fruit in drumstick.

Table 2: Range and mean values of nutrient content in drumstick leaves

Content	Range	Mean
Nitrogen (mg/100gm)	3461.4-4091.7	3766.1±28.9
Phosphorous (mg/100 g)	126.7-203.4	167.5±1.7
Potassium (mg/100g)	654.2-1281.7	968.4±11.5
Calcium (mg/100 g)	1460.7-2044.2	1858.6±16.3
Iron (mg/100g)	14.0-26.8	21.3±1.5
Magnesium (mg/100 g)	245.4-350.0	302.6±1.9

The data were recorded on leaf characteristics namely number of leaflets/leaf, leaf length, dry matter content, chlorophyll, TSS, vitamin C, protein, nitrogen, phosphorus, potassium, calcium, iron, magnesium of 36 genotypes of drumstick (Table 1 and 2). The coefficients of variation for these characters were observed very low which ranged from 1.33 % (Protein) to 13.11 (leaflets/leaf). The ranges were from 8.0 to 13.0 for leaflets per leaf, 28.6 to 66.3 cm for leaf length, 22.0 to 37.4 % for dry matter, 5.3 to 7.8 % for TSS, 0.72 to 1.43mg/g for chlorophyll, 155.4 to 220.2 mg/100g for vitamin C, 22.5 to 26.6 % for protein, 3461.4 to 4091.7

mg/100g for nitrogen, 126.7 to 203.4 mg/100g for phosphorus, 654.2 to 1281.7 mg/100g for potassium, 1460.7 to 1281.7 mg/100g for calcium, 14.0 to 26.8 mg/100g for iron, 245.4 to 350.0 mg/100g for magnesium.

The coefficient of variation for different characters was in the range of 1.13 % (magnesium content) to 15.81 % (pod girth). The maximum CV was recorded for pod girth (15.81%) followed by number of seeds per pod (14.73%), number of leaflets per leaf (13.11) and iron (12.30%). This result was in agreement with the findings of Varalakshmi and Devaraju (2007) who recorded high coefficient of variation for fruit weight (27.06%) followed by fruit girth (20.07%) and fruit length (19.77%). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for different characters are presented in Table 3. In general, the estimates of PCV for all the characters were higher than their corresponding GCV. However, the difference between GCV and PCV was of low under for all the characters. In the present investigation, the values of GCV and PCV for different characters were observed from low to moderate. The maximum value of GCV (31.53 %) and PCV (35.37 %) was recorded for pod girth followed by 10-seed weight (31.1 % and 32.0 %). Moderate values of GCV and PCV were noted for pod weight (28.4 % and 29.0 %), leaf length (19.8 % and 20.8 %), pod length (18.2 % and 20.2 %), potassium (17.1 % and 17.2 %), number of seeds per pod (17.1 % and 22.7 %), iron (16.8 % and 20.9 %) and chlorophyll (14.8 % and 16.9 %g) whereas the low values of GCV and PCV were recorded for remaining characters like dry matter content (13.6 % and 14.0 %), number of leaflets per leaf (11.2 and 17.4), total soluble solids (10.3 % and 12.8 %), phosphorous (10.3 % and 10.4 %), magnesium (9.1 % and 9.2 %), vitamin C (8.7 % and 8.9 %), calcium (7.5 % and 7.6 %), nitrogen and protein (5.4 % and 5.5 %).

The estimates of heritability in broad sense in per cent for different characters are given in Table 3. The heritability estimates were categorized as low (from 5 to 10 %), medium (from 11 to 30 %) and high (above 30 %) as suggested by Robinson (1966). In the present study, the heritability was recorded in the range of low (41.90%) to high (98.51%). The low heritability estimates were observed for number of seeds per pod (56.72 %) and number of leaflets per leaf (41.90%) and moderate for pod length (81.59 %), pod girth (79.46 %), chlorophyll (76.29 %), total soluble solids (64.70 %) and iron (64.53 %). The high heritability estimates were recorded for potassium (98.51 %), magnesium (98.46 %), phosphorous (96.95 %), vitamin C (96.22 %), calcium (95.96 %), pod weight (95.92 %), 10-seed weight (94.47 %), dry matter (94.22 %), protein (94.15 %), nitrogen (94.14 %) and leaf length (90.10 %).

Table 3: Estimates of GCV, PCV, GA and heritability for different characters studied in 36 genotypes of drumstick

Characters	GCV (%)	PCV (%)	h^2 (%)	GA (%)
Pod weight (g)	28.43	29.03	95.92	26.67
Pod length (cm)	18.27	20.22	81.59	14.13
Pod girth (mm)	31.53	35.37	79.46	8.86
Number of seeds/pod	17.10	22.70	56.72	4.52
10 seed weight (g)	31.18	32.08	94.47	2.53
No. of leaflets/leaf	11.29	17.44	41.90	1.64
Leaf length (cm)	19.83	20.89	90.10	18.74
Dry matter (%)	13.62	14.03	94.22	8.52
TSS (%)	10.36	12.88	64.70	1.13
Chlorophyll (mg/g)	14.82	16.97	76.29	0.28
Vitamin C in leaves (mg/100g)	8.76	8.93	96.22	33.39
Protein content (%)	5.41	5.58	94.15	2.65
Nitrogen (mg/100gm)	5.41	5.58	94.14	407.32
Phosphorous (mg/100 g)	10.30	10.46	96.95	34.99
Potassium (mg/100g)	17.12	17.24	98.51	338.91
Calcium (mg/100 g)	7.51	7.67	95.96	281.72
Iron (mg/100g)	16.83	20.95	64.53	5.95
Magnesium (mg/100 g)	9.15	9.23	98.46	56.63

In general, phenotypic coefficient of variation (PCV) was greater than the corresponding genotypic coefficient of variation (GCV) for all the characters indicating the importance of environment in expression of characters. However, the differences between the GCV and PCV for all the characters were narrow suggesting that the characters were less affected by environment. The genotypic coefficient of variation does not offer full scope to estimate the variation that is heritable and therefore, estimation of heritability becomes necessary. Burton (1952) suggested that GCV along with heritability give a better idea about the efficiency of selection. In the present study high heritability was recorded for potassium, magnesium, calcium, phosphorus, vitamin C and pod length. High heritability along with high GCV was recorded for 10-seed weight only suggesting that this trait can be improved by selection. The estimate of heritability along with genetic advance is more reliable than heritability alone for predicting the effect of selection (Johnson *et al.*, 1955). In the present study, high GCV and heritability estimates associated with greater genetic advance was observed for potassium followed by calcium, nitrogen and pod weight indicated that these characters had additive gene effect and therefore, they are more reliable for effective selection.

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EFFECT OF SPLIT APPLICATION OF NITROGEN AND POTASSIUM ON YIELD, NUTRIENT UPTAKE AND NUTRIENT USE EFFICIENCY IN BT COTTON

A.S. BHATI* AND MANPREET SINGH

Regional Station, Abohar, Punjab Agricultural University, Ludhiana (PB)
Received: December, 2013; Revised accepted: October, 2014

ABSTRACT

A field experiment was conducted to assess N and NK split application to synchronize nutrient application with crop demand. Nine timings of application and different dose of N and NK both were taken as different treatments. Timings were planned to supply the fertilizer at different crop growth stages i e., as basal at 30, 45, 60 and 75 DAS. Split application of N and NK did not have any significant effect on seed cotton yield, yield per plant, bolls per plant, boll weight, seed index, lint yield and G.O.T. (Ginning Percentage).Bolls per plant was affected significantly with interaction between the fertilizer and its timing of application. Similarly, split application of N at basal, 30 and 60 DAS (50-25-25), timing of fertilizer application resulted in significant difference for N,P and K uptake. Nitrogen uptake was highest, when the fertilizer was applied in four equal doses at sowing time, 30, 45 and 75 DAS (553 kgha^{-1}). Potassium use efficiency was found to be significantly higher in N split application as compared to NK split application treatment (5.43 KUE).Oil content was found to be significantly higher in NK split application over only N split application. Timing of fertilizer application did not influence the oil content in seeds.

Key words: Bt cotton, nitrogen, potassium, split application, nutrient use efficiency

INTRODUCTION

Cotton is an important commercial crop in India because it plays vital role in Indian economy. Bt cotton has been developed by transferring crystal protein gene (Cry1AC) from a soil bacterium *Bacillus thurigiensis* var. Kurstaki in to cotton. Research on Bt cotton in India is monitored and resulted by the department of Biotechnology, Government of India. Mahyco in collaboration with Monsanto Company of USA started efforts to commercialize Bt cotton in India. In northern cotton growing states, Viz. Punjab, Haryana and Rajasthan six Bt cotton hybrids were approved for commercial cultivation for the first time during 2005. Out of these six Bt cotton hybrids, two each have been developed by Mahyco (MRC 6301 Bt and MRC 6304 Bt), Rasi seeds (RCH 134 Bt and RCH 317 Bt) and Ankur seeds (Ankur 651 Bt and Ankur 2534 Bt) (Singh and Kaushik, 2007).Nitrogen is most essential nutrient for plant growth needs to be supplied in proper time and quantities. A positive correlation between vegetative growth and the number of fruiting points produced by cotton is well known. N supplement therefore by split application becomes important as it is supplied ideally in a time when crop critically requires. Bt cotton differs in its requirement either by total of it in the different stages of crop. Split applications of nitrogen fertilizer can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Application of nitrogen in two or more than two splits doses can help growers enhance nutrient efficiency, promote optimum yield and mitigate the loss of nutrient. Potassium (K) is the third major essential plant nutrient along with N and P. Potassium plays a specific role in most plant species in opening and closing of stomata which cannot be done by other cation (Saxena, 1985).It increases root growth and improves drought resistance, activates many enzymes systems, reduce water loss and willing, prevent energy losses and aids in photosynthesis, respiration and food formation (Tiwari, 2001). As the requirement of plants to potassium differ from stage to stage (Brady, 1996) and there might be better response of plants to potassium, if potassium is applied in splits at different stages. Therefore the present study was initiated using Bt cotton as test crop.

MATERIALS AND METHODS

A field experiment was conducted at PAU, Regional Station, Abohar (Punjab) during kharif season 2008. The soil was sandy loam in texture having organic carbon 4.9 g kg^{-1} available P_2O_5 30 kg ha^{-1} and available k_20 560 kg ha^{-1}. There were 18 treatment combinations comprising N and NK split application Viz. $T_{1,}$ 2 splits (50-50) at sowing and 45 DAS,$T_{2,}$ 3 split (50-25-50) at sowing, 45 and 75 DAS,T_3, 3 splits (30-40-30) at sowing, 45 and 75 DAS,$T_{4,}$ 3 splits (50-25-25) at sowing, 30 and 45 DAS,$T_{5,}$ 3 splits (50-25-25) at sowing, 30 and 60 DAS,$T_{6,}$ 3 splits (50-25-25) at sowing, 45 and 60 DAS,$T_{7,}$ 3 splits (50-25-25) at sowing , 30 and 75 DAS,$T_{8,}$ 4 splits (25-25-25-25) at sowing, 30, 45 and 60 DAS.$T_{9,}$ (25-25-25-25) at sowing, 30, 45and 75 DAS. These were evaluated in factorial randomized block design with three replications in 8 rows × 9 m plots. Bt cotton Hybrid RCH-134 was sown

Corresponding author e-mail: tak.sheetal10@gmail.com, ibmaurya@rediffmail.com

on 18.05.2008. In N split dose plots, whole of P and K was applied at the time of sowing as basal dose in the form of DAP and MOP @ 67.5 kg ha^{-1} and 50 kg ha^{-1}, respectively. The nitrogen was applied in the form of urea @ 325 kg ha^{-1}in the split dose as per treatments. In NK split dose plots, only P was applied as recommended dose, while N and K was applied at the same rates in splits as per treatments. Number of boll per plant, boll weight, yield per plant and seed cotton yield were recorded. The uptakes of N, P and K at harvest by plant were computed by multiplying content value with yield data. Samples were analyzed for N by colorimetric method (Snell and Snell, 1939), P content was determined by vanadomolybdo phosphoric acid yellow method (Jackson, 1973) and K by flame photometer.in di acid digests. Oil content in seed was determined by solvent extraction method. The nutrient use efficiency was worked out by Crasswell and Godwin (1984) and expressed in kg seed cotton kg^{-1} nutrient.

RESULTS AND DISCUSSION

Split application of N and NK did not have any significant effect on seed cotton yield, yield per plant, bolls/plant, boll weight, seed index, lint yield and G.O.T. (Ginning Percentage). Similarly, a non-significant effect due to split application of N was recorded by Solaiappan and Sheriff (1994) and Hallikeri *et al*. (2010). Oil content was significantly higher in NK split application (22.76 %) as compared to N split application. Timing of fertilizer application did not show any significant effect on oil content but higher (22.77%) amount was noted when the fertilizer was applied in three splits (50-50-25) at sowing, 30 and 60 DAS (Table1). Timing of fertilizer application at different stages of crop growth did not show any significant effect on any of these parameters. Bolls/ plant showed significant interaction between the fertilizer and its timing of application (Table.1). Split application of both N and K at basal and 45 DAS (T_1) and basal, 45 and 75 DAS (50-25-25) i.e. T_2: gave higher bolls per plant than other combinations. This might be due to continued availability of nitrogen and potassium to the crop all through its growth period. This is in agreement with the findings of Mondal *et al. (*1982). Similarly, split application of N at basal, 30 and 60 DAS (50-25-25) i.e., T_5 gave higher bolls per plant as compared to NK split application at same timings. Supplementation of N at these stages may be ideal to meet the requirement even for Bt- cotton (Srinivasan 2003). At any other timing, split application of N and NK both exhibit non-significant differences.

Table 1: Interaction effect of split application of N and K fertilizer with timing of fertilizer application

Treatments	Bolls per plant	
	N	NK
$T_{1.}$ 50-50 (0 and 45 DAS)	30.9	44.6
$T_{2.}$ 50-25-25 (0 45 and 75 DAS)	33.7	50.5
$T_{3.}$ 30-40-30(0 45 and 75 DAS)	37.9	43.5
$T_{4.}$ 50-25-25(0 30 and 45 DAS)	35.3	29.3
$T_{5.}$ 50-25-25(0 30 and 60 DAS)	44.9	30.7
$T_{6.}$ 50-25-25(0 45 and 60 DAS)	35.1	41.8
$T_{7.}$ 50-25-25(0 30 and 75 DAS)	35.7	41.7
$T_{8.}$25-25-25-25(0 30, 45 and 60 DAS)	44.5	37.6
$T_{9.}$ 25-25-25-25(0 30, 45 and 75 DAS)	41.7	42.6
CD (P=0.05)	10.4	

The P uptake was significantly higher in N split application as compared to both NK split application, whereas K uptake showed the reverse trend with significantly higher value in NK split application over N application alone. Nitrogen and K in splits might have supplied adequate quantity of nutrients to coincide with peak demand for nutrients to cotton. Besides, the external application of K might

Table 2: Yield and quality parameters of RCH 134 Bt as influenced by split application of N and K fertilizer

Treatments	Seed Cotton Yield (Kg/ha)	Yield per Plant (g)	Bolls per plant	Boll weight (g)	Seed Index (g)	Oil content (%)	Lint yield (Kg ha^{-1})	G.O.T (%)
Fertilizer with split doses								
N	2281	173.3	40.2	4.47	9.64	22.28	790	34.67
NK	2183	165.6	37.8	4.35	9.87	22.76	757	34.64
CD (P=0.05)	NS	NS	NS	NS	NS	0.33	NS	NS
Timing of application								
T_1	2141	166.7	37.8	4.50	9.39	22.64	743	34.74
T_2	2307	180.0	42.1	4.31	9.70	22.74	788	34.16
T_3	2264	170.0	40.7	4.16	9.80	22.29	782	34.66
T_4	2068	138.3	32.3	4.04	9.87	22.30	716	34.60
T_5	2197	168.3	37.8	4.48	9.60	22.77	743	33.76
T_6	2237	171.7	38.4	4.70	9.79	22.56	768	34.16
T_7	2253	171.7	38.7	4.48	9.78	22.35	809	35.94
T_8	2292	176.7	41.1	4.56	9.91	22.39	801	35.07
T_9	2327	181.7	42.2	4.48	9.97	22.64	815	34.84
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

have increased the quantity of readily available K to cotton thus resulting in higher K uptake (Srinivasan, 2003). Nitrogen uptake did not show any significant difference while comparing N and NK split application (Table 2). Timing of fertilizer application resulted in significant differences for N. P and K uptake. Nitrogen uptake was highest when the fertilizer was applied in 4 equal doses at sowing, 30, 45 and 75 DAS (T_9) and was at par with 4 equal doses at sowing, 30, 45 and 60 DAS (T_8). Phosphorus and K uptake was highest when the fertilizer was applied in 4 equal doses at sowing, 30, 45 and 60 DAS (T_8).This might be due to attributed to improved utilization of N in the presence of K. Similar positive effect of potassium application on N uptake was reported by Senthivel and Paloniappan (1985). Superiority of split application of N and NK might be attributed to availability of nutrients at growth stage when cotton crop starts growing faster. This may be due to prevention of loss through leaching.

Table 3: Nutrient uptake inRCH 134 Bt as influenced by split application of N and K fertilizer

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Nutrient Use Efficiency(kg seed cotton kg^{-1} NPK applied)		
				Nitrogen	Phosphorus	Potassium
Fertilizer with split doses						
N	426	163	436	5.56	14.44	5.43
NK	446	148	481	5.34	15.49	4.76
CD (P=0.05)	NS	15	41	NS	NS	0.58
Timing of application						
T_1	489	162	531	4.50	13.63	4.16
T_2	503	155	484	4.79	15.65	4.99
T_3	440	147	392	5.35	15.94	5.86
T_4	303	128	407	6.97	16.53	5.22
T_5	378	153	454	6.00	14.94	5.10
T_6	378	144	410	6.19	15.91	5.71
T_7	343	152	416	6.66	15.18	5.59
T_8	537	182	553	4.34	13.26	4.31
T_9	553	175	480	4.26	13.65	4.90
CD (P=0.05)	84	31	87	1.29	NS	NS

Nutrient use efficiency of nitrogen and phosphorus was not affected significantly by N and NK split application, but K use efficiency was found to be significantly higher in N split application (5.43 kg ha^{-1}) as compared to NK split application treatment. Nutrient use efficiency of P and K was not influence by timing of fertilizer application, whereas N use efficiency was significantly higher (6.97 kg ha$^{-1)}$ when the fertilizer was applied at sowing, 30 and 45 DAS (T_4).

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RESPONSE OF RICE TO ZINC APPLICATION IN ACIDIC SOILS OF ASSAM

G.G. KANDALI, A. BASUMATARY, N.G. BARUA, B.K. MEDHI AND S. HAZARIKA

Department of Soil Science, Assam Agricultural University, Jorhat-785013

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ABSTRACT

Field experiments were carried out in 2011 and 2012 at the Instructional Cum Research Farm of Assam Agricultural University, Jorhat, Assam, to find out the effect of different levels of zinc (0, 5, 10, 15, 20, 25 and 30 kg Zn SO_4 ha^{-1}) on yield, economics and Zn uptake by rice. The results revealed that the rice responded significantly to graded doses of zinc application. The highest grain (4.59 t ha^{-1}) and straw yield (6.64 t ha^{-1}) was recorded at 25 kg $ZnSO_4$ ha^{-1} which was 73.8 % and 20.5% greater than control, respectively. The highest mean zinc concentration (21.7 mg kg^{-1}, 45.6 mg kg^{-1}) and uptake (97.5 g ha^{-1}, 311.7 g ha^{-1}) in grain and straw were recorded at 25 kg $ZnSO_4$ ha^{-1}. The apparent zinc recovery was highest at lower level of zinc application and decreased with increase in zinc doses. Available Zn increased with increasing levels of Zn and maximum value of Zn in post harvest soil was noted at 30 kg Zn SO_4 ha^{-1}. All growth parameters performed better under 25 kg Zn SO_4 ha^{-1}. Net returns (₹. 23198.7 ha^{-1}) and B: C ratios (2.43) were recorded highest with 25 kg Zn SO_4 ha^{-1} and lowest with control.

Key words: Zinc response, yield, zinc uptake, zinc use efficiency, residual zinc, rice.

INTRODUCTION

Out of the seventeen essential elements required for plant growth, Zn is ranked as the fourth most deficient element in Indian soils after N, P and K. Shukla and Behera (2011) reported that 49% of the Indian soils are deficient in Zn. Singh (2009) reported that 34% of the acidic soils of Assam are deficient in Zn. However, recently Shukla (2011) reported about 25% of Zn deficiency in the state of Assam. Zn deficiency continues to be one of the key factors in determining rice production in several parts of the country (Chaudhary *et al*., 2007). Rice is the stable food for more than half of the world population and it provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean *et al*., 2002). At present, lowland rice occupies about 39% of the total cropped area of Assam (Adhya *et al*., 2008). Being the single major source of Agricultural GDP, rice plays a significant role in the state economy. Considering the intensive cultivation of high yielding rice varieties and acidic soil reactions in the rice growing areas of Assam, the response of rice to applied Zn is the subject deserving investigation. In Assam, most of the cultivable land especially rice growing soils are showing Zn deficiency and information in relation to Zn fertilizer management is inadequate. However, though response to zinc application was observed in deficient and marginally zinc deficient areas, but an optimum level of zinc had not been determined and data available are not sufficient to assess an optimum level of zinc in relation to agro climatic conditions of Assam. Therefore, this study was conducted with an objective to find out a suitable level of zinc fertilizer to supply the zinc requirement to increase the yield and productivity of rice in acidic low lying rice growing areas.

MATERIALS AND METHODS

Field experiments were conducted during 2011 and 2012 in the Instructional Cum Research Farm of Assam Agricultural University, Jorhat situated at 26^0 43' 14.1" N and 94^0 11' 42.6" E. The physico-chemical characteristics of the soil were: sandy clay loam in texture, pH 5.2, EC 0.02 dSm^{-1}, organic carbon 8.2 g kg^{-1}, available N 286 $kgha^{-1}$, Bray's P 26 $kgha^{-1}$, K 284 $kgha^{-1}$ and DTPA Zn 0.55 $mgkg^{-1}$. The experiment consisted of six levels of $ZnSO_4$ (0, 5, 10, 15, 20 ,25 and 30 Kg ha^{-1}) which corresponds to 0, 1.05, 2.1, 3.15, 4.2, 5.25, and 6.3 Kg Zn ha^{-1} in a randomised block design with three replications. Twenty five days old seedlings of rice var Ranjit were transplanted with three plants per hill at a spacing of 20x20 cm surrounded by 30 cm wide bunds. Recommended dose of Urea, SSP, and MOP were applied @ 60kg N + 20 kg P_2O_5 + 40 kg K_2O ha^{-1} along with 2t ha^{-1} compost as broadcast and incorporated into the soil by puddling just before transplanting. Urea was applied in three splits viz. at basal, maximum tillering and panicle initiation stage. Plant growth was measured by taking plant height, total tillers, effective tillers, filled grain, saffy grain and thousand grain weight. Crops were harvested at maturity and grain and straw yields were recorded. Dried grain and straw samples were ground and digested in diacid mixture and zinc concentration was determined in Atomic Absorption spectrophotometer. Zinc uptake in grain and straw was calculated by multiplying the grain and straw yield with respective zinc concentration. Zinc use efficiency (kg grain kg^{-1} Zn) and apparent zinc recovery (%) of rice grains were calculated following the procedure of Baligar *et al*. (2001).

RESULTS AND DISCUSSION

Yield: Grain and straw yield of rice responded significantly to zinc application (Table 1). Grain and straw yield increased gradually with the increase in zinc levels. All the treatments produced significantly different grain and straw yield. The grain yield ranged from 2.64 t ha^{-1} to 4.59 t ha^{-1} and straw yield from 5.51 t ha^{-1} to 6.64 t ha^{-1} due to zinc application. The highest grain (4.59 t ha^{-1}) and straw yield (6.64 t ha^{-1}) was found in the treatment receiving 25 kg $ZnSO_4$ ha^{-1} which was significantly higher than all other treatments. The percent increase in grain yield due to zinc application among the treatments varied from 34.4% to 73.8% over control, while in straw yield, percent increase varied from 3.6 to 20.5 percent. Fageria *et al*. (2011) reported 97% increase in rice yield due to zinc fertilization. Similar increase due to Zn application in dry matter and grain yields in different crops have also been reported by Kumar *et al* (2011) and Nagarathna *et al* (2010). The increase in grain and straw yield with application of zinc may be attributed to adequate supply of zinc that might have increased the availability and uptake of other essential nutrients resulting in improvement in metabolic activities and also due to the effect of zinc on the proliferation of roots. Similar findings were also reported by Muthukumaraja *et al.* (2013).

Table 1: Yields of grain and straw and zinc content as affected by zinc (mean data of 2 years)

Treatments $ZnSO_4$ ($kgha^{-1}$)	Grain yield (t ha^{-1})	% response	Straw yield (t ha^{-1})	% response	Zinc in grain (mg kg^{-1})	Zinc in straw (mg kg^{-1})
0	26.41		55.08		17.4	32.5
5	35.51	34.45	57.13	3.72	20.4	33.8
10	35.68	35.1	58.68	6.53	18.2	40.7
15	41.60	57.51	63.06	14.48	18.3	42.2
20	42.61	61.34	65.24	18.44	20.1	39.3
25	45.92	73.87	66.40	20.55	21.7	45.6
30	43.74	65.61	63.07	14.51	20.8	45.4
S.Em	0.69		1.24		0.49	1.5
CD (0.05%)	1.50		2.70		1.06	3.27

Content and uptake of zinc: Zinc concentration (Table 1) and uptake (Table 2) in grain and straw increased gradually with the increase in zinc level up to 25 kg $ZnSO_4$ ha^{-1} and then decreased at 30 kg $ZnSO_4$ ha^{-1}. It was observed that maximum zinc uptake of 97.5 g ha^{-1} and 311.7 g ha^{-1} was recorded with 25 kg $ZnSO_4$ ha^{-1} in grain and straw, respectively which was statistically higher than the treatment receiving 30 kg $ZnSO_4$ ha^{-1}. Dwivedi and Tiwari (1992) also reported that zinc concentration and uptake in grain and straw increased with zinc rate particularly in zinc deficient soils.

Table 2: Effect of zinc on zinc uptake in grain and straw

Treatment $ZnSO_4$ ($kgha^{-1}$)	Zinc uptake in grain (gha^{-1})			Zinc uptake in straw (gha^{-1})		
	2011	2012	mean of two years	2011	2012	mean of two years
0	39.8	51.6	45.8	164.6	194.0	179.3
5	56.3	88.6	72.5	182.3	204.1	193.2
10	59.7	69.8	64.8	236.1	240.9	238.5
15	72.1	79.8	75.9	260.7	272.3	266.5
20	79.6	94.7	87.1	239.6	274.1	256.8
25	97.4	99.6	97.5	302.1	321.3	311.7
30	87.8	89.5	88.6	271.0	301.9	286.5
S.Em	4.41	3.67	3.31	19.73	8.42	10.26
CD (0.5%)	9.6	7.99	7.21	42.99	18.35	22.36

Efficiency indices: Apparent Zn recovery decreased significantly with higher Zn levels (Table 3).This was due to inverse relationship often observed between utilization and rate of application. The maximum values of apparent Zn recovery was noted at 5 kg $ZnSO_4$ ha^{-1}. Thereafter, it tended to decrease with increasing levels of Zn and minimum values were recorded at 30 kg $ZnSO_4$ ha^{-1}.

Available Zn: The mean available Zn content of soil was depleted under control. The mean initial available Zn status of soil which was 0.55 mg kg-^{1} decreased to 0.50mg kg^{-1} after harvest of rice crop. The zinc status of soil varied from 0.50 mg kg^{-1} at control to 1.30 mg kg^{-1} at 30 kg Zn SO_4 ha^{-1}. Depletion of soil available Zn in control without Zn supply and its build up in zinc fertilizer plots has also been reported by Singh (2009).

Economics

Economic analysis of different treatments revealed that the highest cost of cultivation (₹.16230.3 ha^{-1}) was recorded in 30 kg $ZnSO_4$ ha^{-1}. The gross return (₹.39420), net Return (₹.23198.7 ha^{-1}) and B: C ratio (2.43) were recorded highest with 25 kg $ZnSO_4$ ha^{-1}. This might be due to higher yield obtained in this

Table 3: Apparent Zn recovery and available Zn as affected Economic by different treatments

$ZnSO_4$ (kgha^{-1})	Gross Return (₹/ha)	Net Return (₹/ha)	B:C ratio	Apparent Zn recovery (%)	Avail. Zn (mg kg^{-1})
0	202201.5	7760.2	1.47	-	0.50
5	30917.25	14729.95	1.91	2.54	0.75
10	31161	14964.7	1.92	0.90	0.90
15	35929.5	19725.2	2.22	0.96	1.06
20	36850.5	20637.2	2.27	0.99	1.20
25	39420	23198.7	2.43	0.98	1.25
30	37535.25	21304.95	2.31	0.68	1.30
SEm $\pm$	-	-	-	-	0.10
CD (P=0.05)	-	-	-	-	0.21

treatment compared to all other treatments. On the other hand, lowest net returns (₹. 7760.2 ha^{-1}) and B:C ratio (1.47) were recorded under control due to lower yields of grain and straw.

From the present study, it can be concluded that application of 25 kg $ZnSO_4$ ha^{-1} proved significantly beneficial in respect of yield and economics of rice grown in acidic soils of Assam.

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EFFICACY OF BIOAGENTS AND FUNGICIDES AGAINST SEED BORNE FUNGI OF SOYBEAN

KIRTI PAWAR, S.P. MISHRA AND R.K. SINGH

Department of Plant Pathology, College of Agriculture, RVSKVV, Indore 452001 Madhya Pradesh, India
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ABSTRACT

An experiment was conducted to assess the reduction in association of seed borne fungi and enhancement of germination of soybean (Glycine max (L.)Merill) using four varieties JS 335,JS 9305, JS 9560 and NRC 12 with two storage categories (seeds stored in bins and seeds stored in bags) by treatment with fungicides Thiram(0.25%), Captan (0.25%), Carbendazim (0.1%), Thiram + Carbendazim(1:1) and Chlorothalonil(0.2%) and bioagents T. harzianum and T. viride to evaluate their effect on seed borne mycoflora and germination by two different methods of incubation i.e. Standard blotter and Agar plate methods. In all fourteen fungi including ten pathogens were recorded. Out of five fungicides and two bioagents, Thiram and Thiram + Carbendazim and T. viride showed least association of mycoflora and enhanced per cent germination i.e. Thiram (77.5%), Thiram + Carbendazim (76.4 %) and T. viride (68.3%) with seeds stored in bags of all the four varieties employing standard blotter method.JS 9305 and NRC 12 were found tolerant to expression of seed borne mycoflora along with better germinability viz. (77.5% for JS 9305) and (76.4 % for NRC 12). Among two storage categories, seeds stored in bags showed higher germination and lesser percentage of mycoflora associated with seeds as compared to seeds stored in bins. Overall, two varieties JS 9305 and NRC 12 could be stored in bags and by treating with Thiram (0.25%).

Keywords: Bioagents, seed categories, fungicides, germination, management, mycoflora,

INTRODUCTION

Soybean, (*Glycine max* (L) Merill) is a host of several seed borne fungal pathogens. A large number of pathogens are transmitted through seeds which reduce seed germination, seedling vigour and also cause several diseases like anthracnose,(*Colletotrichum truncatum*), rhizoctonia root rot (*Rhizoctonia solani*), phomopsis seed decay *(Phomopsis sojae*), charcoal rot (*Macrophomina phaseolina*), myrothecium leaf spot (*Myrothecium roridum*), alternaria leaf spot(*Alternaria alternata*), purple stain (*Cercospora kikuchii*) and helminthosporium leaf spot (*Helminthosporium* sp). Mycoflora associated with seed results in greater loss in seed quality and also in yield. Seed treatment is one of the best methods to manage seed borne diseases. Several fungicides have been employed to control of fungal diseases of the crop. Agrochemicals like Thiram, Captan and copper oxychloride were used to control many diseases caused by fungal pathogens in soybean**.** Ibiam *et al* (2000) and (2006) observed that seed dressing fungicides- Benlate, Apron plus 50 DS Fernasan- D, Dithane M-45 and Bavistin controlling seed bore fungi of rice. Mane *et al*. (2010) evaluated efficacy of various fungicidal seed treatment on seed mycoflora and seed germination during storage of sorghum. Even though effective and efficient control of seed borne fungi can be achieved by the use of fungicides, the same cannot be applied to grains for reasons of pesticide toxicity (Harris *et al*. 2001). The continuous and indiscriminate use of chemicals to control diseases results in accumulation of harmful residues of chemicals in the soil, water and seed. In recent years, considerable success has been achieved by introducing antagonists to control seed borne fungal pathogens. A remarkable work has been done for management of seedling diseases of many crops caused by *Rhizoctonia solani* and *Sclerotium rolfsii* both *in vitro* and in pot culture experiments by using *Trichoderma* (Akhter 1999, Pradeep *et al*. 2000, Raihan *et al*. 2003, Haider 2005).The present study has, therefore, been undertaken to evaluate the effect of seed treatment with chemicals and/ or bio-agents in reducing the associated seed-borne fungi and in turn enhancing germination of seeds.

MATERIALS AND METHODS

A study was conducted to assess the association of seed borne mycoflora of soybean using four varieties JS 335,JS 9305,JS 9560 and NRC 12 with two different storage categories i.e seeds stored in bins and seeds stored in bags by using two different methods, namely ,Standard blotter paper method and Agar plate method. Seeds were treated with fungicides (Thiram (0.3%) Captan (0.3%), Carbendazim (0.1%), Thiram + Carbendazim (1:1) and Chlorothalonil (0.3%) and talc formulations of bioagents *Trichoderma viride* and *T. harzianum* containing

Corresponding author e-mail: kirtibhavya@gmail.com

10^7cfu/g by two incubation methods (i) Standard blotter method (ISTA, 1978) (ii) Agar plate method (Modified Ulster method, Muskett and Malone, 1948).

Standard blotter method: A set of 400 seeds treated with fungicides/ bioagents were incubated for seven days under alternating cycles of 12 hours NUV (near ultra violet) light and 12 hours of darkness at a temperature of $27^oC \pm 1$.

Agar plate method: In this method, potato dextrose agar medium (PDA) was poured aseptically in the sterilized glass petri dishes of 10 cm diameter @ 15 to 20 ml per petri dish and keeping the seeds treated with fungicides/ bioagents on sterilized blotting paper in aseptic conditions. These petri dishes were further incubated at 27 ± 1^oC for seven days under 12 hours alternating cycles of NUV light and darkness. These seeds were examined for germination and fungal growth after five and eight days of incubation. The seeds were treated with the talc formulations of bio control agents (BCA). Bio-control agents have been used as seed dressers to see their effect on seed borne mycoflora viz., *Trichoderma viride*, *T. harzianum* @ 5 g/kg along with fungicides carbendazim, thiram, chlorothalonil, captan and thiram+ carbendazim were evaluated by Standard blotter method and Agar plate methods. Untreated seeds served as control.Fungi were identified by preparing temporary slides and examining under the compound microscope. In fewer cases the fungi from the incubated seeds were transferred to PDA in petridishes aseptically and incubated at 28±1˚C for 3-10 days and then examined under compound microscope. Identification of fungi was confirmed observing their growth characters on the slides and by examining the cultures under the microscope through the characters of mycelium, spores and fruiting bodies. The total number of fungal species isolated by two incubation methods was calculated on percent basis to find out the arising fungi and the difference between two incubation methods.The data on the percentage germination and association of fungi in different categories, under the influence of fungicide and management of myco flora by bio control agents and/or fungicide were analysed statistically.The values were transformed by $\sqrt{X} + 0.5$ and angular transformation wherever necessary.

RESULTS AND DISCUSSION

The study using seven seed treatments including five fungicides, namely ,Thiram, Captan, Carbendazim, Chlorothalonil and Thiram + Carbendazim and two bioagents *T. harzianum* and *T. viride* revealed association of fourteen seed borne fungi on four varieties of soybean stored in two conditions. The fungi included *A. flavus, A. imperfectii, A. alternata, C. kikuchii, C. truncatum, D. phaseolorum, Helminthosporium* sp., *R. stolonifer, F. oxysporum* and *M. phaseolina, M. roridum, R. bataticola, S. rolfsii* and *P. sojae*. Least association of mycoflora was recorded under Thiram and Thiram + Carbendazim followed by Carbendazim by both incubation methods.The averages of all seven treatments have been presented in Table 1.Seed treatment with Thiram and Thiram + Carbendazim effectively reduced all the fungi except *R. bataticola* and *S. rolfsii.* Out of four varieties employed JS 335 and JS 9560 harbored higher number of fungi on seeds in comparison to JS 9305 and NRC 12, consistently in both the Standard blotter and Agar plate methods.

Table 1: Fungi (%) associated with soybean varieties after treatment with fungicides and bioagents by Standard Blotter and Agar Plate methods

Response of fungicides and bioagents on varieties by ↓	***Fungi associated under two storage conditions (%) →***	***Aspergillus flavus***		***Alternaria alternata***		***Aschochyta imperfeftii***		***Colletotrichum truncatum***		***Cercospora kikuchii***		***Diaporthe phaseolorum***		***Fusarium oxysporum***		***Helminthosporium sp.***		***Macrophomina phaseolina***		***Myrothecium roridum***		***Phomopsis sojae***		***Rhizopus stolonifer***		***Rhizoctonia bataticola***		***Sclerotium rolfsi***	
Standard blotter method		c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2	c_1	c_2
	JS 335 *	2	1	3	2	3	2	3	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	-	-	-	-
	JS 9305	3	2	3	2	-	-	3	2	-	-	-	-	3	1	3	2	-	-	-	-	2	2	2	1	3	1	-	-
	JS 9560	3	2	3	2	3	2	2	1	3	1	3	1	2	1	3	2	3	2	3	1	2	1	3	1	-	-	2	1
	NRC 12	3	2	3	2	-	-	3	1	-	-	-	-	3	2	3	2	2	1	-	-	-	-	2	1	2	1	-	-
	Control	14	12	12	10	11	10	11	9	13	9	12	10	12	13	13	10	9	8	-	-	-	-	9	8	2	4	-	-
Agar Plate method	JS 335	3	1	3	2	3	1	2	1	2	1	3	1	2	1	2	1	2	1	3	1	2	1	3	1	-	-	-	-
	JS 9305	3	2	3	2	-	-	4	2	-	-	-	-	3	2	3	2	-	-	-	-	3	2	3	2	3	1	-	-
	JS 9560	3	2	3	2	3	2	3	2	3	1	3	2	3	2	3	1	3	2	3	2	3	1	2	1	-	-	2	1
	NRC 12	3	2	3	3	-	-	3	2	-	-	-	-	3	2	3	2	3	2	-	-	-	-	3	2	3	2	-	-
	Control	13	12	13	10	12	10	12	8	13	9	13	9	12	9	12	10	13	12	10	8	12	9	10	8	13	10	9	8

**Average of 7 treatments viz., T1-Captan(0.25%),T2- Thiram (0.25%) ,T3-Carbendazim(0.1%),* T_4*-Thiram + Carbendazim (0.1%),* T_5*-Chlorothalonil(0.2%),* T_6*- T.harzianum,* T_7*- T.viride ,* C_1 *– stored in bins, C2- stored in bags*

However, fungicides or bioagents applied as seed dressers drastically reduced the intensity of seed mycoflora as compared to control. It was observed that intensity of seed borne mycoflora was higher on seeds stored in bins in comparison to those stored in bags. Thus varieties JS 9305 and NRC 12 showed tolerance to seed borne mycoflora under storage in bags. The data on germination of seeds of four varieties stored in bins and bags as evident by both the test methods, Standard blotter method (Table 2) and Agar Plate method (Table 3) indicated that significantly higher germination was recorded in seeds stored in bags as compared to those stored in bins. Varieties JS 9305 and NRC 12 responded better to seed treatments exhibiting higher germination as compared to JS 335 and JS 9560. Seed treatment with Thiram resulted in maximum percentage germination of seeds stored in bag (77.5%) of all the varieties followed by Thiram + Carbendazim (76.4%) and Carbendazim (73.2%). The corresponding per cent germination in control was (55.5%) through Standard Blotter Method. In case of seeds stored in bin, seed treatment with Thiram (70.2%) and Thiram + Carbendazim (70.06%) showed maximum per cent germination followed by Carbendazim (67.0%) and Captan (66.5%) as compared to 48.55% in control by Standard Blotter Method.By Agar Plate method, Thiram showed maximum seed germination (74.7%) followed by Thiram + Carbendazim(73.2 %) & Carbendazim (70.7%) and (53.7%) in control for seeds stored in bags and for seeds stored in bins (Carbendazim (67.1%) and Thiram (66.7%)showed maximum percent germination followed by Thiram + Carbendazim (64.6%) as compared to (46.2%) in Control (Table 3). Their seed treatment eliminated the seminosphere mycoflora and results in slight improvement in seed germination and seedling vigor.

Table 2: Effect of seed treatment with fungicide and bioagents on germination % of different soybean varieties using Standard Blotter method

Seed category (C) →	Germination(%) of seeds during storage in										Overall mean
	bins					bags					
Seed treatment with ↓	JS 335	*JS 93-05*	JS 95-60	NRC-12	Mean	JS 335	JS 93-05	JS 95-60	NRC 12	Mean	
Captan	60.3 (50.9)	68.4 (55.8)	61 (51.3)	76.2 (60.8)	66.5 (54.7)	70.2 (56.9)	68 (55.5)	66.3 (54.5)	78.4 (62.3)	70.8 (57.3)	68.6 (56.1)
Thiram	64.4 (53.3)	71.2 (57.5)	65.5 (54)	79.6 (63.1)	70.2 (57)	75.3 (60.2)	81.2 (64.3)	70.4 (57)	83.2 (64.3)	77.5 (61.9)	73.8 (59.4)
Carbendazim	59.9 (50.6)	65.5 (54)	66.7 (54.7)	76.1 (60.7)	67 (55.1)	68.4 55.9)	72.5 (58.3)	71.1 (57.4)	81.1 (64.1)	73.2 (58.9)	70.1 (57))
Thiram+ Carbendazim	68.3 (55.7)	70.2 (56.9)	63.4 (52.8)	78.2 (62.1)	70.1 (56.9)	73.3 (58.8)	80.7 (63.9)	71.4 (57.6)	80.5 (63.7)	76.4 (61.1)	73.2 (58.9)
Chlorothalonil	58.2 (49.7)	65.3 (53.9)	60 (50.7)	71.3 (57.6)	63.7 (53.0)	65.3 (53.9)	73.4 (58.9)	68.2 (55.6)	76.3 (60.8)	70.8 (57.3)	67.2 (55.1)
T. harzianum	58 (49.6)	67.3 (55.1)	62.6 (52.3)	73.2 (58.8)	65.2 (53.9)	60.2 (50.8)	68.3 (55.7)	64.3 (53.3)	76.3 (60.8)	67.2 (55.2)	66.2 (55.5)
T. viride	61.3 (51.5)	65.2 (53.8)	55.2 (47.9)	74.1 (59.4)	63.9 (53.1)	63.1 (52.5)	69.7 (56.6)	61.2 (51.4)	79.3 (62.9)	68.3 (55.9)	66.1 (54.5)
Control	42.3 (40.5)	46.4 (42.9)	51 (45.5)	54.4 (47.5)	48.5 (44.1)	49.3 (44.6)	58.8 (50.1)	48.4 (44.1)	65.7 (54.1)	55.5 (48.2)	52.1 (46.1)
Mean	58.8 (50.1)	64.5 (53.5)	61.2 (51.5)	72.6 (58.6)	64.3 (53.4)	66.9 (55.1)	72.4 (58.5)	65.9 (54.4)	77.5 (61.8)	70.73 (57.4)	67.53 (55.4)

Comparison of	SEm(±)	CD(P=0.05)	Comparison of	SEm(±)	CD(P=0.05)
Varieties(V)	0.23	0.65	V×T	0.56	1.59
Treatment(T)	0.28	0.79	V×C	0.33	0.92
Category©	0.17	0.46	T×C	0.39	1.12
			V×T×C	0.78	2.25

In the present study also reduced association of the myco flora and improvement in germination was observed with treated seeds and additive effects of fungicides and bio-agents as seed dressers in reducing the internally seed-borne fungi is quite obvious. Hall and Xue (1995) observed Thiram, Carbendazim, benomyl and Captan to be effective in eliminating the pathogens.Maximum per cent germination was recorded by Thiram and Thiram + Carbendazim in seeds stored in bags and by Carbendazim and Thiram in seeds stored in bin using Standard blotter method and Agar Plate method. Rathod and Pawar (2013) isolated seed borne fungi of soybean variety Durga and evaluated the effect of various fungicides on mycoflora and germination and observed that copper oxychloride increased the germination and reduced the mycoflora. In the present study, among the bio-agents *T. viride* was found to be more effective in reducing seed myco flora and enhancing percentage germination (68.3%) followed by *T. harzianum* (67.2%)in seeds stored in bags while in seeds stored in bins, treatment with *T. harzianum* resulted in maximum percentage seed germination (65.2%) followed by *T. viride* (63.9%) by Standard Blotter Method (Table 2) and in Agar Plate Method *T. viride* was observed to show maximum percentage germination (66.1%) on seeds of all the four varieties, followed by *T. harzianum* (65.9%) in seed stored in bag as, while, on seeds stored in bin, treatment with *T. harzianum* resulted in maximum percentage seed germination (64.6%) followed by *T. viride* (62.9%) (Table 3).Girija and Umamaheshwaran (2003) reported the reduction of mycelium growth of *S. rolfsii* in interaction with *Trichoderma* spp .Among the two incubation method, Standard blotter method showed maximum percentage germination as compared to Agar plate method.(Table 2 and 3). Among all the various interactions studied, interactions between varieties with seed category, varieties with treatments, seed category with treatments, varieties and seed category with treatments, all of them were found to be statistically significant. The present observations have shown the value of seed treatments for improving stand and yield of soybean.

Table 3: Effect of seed treatment with fungicide and bioagents on percent germination of different soybean varieties using Agar Plate method

Seed category© →	**Germination (%) of seeds during storage in**										**Overall mean**
	bins					**bags**					
Seed treatment with↓	**JS 335**	**JS 93-05**	**JS 95-60**	**NRC-12**	**Mean**	**JS 335**	**JS 93-05**	**JS 95-60**	**NRC 12**	**Mean**	
Captan	58.0 (49.6)	63.4 (52.7)	55.1 (47.9)	50.6 (45.5)	56.7 (48.9)	68.2 (55.6)	65.3 (53.9)	63.1 (52.5)	77.5 (61.6)	68.5 (55.9)	62.6 (52.4)
Thiram	63.2 (52.6)	66.1 (54.3)	62.3 (52.1)	75.2 (60.1)	66.7 (54.8)	73.2 (58.7)	78.3 (62.2)	66.1 (54.4)	81.3 (64.3)	74.7 (59.9)	70.7 (57.3)
Carbendazim	65.3 (53.9)	69.4 (56.4)	61.5 (51.6)	72.2 (58.1)	67.1 (55.1)	66.2 (54.4)	69.5 (56.4)	68.3 (55.7*)	79.1 (62.7)	70.7 (57.3)	68.9 (56.1)
Thiram+ Carbendazim	61.4 (51.5)	63.2 (52.6)	60.7 (51.1)	73.1 (55.7)	64.6 (53.5)	71.2 (57.4)	77.2 (61.4)	65.4 (53.9)	79.3 (62.9)	73.2 (58.9)	68.9 (56.2)
Chlorothalonil	61.2 (51.4)	65.3 (53.9)	58.1 (50.1)	68.2 (55.6)	63.3 (52.7)	62.1 (52.0)	71.3 (57.6)	67.1 (55.0)	74.3 (59.5)	68.7 (56.0)	66.1 (54.4)
T. harzianum	56.2 (48.5)	65.2 (53.8)	65.3 (53.9)	72.0 (64.6)	64.6 (53.6)	61.3 (51.5)	65.2 (53.8)	62.2 (52.1)	75.1 (60.1)	65.9 (54.3)	65.3 (53.9)
T. viride	61.1 (51.4)	63.7 (52.9)	53.4 (46.9)	73.6 (59.1)	62.9 (52.6)	61.1 (51.4)	66.5 (54.6)	60.0 (50.7)	77.1 (61.4)	66.1 (54.5)	64.5 (53.5)
Control	41.3 (39.1)	42.1 (40.4)	49.2 (44.5)	52.3 (46.3)	46.2 (42.8)	48.5 (44.1)	56.7 (48.8)	46.3 (42.8)	63.3 (52.7)	53.7 (47.1)	49.9 (44.9)
Mean	58.4 (49.8)	61.6 (51.7)	57.9 (49.5)	65.2 (54.2)	60.8 (51.3)	64.9 (53.7)	69.7 (56.7)	62.7 (52.4)	75.8 (60.6)	68.3 (55.8)	64.5 (53.6)

Comparison of	**SEm(±)**	**CD(P=0.05)**	**Comparison of**	**SEm(±)**	**CD(P=0.05)**
Varieties(V)	0.36	1.03	V×T	0.88	2.52
Treatment(T)	0.44	1.26	V×C	0.51	1.46
Category©	0.25	0.73	T×C	0.62	1.78
			V×T×C	1.24	3.57

Seed treatment with Thiram and Thiram + Carbendazim effectively reduced the seed borne mycoflora except *R. bataticola* and *S. rolfsii.* Varieties JS 9305 and NRC 12 were tolerant whereas JS 335 and JS 9560 were more prone to expression of seed borne mycoflora. Varieties JS 9305 and NRC 12 also responded to higher seed germination than the other two varieties in response to seed treatment and storage conditions. Among the two storage categories, seeds stored in bags showed higher germination and lesser percentage of mycoflora associated with seeds as compared to seeds stored in bin for evaluating the effect of fungicides and /or bio-agents on seed borne mycoflora and enhancing the germination.

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PRODUCTION POTENTIAL OF RICE- WHEAT CROPS AS INFLUENCED BY ZINC MANAGEMENT IN PARTIALLY RECLAIMED SODIC SOIL

B.N. TRIPATHI, V.K. YADAV, H.C.TRIPATHI, ASHWINI SINGH, HARI RAM AND U.C. MISHRA

All India Co-Ordinate Research Project on Rice, C.S. Azad University of Agriculture and Technology, Kanpur (U.P) 208 002
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ABSTRACT

Field and laboratories studies were conducted for three consecutive years (2008-09 to 2010-11) to evaluate the production potential of rice-wheat crops as influenced by zinc management in partially reclaimed sodic soil at Kanpur (U.P). The results revealed that the maximum grain (4.3 and 3.8 t ha^{-1}) and straw (5.4 and 4.6 t ha^{-1}) yield of rice and wheat, respectively were recorded with application of 50 kg $ZnSO_4$ ha^{-1} each in kharif and rabi season. The mean increases over control varied from 11.5 to 99.2 % and 24.5 to 195.5% in grain and 11.5 to 97.0 % and 29.9 to 178.6% in straw of rice and wheat, respectively. Application of 50 kg $ZnSO_4$ ha^{-1} in each kharif and rabi season recorded highest uptake of N (81.3 kg ha^{-1}), P (16.2 kg ha^{-1}), K (87.8 kg ha^{-1}) and Zn (86.9g ha^{-1}) by grain and 40.8, 7.3, 73.5 kg ha^{-1} and 82.7 g ha^{-1} by straw of wheat, respectively. The maximum uptake values of these nutrients by rice cultivar were higher than that of wheat. The average value of apparent zinc recovery of rice differed from 5.9 to 90.0 and wheat 8.0 to 87.3, respectively. The maximum net return ₹. 29517 with benefit cost ratio 2.8 of rice and ₹. 33125 with B: C ratios 2.2 of wheat were recorded under the influence of 50 kg $ZnSO_4$ ha^{-1} applied in both kharif and rabi seasons.

Kew words: Zinc management, yield nutrient, uptake, rice- wheat cropping system, sodic soil.

INTRODUCTION

Salt affected soils are wide spread in northern part of the country. These soils bear distinctive characters of containing excessive concentration of soluble salts of sodium. Sodic soil pose many limitation to crop growth by way of the toxic effect of sodicity and certain nutrients element as well as poor fertility due to restriction availability of certain major and micro-nutrients. Availability of nitrogen and zinc to plants in these soils is extremely poor (Chaudhary *et al.* 2003 and Tripathi *et al.* 2012). Rice-wheat cropping system is well documented in partially amended sodic soil. Enhancing the yield potential of rice- wheat crops in such type of soil requires special management of soil, fertilizer nutrients and micro-nutrients. Availability of zinc to plants is extremely poor in sodic soil (Tripathi and Kumar 2013 and Tripathi *et al.* 2010). Zinc deficiency has been recognized as an important and wide spread nutritional disorder in such type of soils. The physico-chemical condition of sodic soil is also a serious problem in plant nutrition because these soils are very poor in organic matter (Chaudhary *et al.*2003 and Singh and Tripathi 2005). But for, with passage of time productivity growth of rice-wheat crops in partially reclaimed sodic soil with full complement of major nutrients treatments fell and become unsuitable (Singh and Tripathi 2008). For maximization of rice-wheat production there is urgent need for quantum jump in productivity as expansion of cultivable lands has become prohibiting. Taking these facts in view, an investigation was aims at examining the suitable level and addition system of zinc sulphate with key objective of identification the most efficient ones for rice- wheat cropping pattern in partially reclaimed sodic soil.

MATERIALS AND METHODS

The present investigation was planned and conducted during *kharif and rabi* season of 2008 to 2011 in a fixed layout in sodic soil of crop production farm Bojha, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.). The initial physico-chemical and mechanical characteristics of the partially reclaimed experimental soil were sand 48.5%, silt 34.0% and clay 17.5%, pH 9.6, E.C. 1.25 dSm^{-1}, exchangeable Na^+ 65.5%, CEC. 12.37 cmol (P^+)kg$^{-1,}$ organic carbon 1.7 g kg^{-1}, bulk density 1.46 Mgm^{-3}, particle density 2.54 Mgm^{-3}, porosity 37.8 %, hydraulic conductivity 0.28 cm hr^{-1}, volume expansion 12.5 %. The texture of the soil was clay-loam under Typic Natrustals Taxonomical class having available N, P_2O_5, K_2O 145, 28, 215 kg ha^{-1}, respectively, DTPA extractable Zn was 0.18 mg kg^{-1} soil. The levels and application sequence of zinc sulphate namely T_1 – control (no zinc), T_2- 25 kg $ZnSO_4$ ha^{-1} only in first *kharif* season, T_3- 25 kg $ZnSO_4$ ha^{-1} alternate in *kharif* season, T_4- 25 kg $ZnSO_4$ ha^{-1} in alternate *rabi* season, T_5- 25 kg $ZnSO_4$ ha^{-1} each in both season, T_6- 50 kg $ZnSO_4$ ha^{-1} in first *kharif* season, T_7- 50 kg $ZnSO_4$ ha^{-1} in alternate *kharif*

Corresponding author e-mail:dr.bnt1957@gmail.com. Co author. ashwiniemail08@gmail.com

season, T_8-50 kg $ZnSO_4ha^{-1}$ in alternate *rabi* season, T_9- 50 kg $ZnSO_4$ ha^{-1} each in both season T_{10}- 75 kg $ZnSO_4$ ha^{-1} in first *kharif* season, T_{11}- 75 Kg $ZnSO_4$ ha^{-1} in alternate *kharif* season, T_{12} - 75 kg $ZnSO_4$ ha^{-1} alternate in *rabi* season and T_{13}- 75 kg $ZnSO_4$ ha^{-1} each in both season. Seedlings of rice 'NDR-359' 35 days old were transplanted in second week of July during each year and wheat 'PBW-343' was sown in fourth week of November during all experimental years.The experiment was conducted in randomized block design with four replication. Nitrogen, phosphorus and potassium were applied @ 150, 60 and 40 $kgha^{-1}$, through urea, diammonium phosphate and muriate of potash, respectively. Each levels of $ZnSO_4$, phosphorus and potassium along with 1/3 dose of urea were added as basal at the time of transplanting/sowing of rice and wheat crops. Remaining doses of urea (N) was applied at tillering and flowering stage of rice and wheat crops Agronomical cultural practices such as irrigation, weeding and plant protection measures have been performed as per requisited. At maturity of rice and wheat crops, grain and straw yields were recorded. The net return and benefit: Cost ratios of both the crops under the influence of various treatments were calculated. Grain and straw samples were analyzed for their nitrogen content by modified Kjeldahl method (Jackson 1973), Phosphorus was determined by vanadomolybdate yellow colour method and patossium by flame photometer in di-acid digest. Zinc in di acid digest was estimated on atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Grain and straw yield

It is obvious from the data (Table 1) that the grain and straw yields of both rice and wheat under the influence of various treatments significantly increased over control. The mean grain and straw yield of rice and wheat varied from 2.2 to 4.3 t ha^{-1} and 1.3 to 3.8 t ha^{-1} and 2.7 to 5.4 and 1.6 to 4.6 t ha^{-1}, respectively. In general, increasing dose of zinc sulphate markedly increased the grain yield of both crops but maximum grain and straw yields of rice (4.3 and 5.4 t ha^{-1}) and wheat (3.8 and 4.6 t ha^{-1}) were recorded under the influence of 50 kg $ZnSO_4$ ha^{-1} applied in each *kharif and rabi* season followed by 50 kg $ZnSO_4$ ha^{-1} and 75 kg $ZnSO_4$ ha^{-1} applied in alternate *kharif* season. Application of 75 kg $ZnSO_4$ ha^{-1} in each season showed adverse effect on the yield of rice and wheat crops. Lowest yields of rice and wheat were noticed in control plots. Thus, it is clear from the results that addition of 50 kg $ZnSO_4$ ha^{-1} each in *kharif and rabi* crops responded more in both rice and wheat crops in partially reclaimed sodic soil. These results are comparable to those reported by Tripathi *et al.* (2012) and Tripathi and Kumar (2013). On pooled basis the increases over control ranged from 11.5 to 99.2 and 14.8 to 97.2 % in grain and straw of rice and 24.5 to 195.5 and 29.9 to 178.6 % in grain and straw of wheat. Maximum average increase in grain (195.5%) and straw (178.6 %) of wheat has been recorded under 50 kg $ZnSO_4$ ha^{-1} applied in both *kharif* and *rabi* season. This fevourable effect of Zn may be because addition of zinc might have maintained a favourable balance among nutrients in wheat plants for optimum growth. Chauhan *et al.* (2014) also reported response of wheat to zinc application.

Table 1: Response of zinc management practices on the yield and zinc use efficiency of wheat and rice (mean of 3 years)

Treatment	Rice				Wheat			
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Net return ₹. ha^{-1}	B:C ratio	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Net return ₹. ha^{-1}	B:C ratio
T_1	2.2	2.7	1541	0.4	1.3	1.6	1145	0.3
T_2	3.2	3.9	19298	1.5	2.4	3.0	7967	1.3
T_3	3.5	4.3	19359	1.7	2.6	3.0	13307	1.5
T_4	2.4	3.1	4540	1.3	1.6	2.1	1135	1.2
T_5	3.6	4.4	18416	1.6	2.4	3.1	10025	1.4
T_6	3.8	4.8	23329	1.7	3.2	3.5	17510	1.6
T_7	4.2	5.3	27312	2.7	3.6	4.4	31347	2.0
T_8	2.5	3.2	5719	1.4	2.2	2.7	10057	1.3
T_9	4.3	5.4	29517	2.3	3.8	4.6	33125	2.2
T_{10}	3.7	4.6	25575	1.6	2.9	3.6	14434	1.5
T_{11}	3.9	4.9	25299	1.9	3.3	3.8	19402	1.8
T_{12}	2.6	3.2	3545	1.1	2.0	2.5	3129	1.2
T_{13}	3.6	4.5	19130	1.0	2.8	3.4	8855	1.1
CD (P=0.05)	1.8	2.3			1.3	1.7	-	-

Economics

The result revealed that net returns with benefit: cost ratio varied from ₹.1541 to ₹. 29517 with 0.4 to 2.8 from rice and ₹. 1145 to ₹. 33125 with 0.3 to 2.2 from wheat, respectively (Table 1). Application of 50 kg $ZnSO_4$ ha^{-1} each in *kharif* and *rabi* season in both crops gave maximum net return with highest benefit: cost ratio. The lowest net return with minimum benefit: cost ratio were recorded in that sequence in which zinc sulphate was neither applied in *kharif* nor in *rabi* season. Application of 75 kg $ZnSO_4$ ha^{-1} through various sequences in each *kharif* and *rabi* season could not enhance the net returns and benefit: cost ratio in comparison to 50 kg $ZnSO_4$ ha^{-1} applied both in rice and wheat crops. Therefore, on the economic point of view, 50 kg $ZnSO_4$ ha^{-1} in both rice and wheat crop was found most beneficial**.** The increase in net returns by the application of Zn SO_4 might be due to positive effect of Zn grain and straw yield. The results have close conformity with those reported by Singh and Tripathi (2008), Mandal *et al.* (2009) and Chauhan *et al.* (2014).

Table 2: Effect of zinc management on uptake by of N, P, K, (Kg ha^{-1}) and Zn (g ha^{-1}) by grain and straw of rice (mean data of 03 years)

Treatment	Uptake by grain				Uptake by straw			
	N	P	K	Zn	N	P	K	Zn
T_1	26.8	5.7	30.4	44.8	22.0	3.8	35.4	43.2
T_2	55.4	8.9	51.4	68.4	33.5	5.7	63.4	64.6
T_3	61.6	10.0	65.1	76.0	37.1	6.5	72.5	71.2
T_4	43.0	7.0	45.9	53.0	26.2	4.5	50.6	50.2
T_5	64.9	10.7	67.0	78.8	38.1	6.7	74.9	73.0
T_6	75.3	12.8	75.1	85.5	42.4	7.5	83.0	81.8
T_7	84.6	15.4	83.6	95.5	47.4	8.4	93.2	91.3
T_8	50.1	9.9	49.5	56.4	27.9	5.0	54.5	54.8
T_9	88.8	18.2	84.2	97.6	48.0	8.6	98.8	92.5
T_{10}	76.7	13.5	71.8	84.8	40.8	7.3	83.8	79.3
T_{11}	82.0	14.3	76.6	90.0	42.6	7.9	89.8	85.2
T_{12}	53.7	9.9	49.9	58.7	28.4	5.1	58.8	55.7
T_{13}	76.8	15.0	70.5	85.7	40.3	7.3	84.0	76.6
CD (P= 0.05)	1.9	0.6	2.2	2.4	1.8	0.4	2.1	2.3

Uptake of nutrients

It is obvious from the data (table-2) that mean values of uptake of N,P,K and Zn by grain of rice varied from 26.8 to 88.8, 5.7 to 18.2, 30.4 to 84.2 kg ha^{-1} and 44.8 to 97.6 g ha^{-1}, respectively. The corresponding ranges of uptake of these nutrients in straw were from 22.0 to 48.0, 3.8 to 8.6, 35.4 to 98.8 kg ha^{-1} and 43.2 to 92.5 g ha^{-1}. Maximum uptake of N, P, K, and Zn by rice grain and straw were recorded with 50 kg $ZnSO_4$ ha^{-1} applied in both *kharif* and *rabi* season followed by its application alternate in *kharif* seasons. This trend again confirmed the results of Mandal *et al.* (2009), Singh and Tripathi (2005) and Tripathi and Rawat (2002). In general, N, P, K and Zn uptake by grain and straw of wheat under the influence of zinc sulphate application ranged from 16.1 to 81.3, 3.4 to 16.2, 20.7 to 73.5 kg ha^{-1} and 26.9 to 86.9 g ha^{-1}, respectively and 13.3 to 40.8, 2.3 to 7.3, 21.1 to 87.8 kg ha^{-1} and 25.9 to 82.7 g ha^{-1}. This increase in uptake of nutrients by the crop withZn application may be ascribed to greater grain and straw production. Similar results were reported by Chauhan *et al.* (2014) in wheat and Tripathi et al. (2014) in rice.

From the results, it is concluded that increasing levels of $ZnSO_4$ up to 50 kg ha^{-1} markedly enhanced the grain and straw yield as well as nutrients uptake in both rice and wheat crops. Application of 75 kg $ZnSO_4$ ha^{-1} in *kharif* and *rabi* season showed adverse effect on yield and uptake of nutrients by both the crops.

Table 3: Effect of zinc management on uptake by of N, P, K, (Kg ha^{-1}) and Zn (g ha^{-1}) by grain and straw of wheat (mean data of 03 years)

Treatment	**Uptake by grain**				**Uptake by straw**			
	N	**P**	**K**	**Zn**	**N**	**P**	**K**	**Zn**
T_1	16.1	3.4	20.7	26.9	13.3	2.3	21.1	25.9
T_2	41.6	6.7	41.5	51.3	23.5	4.0	48.9	45.2
T_3	47.2	7.6	45.6	57.2	25.9	4.5	54.6	49.8
T_4	29.4	4.8	32.1	44.7	18.3	3.2	34.0	35.2
T_5	44.1	7.3	46.9	53.4	26.8	4.7	50.9	51.1
T_6	67.2	11.3	66.9	76.2	37.6	6.7	73.9	72.7
T_7	75.1	14.4	71.7	84.8	40.7	7.3	83.9	78.1
T_8	44.5	8.9	42.0	50.3	23.9	4.3	50.5	45.8
T_9	81.3	16.2	73.5	86.9	40.8	7.3	87.8	82.7
T_{10}	58.8	10.0	56.0	65.4	31.8	5.8	62.2	61.8
T_{11}	63.7	11.9	59.4	70.5	33.8	6.2	69.8	66.0
T_{12}	41.9	7.9	39.0	46.1	22.2	4.0	45.7	43.4
T_{13}	60.0	11.7	53.9	66.1	30.8	5.6	65.5	60.1
CD (P=0.05)	1.8	0.4	1.9	2.0	1.7	0.4	1.9	2.2

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON RICE PRODUCTIVITY, PROFITABILITY AND SOIL FERTILITY

L.K. BAISHYA[*1], S.S. RATHORE[2]. DHARMENDRA SINGH[3]. DIBYENDU SARKAR[4] AND B.C. DEKA[5]

ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema- 797106
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ABSTRACT

A field experiment was conducted at Nagaland Centre, Medziphema during Kharif season of 2010 and 2011 to study the effect of integrated nutrient management on rice productivity, profitability and soil fertility in eastern Himalayan region on a sandy loam soil. The experiment was laid out in ramdomized block design with 16 treatments with 3 replications. Among the organic sources, poultry manure (2.5 t ha^{-1}) was found to be most profitable in terms of productivity, profitability and sustaining soil fertility. The crop receiving 2.5 t poultry manure ha^{-1} along with 75 kg N +16.5 kg P + 31.3 kg K ha^{-1} improved yield attributes and yield (6.03 t ha^{-1}) as well as nutrient uptake and crop profitability (₹. 366.28 /ha/day) over other treatments. The same treatment recorded significant improvement in soil organic carbon, nitrogen, phosphorus and potassium status of soil after harvest of the crop. The highest benefit : cost ratio (2.76) and returns (₹. 47616 ha^{-1}) were recorded with 5 t Sesbenia green manure ha $^{-1}$ + 75 kg N +16.5 kg P + 31.3 kg K ha^{-1} and 2.5 t poultry manure ha^{-1} + 125% CDF, respectively over other treatments. The lowest net returns (₹. 11508 ha^{-1}) and B: C ratios (1.66) were recorded under 5t Sesbenia green manure ha^{-1}.

Key words: Economics, organic manures, inorganic fertilizers, nutrient uptake, rice, yield

INTRODUCTION

Among the cereals, rice (*Oryza sativa* L.) is the major source of calories for 40 % of the world population. In India, rice is cultivated on 44 million ha and contributing 104.32 million tonnes grain production with productivity of 2.37 t ha^{-1}.Cultivation of high yielding dwarf varieties responsive to fertilizer and excess use of inorganic fertilizers has depleted the inherent soil fertility. The decline or stagnation in yield has been attributed to nutrient mining and reduced use of organics (John *et al*. 2001). Several long-term experiments conducted all over India indicated a decrease in rice productivity due to continuous use of chemical fertilizers. Integrated nutrient management (INM) aims to improve soil health and sustain high level of productivity and production (Prasad et al, 1995). Singh and Kumar (2014) reported increased yield and nutrient use efficiency in rice with organics. Organic supply of nutrients at the peak period of absorption also provide micro nutrients and modify soil-physical behavior as well as increase the efficiency of applied nutrients (Pandey et al., 2007). The combined use of organic and inorganic fertilizers has been reported not only to meet the nutrients need of the crop but also has been fund to sustain large scale productivity goals (Yadav and Meena 2014) Crop fertilization refers to fertilizer application according to the crop demands, while soil fertilization is targeted to replenish its fertility level. So, the present investigation "integrated nutrient management on rice productivity, profitability and soil fertility" was undertaken to meet the urgent need of the farmers of eastern Himalayan Region.

MATERIALS AND METHODS

The field experiment was conducted at the Research farm of ICAR Research complex for North Eastern Hill Region (NEHR), Nagaland Centre, Medziphema during *kharif* season of 2010 and 2011 using paddy as test crop. The experimental site was located between 25.45^0 N latitude 93.53^{0}E longitudes with a mean altitude of 295 m above mean sea level. Temperature and relative humidity during the experiment ranged from 15.6^{0}C to 32.6^{0}C and 81% to 85%, respectively. The experiment was conducted in randomized block design in three replications with 16 treatments. The treatments consisted of different sources of organic manures and inorganic fertilizer viz., T_1 , 5 t *Sesbenia* green manure ha^{-1}, T_2 , 5t *Sesbenia* green manure ha^{-1}+ 75% CDF(chemical fertilizers dose), T_3, 5t *Sesbenia* green manure ha^{-1} + 100% CDF, T_4, 5t *Sesbenia* green manure ha^{-1} + 125% CDF FYM (5t ha^{-1}), T_5, 5t FYM ha^{-1} , T_6, 5t FYM ha^{-1} + 75% CDF, T_7, 5t FYM ha^{-1} + 100% CDF, T_8, 5t FYM ha^{-1} + 125% CDF, T_9 , 1t Vermicompost ha^{-1}, T_{10}, 1t Vermicompost ha^{-1} + 75% CDF, T_{11} ,1t Vermicompost ha^{-1} + 100% CDF, T_{12} , 1t Vermicompost ha^{-1} + 125% CDF, T_{13} ,2.5 t Poultry manure ha^{-1}, T_{14} ,2.5 t Poultry manure ha^{-1} + 75% CDF, T_{15} , 2.5 t Poultry manure ha^{-1}+ 100% CDF, T_{16}, 2.5 t Poultry manure ha^{-1}+ 125% CDF. The chemical dose of fertilizers used by the farmers in paddy was

Corresponding author e-mail: Corresponding author email: lkbaishya@rediffmail.com [1]Senior Scientist (Agronomy), ICAR RC for . Region,
Manipur Centre.[2]Senior Scientist (Agronomy), DRMR, Bharatpur.[3]SMS (Agronomy), Krishi Vigyan Kendra, Morena
.[4]Scientist (Soil Science), ICAR RC for NEH Region, Manipur Centre.[5]Joint Director ICAR RC for NEH Region, Nagaland Centre

60 kg N + 13.1 Kg P + 25.0 kg ha^{-1}. The percent N, P and K content of *Sesbenia* green manure, FYM, Vermicompost and poultry manure were 0.7-0.5-0.6, 0.50 - 0.29- 0.61, 1.20-0.65-0.80 and 1.52- 0.82-0.87%, respectively. Organic manures were applied before 15 days of transplanting. The soil fertility dynamics under various treatments were estimated by soil analysis of composite soil sample from each plot before transplanting and after harvesting of crop. The soil of the experimental site was sandy loam, acidic in reaction with pH 5.4, medium in organic carbon 6.7g kg^{-1}, deficient in nitrogen (156 kg ha^{-1}) moderate in phosphorus (22 kg ha^{-1}) and low in potassium (60 kg ha^{-1}). The experimental site comes under sub humid region where monsoon normally starts by the middle of April and extends up to September. The annual rainfall during crop growing season from 25 June to 10 November was 1047.5 mm in 2010 and 1235.1 mm during 2011 which was less than annual average rainfall 1570 mm. The crop variety IET-16313 was transplanted when sufficient rain was received (last week of June). The crop was harvested at maturity, dried in the sun and weighed for yield. Observations on yield and yield attributes viz. plant height, effective tillers, length of panicle were recorded. Economics was worked out by taking into account the cost of inputs and income obtained from produce (grain and straw yield). Minimum support price (Fixed by Government of India) of rice in 2012 was ₹.10800 t^{-1}. The N P and K uptake by the crop and available N P and K content of soil after two years of the experimentation was estimated with standard procedures (Jackson, 1973). Crop profitability (₹/ha/day)=Net returns (₹ ha^{-1}) ÷ number of days field occupied.

RESULTS AND DISCUSSION

Growth and yield

Various sources of organic manure and inorganic fertilizers influenced positively the growth and yield of paddy (Table 1). The crop receiving higher amount of nutrients through organic or inorganic sources recorded higher growth and yield. Among the nutrient management practices, the crop receiving 2.5 t poultry manure ha^{-1} + 125% CDF (75 + 16.5 + 31.3 kg N P and K ha^{-1}) recorded the taller plants (112.27cm), higher effective tillers (14.60), panicle length (24.93cm), grain yield (6.03t ha^{-1}) and straw yield (9.41t ha^{-1}) closely followed by the 2.5 t poultry manure ha^{-1} + 100% CDF (60 +13.1 + 25 kg N, P and K ha^{-1} and 5t FYM ha^{-1} along with 125% CDF (75 + 16.5+ 31.3 kg N P and K ha^{-1}. The lowest growth and yield of paddy was found with application of organic manures alone as compared to integrated nutrient management practices. However, among the organic sources, addition of vermicompost (1t ha^{-1}) produced higher crop growth and grain yield closely followed by 2.5 t poultry manures ha^{-1} and 5t FYM ha^{-1}. This might be due to better and timely nutrient availability to the crop from the vermicompost as compared to other sources of organic manure. This is in conformity with the findings of Singh and Kumar (2014). The higher yield with increasing levels of fertilizers might be due to higher amount of nutrients added to soil Yadav and Meena, (2014) reported similar results. The favorable effect of integrated nutrient management through both inorganic fertilizers and organic manures on higher crop growth and yield was also reported by Kumar *et al.* (2008) and Savina Ahmed *et al.* (2014).

Table 1: Effect of different sources of organic manures and inorganic fertilizers on growth and yield of rice

Treatments	Plant height (cm)	No of tillers	Length of panicle (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
5t *Sasbenia* green manure ha^{-1}	93.03	13.0	17.03	2.23	4.02
5t *Sasbenia* green manure ha^{-1}) + 75% CDF	107.40	13.6	22.00	4.07	7.12
Sasbenia green manure (5t/ha) + 100% CDF	110.33	13.9	23.20	4.43	7.45
5t *Sasbenia* green manure ha^{-1}) + 125% CDF	114.50	14.1	23.73	4.93	7.89
5 t FYM ha^{-1}	93.30	12.4	16.20	3.07	5.52
5 t FYM ha^{-1} + 75% CDF	103.50	13.5	17.37	4.63	7.88
5 t FYM ha^{-1} + 100% CDF	106.27	14.0	22.07	4.90	8.18
5 t FYM ha^{-1} + 125% CDF	110.37	14.3	23.23	5.37	8.59
1 t Vermi compost ha^{-1}	93.70	13.3	17.37	4.33	7.37
1 t Vermi compost ha^{-1}+ 75% CDF	104.63	14.0	22.93	4.83	7.73
1 t Vermi compost ha^{-1}+ 100% CDF	105.03	14.3	23.97	5.17	8.11
1 t Vermi compost ha^{-1}+ 125% CDF	110.30	14.5	24.75	5.53	8.69
2.5t Poultry manure ha^{-1}	92.47	12.7	17.27	3.87	6.57
2.5t Poultry manure ha^{-1}+ 75% CDF	107.47	13.7	23.67	5.33	8.53
2.5t Poultry manure ha^{-1}+ 100% CDF	110.40	14.5	24.63	5.60	8.85
2.5t Poultry manure ha^{-1}+ 125% CDF	112.27	14.6	24.93	6.03	9.41
SEm ±	2.15	0.5	0.48	0.09	0.15
CD (P=0.05)	6.24	1.3	1.40	0.25	0.43

Table 2: Effect of different sources of organic manure and inorganic fertilizer on nitrogen, phosphorous and potassium uptake (kg ha^{-1}) by rice grain and straw

Treatments	**Nitrogen**		**Phosphorous**		**Potassium**	
	Grain	**straw**	**Grain**	**straw**	**Grain**	**straw**
5t *Sasbenia* green manure ha^{-1}	17.8	20.1	6.4	4.0	8.9	54.2
5t *Sasbenia* green manure ha^{-1}) + 75% CDF	36.6	36.3	12.2	7.8	17.0	96.7
Sasbenia green manure (5t/ha) + 100% CDF	44.3	38.7	13.7	8.9	19.0	102.0
5t *Sasbenia* green manure ha^{-1}) + 125% CDF	54.2	41.8	15.7	10.2	21.7	108.9
5 t FYM ha^{-1}	24.5	27.6	8.8	5.5	12.2	74.5
5 t FYM ha^{-1} + 75% CDF	41.7	40.1	13.9	8.6	19.4	107.1
5 t FYM ha^{-1} + 100% CDF	49.0	42.5	15.1	9.8	21.0	112.1
5 t FYM ha^{-1} + 125% CDF	59.0	45.5	17.1	11.1	23.6	118.5
1 t Vermi compost ha^{-1}	34.6	36.8	12.5	7.3	17.3	99.4
1 t Vermi compost ha^{-1}+ 75% CDF	43.5	39.44	14.5	8.5	20.3	105.1
1 t Vermi compost ha^{-1}+ 100% CDF	51.6	42.1	16.0	9.7	22.2	111.1
1 t Vermi compost ha^{-1}+ 125% CDF	60.8	46.0	17.7	11.3	24.35	119.8
2.5t Poultry manure ha^{-1}	30.9	32.8	11.2	6.5	15.47	88.7
2.5t Poultry manure ha^{-1}+ 75% CDF	48.0	43.5	16.0	9.3	22.40	116.0
2.5t Poultry manure ha^{-1}+ 100% CDF	56.0	46.0	17.3	10.6	24.08	121.2
2.5t Poultry manure ha^{-1}+ 125% CDF	66.3	49.8	19.3	12.2	26.55	129.8
SEm ±	0.8	0.7	0.3	0.2	0.37	2.0
CD (P=0.05)	2.4	2.2	0.8	0.5	1.06	5.8

Nutrient uptake

The effect of organic manures and chemical fertilizers was significant on the uptake of N, P and K by the crop (Table 2). The highest uptake of these nutrients was recorded in the treatment combination 125% CDF and 2.5t poultry manure ha^{-1} closely followed by 125% CDF + 1t vermicompost ha^{-1} and 125% CDF + 5t FYM ha^{-1}. This might be ascribed to greater dry matter production as well as nutrient concentration with combined use of organic and inorganic fertilizers. Better performance under these treatments might also be due to favorable soil environment, which encouraged better root proliferation and ensured higher nutrient uptake. These results corroborate with the findings of Sabina Ahmed *et al.* (2014). The organic manures recorded comparatively lower uptake of N, P and K as compared to integration of organic manures with inorganic fertilizers. This might be due to slow mineralization of organic manures as they could not supply the nutrient to the crop timely as well as higher yield of the crop with the integration of organic and inorganic sources of nutrients.

Table 3: Effect of different sources of organic manure and inorganic fertilizers on economics of rice

Treatment	**Gross return (₹. ha^{-1})**	**Net return (₹. ha^{-1})**	**B: C ratio**	**Crop profitability (₹/ha/day)**
5t *Sasbenia* green manure ha^{-1}	28908	11508	1.66	88.52
5t *Sasbenia* green manure ha^{-1}) + 75% CDF	52500	31899	2.55	245.38
Sasbenia green manure (5t/ha) + 100% CDF	56784	35116	2.62	270.12
5t *Sasbenia* green manure ha^{-1}) + 125% CDF	62712	39977	2.76	307.52
5 t FYM ha^{-1}	39780	17380	1.78	133.69
5 t FYM ha^{-1} + 75% CDF	59460	34924	2.42	268.65
5 t FYM ha^{-1} + 100% CDF	62736	36068	2.35	277.45
5 t FYM ha^{-1} + 125% CDF	68304	39504	2.37	303.88
1 t Vermi compost ha^{-1}	55608	28208	2.03	216.98
1 t Vermi compost ha^{-1}+ 75% CDF	61440	31906	2.08	245.43
1 t Vermi compost ha^{-1}+ 100% CDF	65568	33900	2.07	260.77
1 t Vermi compost ha^{-1}+ 125% CDF	70152	36350	2.08	279.62
2.5t Poultry manure ha^{-1}	49680	27280	2.22	209.85
2.5t Poultry manure ha^{-1}+ 75% CDF	67800	43264	2.76	332.80
2.5t Poultry manure ha^{-1}+ 100% CDF	71100	44432	2.67	341.78
2.5t Poultry manure ha^{-1}+ 125% CDF	76416	47616	2.65	366.28

DHAINSA @₹.1/-; FYM @₹.2/- V.C @₹8/- PM @₹.2/-; 60-30-30 NPK IC UREA: 123 KG @ RS. ₹/= 1230; SSP =2437/- MOP =601/- TOTAL ₹=4268/-

Soil fertility

The organic carbon, available nitrogen, phosphorus and potassium status of soil after harvest of the crop increased due to application of 125 % CDF or through integrated application of inorganic fertilizers and organic manure. The plot receiving 2.5 t poultry manure ha^{-1} + 125% CDF registered highest available organic carbon, N, P and K status in the soil. The application of organic manures along with inorganic fertilizers (Table-4) increased soil organic carbon (7.8-9.4 g kg^{-1}) nitrogen (166.6-203.0 kg ha^{-1}), phosphorus (23.3-32.6 kg ha^{-1}) and potassium (61.0-92.3 kg ha^{-1}). Addition of inorganic fertilizers along with organic manures helps in mineralization which resulted in rapid conversion of organically bound forms of nutrients to organic forms, however, it was observed that crop receiving same source of organic manures along with different levels of inorganic fertilizers did not vary significantly in respect of organic carbon content of soil. Such favorable effect of integrated nutrient management on increasing the available N, P and K content in soil were noticed by Kumar *et al.* (2008).

Economics

The results showed that the gross return and net return (₹. 76416/- and ₹. 47616/-) were markedly higher with 125% CDF + 2.5 t poultry manure ha^{-1} closely followed by 100% CDF + 2.5 t poultry manure ha^{-1} and 75 % CDF + 2.5 t poultry manure ha^{-1} (Table 3). However, higher benefit cost ratio (2.76) was recorded with 125% CDF + 5 t *Sasbenia* green manure ha^{-1} and 75% CDF + 2.5 t poultry manure ha^{-1} The highest crop profitability (₹. 366.28/-/day/ha) was recorded with 125% CDF + 2.5 t of poultry manure ha^{-1}. This trend in economic return is mainly due to the treatment effect on the grain and stover yield of rice.

Table 4: Status of organic carbon, available N, P_2O_5 and K_2O in post harvest soil

Treatments	O. carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
5t *Sasbenia* green manure ha^{-1}	7.8	166.6	23.3	61.0
5t *Sasbenia* green manure ha^{-1}) + 75% CDF	7.9	181.6	28.1	74.0
Sasbenia green manure (5t/ha) + 100% CDF	8.1	193.3	28.4	78.6
5t *Sasbenia* green manure ha^{-1}) + 125% CDF	8.8	198.7	29.0	80.0
5 t FYM ha^{-1}	8.1	182.0	25.7	81.6
5 t FYM ha^{-1} + 75% CDF	8.6	188.6	26.8	73.8
5 t FYM ha^{-1} + 100% CDF	8.9	198.1	27.7	78.5
5 t FYM ha^{-1} + 125% CDF	9.0	202.3	28.1	80.5
1 t Vermi compost ha^{-1}	7.9	185.0	23.5	80.6
1 t Vermi compost ha^{-1}+ 75% CDF	8.2	192.3	24.7	82.6
1 t Vermi compost ha^{-1}+ 100% CDF	8.5	198.0	25.3	86.5
1 t Vermi compost ha^{-1}+ 125% CDF	8.2	202.5	26.6	90.0
2.5t Poultry manure ha^{-1}	7.7	183.5	25.6	79.6
2.5t Poultry manure ha^{-1}+ 75% CDF	8.9	192.6	28.8	88.3
2.5t Poultry manure ha^{-1}+ 100% CDF	9.2	197.3	31.00	90.3
2.5t Poultry manure ha^{-1}+ 125% CDF	9.4	203.0	32.0	92.3
SEm±	0.2	2.35	0.59	0.9
CD	0.6	6.82	1.71	2.7

From the study, it can be concluded that application of 75 kg N +16.5 kg P + 31.3 kg K ha^{-1} + 2.5 t poultry manure ha^{-1} was found to be most effective for sustainable rice production, profitability and soil fertility. However, incorporation of 5 t *Sesbenia* green manure ha^{-1} + 75 Kg N +16.5 Kg P + 31.3 kg K ha^{-1} may be opted for getting higher benefit: cost ratio.

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CHARACTERIZATION AND DISTRIBUTION OF SALT-AFFECTED SOILS OF SULTANPUR DISTRICT, UTTAR PRADESH

D.K. KATIYAR, C.S. WALIA, R. SINGH[1] AND T.P. VERMA[1]

National Bureau of Soil survey and Land Use Planning, Regional Centre, IARI Campus, New Delhi-110 012
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ABSTRACT

Using remote sensing technique, soil survey was carried out to characterize and delineate the salt-affected soils of Sultanpur district of eastern Uttar Pradesh occurring under various land forms for an appraisal of the causes of their development and management. Five soil series namely Pura Ausan Singh, Sayaid Nagar, Jagmalpur, Pura Subba Pandey and Dhanapur of salt-affected soils were identified. The salt affected soils occurring on old flood plain with fluctuating ground water and periodcal water logging are put under Pura Ausan Singh and characterized by formation of calcic horizon (Bk). The soils occurring on old flood plain with concave relief are put under Sayaid Nagar and Jagmalpur Series which are characterized by presence of mottling in their substratum due to oxidizing and reducing conditions. Salt affected soils occurring on old flood plain with high water table and on fluvial channels are put under Pura Subba Pandey and Dhanapur series, respectively. The soils were characterized by presence of reduced mottles in middle horizons just after 40 to 45 cm depth due to prevailing moist conditions in the soils. These soils were deep to very deep, moderately to imperfectly drained, dark greyish brown olive brown to yellowish brown in colour, sandy loam to clay loam in texture and have low to medium organic carbon. In general, soils under study were alkaline in nature having pH, EC and ESP higher in surface and decreased with depth. Further, the clay content was higher in substratum, which directly contributed to CEC. The soils under investigation wer e classified as Typic Calciustepts (P1), Natric Haplustepts (P2 and P3), Typic Halaquepts (P4) and Aeric Halaquepts (P5). Four categories of soil salinity/alkalinity were identified and delineated as moderately sodic, strongly sodic and strongly saline, strongly sodic and slightly saline and strongly sodic and moderately saline covering an area of 3.5, 2.1, 8.1 and 4.9 % of TGA of the district, respectively..

Key words: Salt-affected soil, characteristics, soil classification, soil distribution.

INTRODUCTION

Soil salinity/sodicity is one of the major problems of land degradation in irrigated area of the world. The primary process involved transportation and deposition of alkaline salts from the HIMALAYA and Shivalik to the Indo-Gangetic plain (Bhargava *et al.* 1980). In India salt-affected soils occur to the extent of 6.7 m ha in arid and semi-arid regions, out of this area nearly 40 % (2.8 m. ha) occurs in the Indo-Gangetic alluvial plain of Uttar Pradesh, Haryana, Punjab, Delhi and part of Rajasthan and Bihar (NRSA 1996). In the Uttar Pradesh state alone about 1.25 m ha area is salt-affected. These soils occur in association with the normal soils and either barren or under restricted cultivation. These soils if reclaimed will contribute a major share to total production of the state. The Sultanpur district was chosen for present study as the district is badly infested with salt-affected soils due to large scale in production of irrigation under Sharda Sahayak Command Area Project.

MATERIALS AND METHODS

Sultanpur district lies between 81°32’ to 82°41’ E and 25°59’ to 26°40’ N in eastern Uttar Pradesh and covers about 4.4 lakh hectare area with mean annual temperature of 25°C and mean annual rainfall of 1025 mm representing old and recent flood plain of Gomati river with elevation ranging from 95 to 111 m above MSL. As per the climatic classification suggested by Mandal *et al.* (1999) the district is semi-arid and soil moisture and temperature regimes are ustic and hyperthermic, respectively. A three-tier approach (Sehgal *et al.*, 1987) consisting of image interpretation, ground truth collection and laboratory characterization and cartographic output was made for the survey of the area using base maps consisting of physiographic delineation on 1:50,000 scale. To demarcate areas of similar soils, several auger holes and field checks were undertaken in each physiographic unit and representative pedon sites were selected for detailed investigation. The representative pedons of each soil series were sampled horizon wise for laboratory characterization using standard analytical techniques (Jackson, 1973 and Sarma *et al.*, 1987). Soils were classified taxonomically (Soil Survey Staff, 2010). Five representative pedons were selected for present study. Based on the values of EC_W and PH_w, soils were categorized and delineated.

Corresponding author email: rssnbss@gmail.com
[1]Present address, NBSS & LUP (ICAR), Regional Centre, Udaipur-313001, Rajasthan

RESULT AND DISCUSSION

Morphological characteristics

Morphological characteristics of various pedons under study are presented in Table 1. Pedon 1 (Pura Ausan Singh Series) is occurring on old flood plain with fluctuating ground water and periodical water logging which are moderately well drained, greyish, brown to olive brown in colour. The texture is sandy loam (surface) and is dominantly clay loam in the subsoil. Soil structure is granular in surface and sub-angular blocky in rest of the soil profiles. Fe-Mn nodules are present in lower horizons. Lime concretions of different sizes in the form of thick compact layer (calcic layer) observed in the subsoil creating several physical impediments for capillary movement of moisture and downward growth of the roots (Sharma *et al.*, 1996, Pal *et al.*, 1999, West *et al.*, 1988). Taxonomically these soils are classified as fine loamy, mixed (cal), hyperthermic, typic calciuslepts. Pedon 2 (Saiyad, Nagar Series) and Pedon 3 (Jagmalpur Series) occurring on old flood plain with concave relief were imperfectly drained, yellowish brown to olive brown in colour. The surface texture is sandy loam (P2) to loamy sand (P3) and subsoil is sandy loam (P3) to loam (P2). The structure is sub-angular blocky. The soils are calcareous and alkaline in nature. The Fe-Mn nodules and mottling in their substratum associated with alternate oxidizing and reducing conditions (Gotoh and Patrick, 1972) subject to repeated dry and wet cycles particularly during summer and rainy seasons. The soils are classified as fine loamy, mixed (cals, hyperthermic, Natric Haplustepts (P2) and coarse loamy, mixed (cal), hyperthermic Natric Haplustepts (P3). Pedon 4 (Pura Subba Pandey Series) occurring on old flood plain with high water table which are imperfectly drained, dark greyish brown to light olive brown in colour. The texture was clay loam

Table 1: Morphological characteristics of soils*

Horizon	Depth (cm)	Colour	Texture	Structure	Consistency			Lime concretion		Root		Effervescence with dil. HCl	Mottles	Other features
					D	M	W	S	Q	S	Q			
Pedon 1 (Pura Ausan Singh Series) Fine loamy, mixed (calcareous), hyperthermic, Typic Calciustepts														
Ap	0-20	2.5Y5/2	sl	granular	Sh	fr	ss ps	-	-	f	m	nil	-	-
Bw1	20-33	2.5Y4/4	cl	m 2 sbk	-	Fr	sp	-	-	f	m	e	-	-
Bw2	33-47	2.5Y4/4	cl	m 2 sbk	-	fr	sp	f	f	f	c	e	-	-
Bw3	47-62	2.5Y4/4	cl	m 2 sbk	-	fr	Fr sp	f	f	f	f	e	-	-
Bk	62-98	2.5Y4/4	gl	m 2 sbk	-	fr	fr sp	f	f	-	-	ev	-	> 35% lime kankars
Bm	98+	An impervious lime coated concretion layer.												
Pedon 2 (Saiyad Nagar Series) Fine loamy, mixed (calcareous), hyperthermic, Natric Haplustepts														
Ap	0-16	10YR6/6	sl	m 1 sbk	sh	vfr	so po	-	-	f	c	e	-	-
AB	16-40	10YR6/6	l	f 1 sbk	-	fr	ss ps	f	f	f	f	e	-	-
Bw1	40-64	10YR5/6	l	m 2 sbk	-	fr	sp	f	f	f	f	e	-	-
Bw2	64-89	10YR5/6	l	m 2 sbk	-	fr	sp	f	f	f	f	e	f f d	-
Bw3	89-120+	10YR5/6	l	m 2 sbk	-	fr	sp	f	f	vf	f	e	f f d	-
Pedon 3 (Jagmalpur Series) Coarse loamy, mixed (calcareous), hyperthermic, Natric Haplustepts														
Ap	0-15	2.5Y6/2	ls	-	sh	vfr	sopo	-	-	f	m	e	-	-
Bw1	15-36	2.5Y6/4	sl	f 1 sbk	-	fr	sopo	-	-	f	m	es	-	-
Bw2	36-58	2.5Y4/4	sl	m 2 sbk	-	fr	ssps	f	f	vf	m	es	-	-
Bw3	58-85	2.5Y4/4	sl	m 2 sbk	-	fr	sp	c	m	vf	c	e	-	-
Bw4	85-110	2.5Y4/4	sl	m 2 sbk	-	fr	sp	c	m	vf	f	e	f f d	-
Bw5	110-145	2.5Y4/4	sl	m 2 sbk	-	fr	sp	-	-	-	-	ev	f f d	> 15% lime kankars
Pedon 4 (Pura Subba Pandey Series) Fine loamy, mixed (calcareous), hyperthermic, Typic Halaquepts														
Ap	0-13	2.5Y5/2	cl	m 2 sbk	-	fr	sp	-	-	f	m	es	-	-
Bw1	13-38	2.5Y4/2	cl	m 2 sbk	-	fi	sp	-	-	f	m	es	-	-
Bw2	38-65	2.5Y4/2	cl	m 3 abk	-	fi	sp	f	f	f	c	es	f f d	-
Bw3	65-86	2.5Y5/4	cl	m 3 abk	-	fi	sp	f	c	f	c	es	c f d	-
Bw4	86-115	2.5Y5/4	cl	m 3 abk	-	fi	sp	f	c	f	c	es	c m d	-
Bw5	115-150	2.5Y5/4	cl	m 2 sbk	-	fi	sp	f	c	f	f	es	c m d	-
Pedon 5 (Dhanapur Series) Fine loamy, mixed (calcareous), hyperthermic, Aeric Halaquepts														
Ap	0-17	10YR5/2	SL	f 1 sbk	sh	fr	sspo	-	-	f	m	ev	-	-
AB	17-38	2.5Y4/2	l	m 2 sbk	sh	fr	sps	-	-	f	f	ev	-	-
Bw1	38-60	2.5Y6/3	l	m 2 sbk	-	fr	sp	fm	F	vf	f	ev	f f f	-
Bw2	60-84	2.5Y6/3	l	m 2 sbk	-	fr	ssps	fm	c	vf	f	ev	f f f	-
Bw3	84-103	2.5Y6/4	sl	m 2 sbk	-	fr	sssp	c	c	vf	f	ev	c f d	-
Bw4	103-148	2.5Y4/4	l	m 2 sbk	-	fr	sp	c	c	vf	f	ev	c m d	-

** Symbols used according to Soil Survey Manual notations (Soil Survey Division Staff 2004)* and sub-angular to angular blocky in structure. Pedon 5 (Dhanapur series) occurs on fluvial channels which were imperfectly drained, dark greyish brown to light yellowish brown in colour. The texture was sandy loam in surface and dominantly loam in sub surface horizons having sub-angular blocky structure. Both the soils (Pedon 4 and Pedon 5) were highly calcareous and alkaline is nature and presence of Fe-Mn nodules and reduced mottles, just after 38 cm depth are evidents to prevailing moist conditions in the soil (Mehta *et al.*, 1969 and Garg *et al.* 2000). The soils were classified as fine loamy, mixed (cal), hyperthermic, typic Halaquepts (P_4) and fine loamy, mixed (cal) hyperthermic, aeric Halaquepts (Pedon 5).

Table 2: Physico-chemical characteristics of soils

Horizon	Particle size			pH	EC (dSm^{-1})	O.C. ($g\ kg^{-1}$)	$CaCO_3$ ($g\ kg^{-1}$)	Exchangeable Cations [cmol (p+) kg^{-1}]				CEC cmol (p+) kg^{-1}	ESP
	Sand	Silt	Clay					Ca	Mg	Na	K		
Pedon 1 (Pura Ausan Singh Series) Fine loamy, mixed (calcareous), hyperthermic, Typic Calciustepts													
Ap	53.4	28.3	18.2	8.4	4.65	4.8	1.0	3.54	1.12	1.30	0.64	6.60	16.0
Bw1	36.6	28.9	34.5	9.0	2.35	4.0	4.0	6.87	4.06	2.93	1.75	15.61	22.0
Bw2	32.9	31.3	35.8	9.2	2.10	2.4	9.0	7.27	3.84	2.82	1.48	14.41	21.0
Bw3	38.6	28.4	33.0	9.5	1.10	1.8	15.0	6.96	4.55	3.15	2.11	16.77	24.0
Bk	44.8	29.9	25.3	9.7	1.10	1.0	353.3	6.20	4.03	4.41	1.21	15.85	23.0
Pedon 2 (Saiyad Nagar Series) Fine loamy, mixed (calcareous), hyperthermic, Natric Haplustepts													
Ap	60.7	25.0	14.3	10.3	3.20	2.0	8.5	3.46	0.81	3.47	0.89	8.91	39.0
AB	46.6	31.1	22.3	10.1	1.80	1.4	9.0	4.42	1.87	4.78	2.04	13.89	34.0
Bw1	43.3	30.9	25.8	9.6	1.10	1.2	9.0	4.24	2.00	4.02	1.72	12.56	32.0
Bw2	47.6	33.1	19.3	8.3	0.30	1.0	9.0	4.00	1.37	1.95	1.02	9.37	21.0
Bw3	46.9	33.3	19.8	8.2	0.17	1.0	12.5	3.39	1.49	1.84	0.83	8.69	21.0
Pedon 3 (Jagmalpur Series) Coarse loamy, mixed (calcareous), hyperthermic, Natric Haplustepts													
Ap	80.1	11.2	8.8	10.1	1.50	4.3	13.5	2.58	2.10	2.19	0.38	7.80	28.0
Bw1	59.9	28.2	12.0	10.3	1.70	1.6	22.5	4.28	2.54	2.60	0.38	10.90	24.0
Bw2	50.8	30.7	18.5	10.3	1.50	0.2	45.0	5.41	3.84	2.80	0.44	13.65	21.0
Bw3	50.5	36.5	13.0	9.8	1.20	0.2	4.5	3.49	3.54	2.71	0.59	11.43	24.0
Bw4	59.6	29.4	11.0	9.0	0.24	0.2	9.0	4.01	4.04	3.06	0.32	11.48	21.0
Bw5	54.9	26.6	18.5	8.9	0.25	0.2	126.0	2.28	2.19	1.73	0.38	8.58	22.0
Pedon 4 (Pura Subba Pandey Series) Fine loamy, mixed (calcareous), hyperthermic, Typic Halaquepts													
Ap	38.8	31.5	29.8	9.6	0.67	4.1	63.0	2.67	1.34	4.35	0.96	10.30	42.0
Bw1	24.9	41.3	33.8	9.4	0.54	2.2	40.5	1.62	1.17	4.56	1.28	9.55	48.0
Bw2	23.8	46.7	29.5	9.3	0.68	1.6	18.0	2.14	1.60	4.87	1.09	10.90	45.0
Bw3	22.9	39.5	37.5	9.5	0.65	1.4	22.5	5.24	1.97	5.91	0.76	15.00	39.0
Bw4	26.5	46.2	27.3	9.3	0.92	1.0	36.0	5.31	1.90	4.26	1.21	13.56	31.0
Bw5	22.1	48.4	29.5	9.1	0.65	0.8	171.0	4.67	2.82	3.36	0.76	12.26	27.0
Pedon 5 (Dhanapur Series) Fine loamy, mixed (calcareous), hyperthermic, Aeric Halaquepts													
Ap	66.8	20.7	12.5	10.2	1.05	6.8	85.5	1.86	1.09	1.25	1.15	5.50	23.0
AB	47.9	27.5	24.5	9.9	0.37	6.3	93.5	1.59	1.98	1.89	0.64	6.50	29.0
Bw1	42.5	31.5	26.0	9.3	0.19	4.0	82.5	3.56	1.92	1.87	0.64	8.90	21.0
Bw2	41.6	40.8	17.5	9.1	0.14	2.5	94.0	3.36	1.86	3.19	0.64	9.95	32.0
Bw3	69.2	12.3	15.5	9.0	0.14	1.5	74.0	3.23	1.50	1.65	0.70	6.80	24.0
Bw4	38.1	36.9	25.0	9.0	0.19	1.1	94.0	2.85	1.57	1.54	0.68	7.32	21.0

Physico-chemical characteristics

The physico-chemical characteristics of various pedons under study are presented in table 2. The clay content of these pedons ranged from 11.0 to 37.5 per cent. The % clay content was maximum in Pedon 4 and minimum in pedon 3. It is further inferred from the data that clay fraction, in general, is more concentrated in the subsurface layers of the various pedons. Clay accumulation in subsurface horizons may be due to mass movement of fine clay (Pal *et al.*, 1999) through the process of illuviation. These soils were strongly alkaline in nature as their pH of upper horizons (50 cm) is ranged from 9.5 to 10.4. The pH sharply decreased with depth except in Pedon 1. Electrical conductivity (EC) ranged from 0.67 to 4.65 dSm^{-1} in surface horizons of all the pedons and showed a decreasing trend with depth. This trend is probably caused by leaching of soluble salts (Garg *et al.*, 2000) resulting in amelioration of the soil. The organic carbon content ranged from 2.0 to 6.8 g kg^{-1} in the surface soils showing minimum value in Pedon 2 and maximum in Pedon 5.

Decreasing trend of organic carbon with depth in all the pedons was observed as found in central alluvial region of UP (Tiwari *et al.*, 1985). The $CaCO_3$ content of salt-affected soils varied from 0.10 to 35.5 %. In general, the $CaCO_3$ content in all the pedons increased with depth, which explain downward movement of $CaCO_3$ (Joshi and Kadrekar 1987, Pal *et al.*, 1999). Further, a higher amount of $CaCO_3$, in sub soils also deteriorates drainage conditions (Nayak *et al.*, 2000). The Cation Exchange Capacity (CEC) varied from 5.50 to 16.77 cmol (P^+) kg^{-1}. The CEC value in general, increased with increasing clay content, since the soils are low in organic carbon content. Among the exchangeable cations Ca^{2+} and Mg^{2+} were dominant cations followed by Na^+ and K^+. However, the exchangeable Na^+ was higher than Ca^{2+} and Mg^{2+} in Pedon 4 which is characterized by high values of ESP. However, ESP values were greater than 15 in all the pedons at varying depths.

Distribution of salt-affected soils

The information on the degree and extent of salt-affected soils is basic for amelioration of such degraded soils. The following criteria are used for differentiating the degree of salinity and sodicity of salt-affected soils (Sidhu *et al.*, 1995).

Class	Sodicity (pH 1:2.5)	Salinity (EC dSm^{-1}, 1:2.5)
Normal	< 8.7	< 0.8
Slight	8.7 – 9.2	0.8 – 1.6
Moderate	9.3 – 9.5	1.7 – 2.5
Strong	> 9.5	> 2.5

Four kinds of salt-affected soils were identified and delineated (Table 3 and Fig. 1).

Table 3: Distribution of salt-affected soils

Soil salinity/ Sodicity class	Area (ha)	% of TGA*
Normal soils	339621	77.20
Moderately sodic	15184	3.50
Strongly sodic and strongly saline	9146	2.10
Strongly sodic and slightly saline	35615	8.10
Strongly sodic and moderately saline	21620	4.90

**TGA – Total Geographical Area of the district*

The data indicated that nearly 3.4 lakh hectare area (77.2 % of TGA) comes under the category of normal soils and 0.82 lakh hectare area (18.6 %) suffering from salinity/sodicity of TGA problems. About 3.5 % of TGA have a problem of moderate sodicity and about 15 % of TGA is suffered from strong sodicity and accompanied by varying degree of salinity and requiring gypsum or other amendments for their amelioration. However, provision of drainage is essential for the reclamation of these soils.

The study revealed that micro-relief, impeded drainage, repeated cycles of wetting and drying, high water table leads to accumulation of salts at the surface. Sodiumization begins of the surface and relatively low or absent in lower horizons in soils of relatively young geomorphic units but it increases with depth in soils of older surfaces in which sodiumization/salinization starts at the surface and deepens with the time indicating the movement of alkali salts solution or illuviation of deflocculated clay with advanced development.

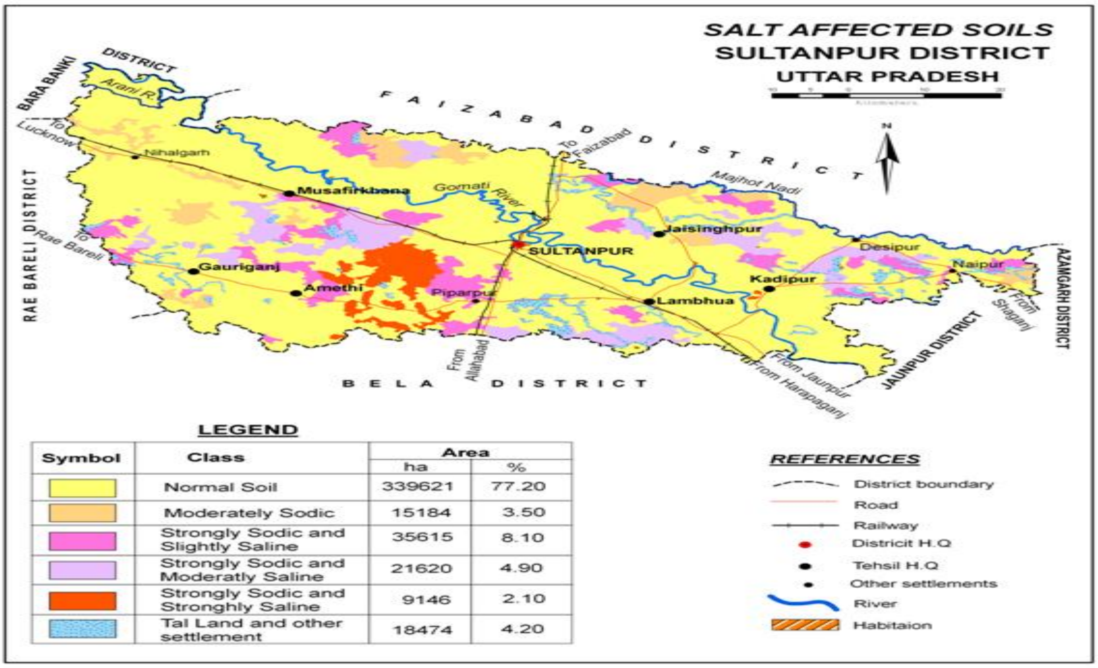

Fig 1: Distribution of salt affected soils

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EFFECT OF IRRIGATION AND NITROGEN ON GROWTH AND YIELD OF FIELD PEA VARIETIES

LAKHPAT SINGH[1], S.B. SINGH, DINDAYAL GUPTA[1] AND MURARI LAL

Department of Agronomy, Raja Balwant Singh (Dr. B.R.A.University, Agra) College, Bichpuri, Agra, (U.P.)-283105
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ABSTRACT

A field experiment was conducted during rabi season of 2008-09 at R.B.S. College Agriculture farm Bichpuri (Agra) to evaluate the effect of irrigation and nitrogen on growth yield of pea varieties. The experiment comprised of two irrigation, three nitrogen levels and two pea varieties was laid out in spilt-split plot design with four replicaions.The results revealed that the maximum value of growth characters, yield attributes and yields were recorded with the application of one irrigation than no irrigation. The biological, grain and straw yields increased by 25.9, 22.5 and 27.8 % with one irrigation over no irrigation, respectively. The growth parameters, yield attributes and yields increased significantly with the application of 15 kg N ha^{-1} over control. Although maximum values of these parameters were obtained with 30 kg N ha^{-1} but it was statistically at par with 15 kg N ha^{-1}. Application of 15 kg N ha^{-1} caused 13.9, 10.2 and 21.3% increase in biological, straw and grain yields, respectively over control. Significantly higher values of growth parameters, yield attributes and yields were obtained with variety Aparna than Pant P-13. Variety Aparna produced significantly more biological, grain and harvest index by 13.0, 9.9 and 1.30 % than that of Pant P-13,

Key Words: Growth, yields, irrigation, nitrogen, varieties, pea

INTRODUCTION

Pea (*Pisum sativum* L.) is the popular pulse crop throughout the world. Grain legumes fix atmospheric nitrogen (N) to the system and produce grain rich in protein while improving soil N for the succeeding crop. Irrigation plays an important role in raising yield potential of crop. Shortage of water is the most terrible constraint for agricultural development. Under this condition, demand to use the available water economically and expeditiously is unquestionable in India. In the field, soil water appears to be greater importance since it acts both directly on plant growth and function and indirectly by affecting other related factors such as aeration, soil impedance and soil temperature prevailing in the root zone (Sharma 2005). Acute shortage of irrigation water is adversely affecting crop production in general and pulse production in particular. Irrigation management is of special importance as the proper irrigation may bring 100-150 percent increase in the yield depending upon the soil type, winter rains and depth of the water table (Singh, 2001). Nitrogen plays a big role in all metabolic processes. It forms an important constituent of cell structure and is indispensable for the transfer of genetic information.. Cultivar plays a vital role in crop production. Any cultivar of pea before recommended for general cultivation for particular region must be judged for its potential, tolerance against disease, in general, and in particular responsiveness to added water and fertilizer and adaptability to different agro-climatic conditions. Thus, the value of stable and high yielding cultivar has been universally recognized as an important factor for boosting crop production. The new cultivars display improvements including disease resistance, plant architecture (standability), seed quality and yield, whilst there are also changes in flowering and maturity that could affect agronomic management. Since the irrigation and fertilizer management have a direct role in quantity and quality of yield, so the present study was carried out to find the effect of irrigation and nitrogen on growth and yield of pea - varieties in semi arid condition of Agra region.

MATERAILS AND METHODS

A field experiment was conducted during winter (*rabi*) season of 2008-09 at R.B.S. College, Agricultural Research Farm, Bichpuri, Agra (U.P.). The soil of the experimental field was sandy loam in texture, having pH 8.2, organic carbon 3.5 g ha^{-1}, available N (178 kg ha^{-1}), available P_2O_5 (24 kg ha^{-1}) and K_2O (112 kg ha^{-1}). The treatments comprised two irrigation (no irrigation and one irrigation), three levels of nitrogen (0, 15 and 30 kg ha^{-1}) and two varieties (Aparna and Pant P-13) were tested in split-split plot design, keeping irrigation in main plot, N levels in sub plot and varieties in sub-sub plot with four replications. Urea, singlesuper phosphate and muriate of potash were used as the source of N, P_2O_5 and K_2O, respectively. Half dose of N as per treatment and full dose of P_2O_5 and K_2O were applied at the time of sowing as basal. The remaining half dose of N was top dressed after 40 days after sowing.

Corresponding author e-mail: dgupta072@gmail.com, Shri Megh Singh College, Abidgarh, Agra

Pea cultivars were sown on 5 Nov, 2008 using seed rate of 100 kg ha^{-1} and row spacing 30 cm apart. All improved packages of practices were followed to raise the crop. The observations were recorded on growth and yield attributes and yields at harvest.

RESULTS AND DISCUSSION

Growth parameters

The data (Table 1) indicated that plant height, primary branches, dry matter accumulation $plant^{-1}$, length of root, weight of root, effective nodules $plant^{-1}$ and weight of nodules $plant^{-1}$ were significantly higher with one irrigation over no irrigation. The corresponding increases in growth characters with one irrigation were 18.0, 21.6, 11.0, 16.2, 81.9, 11.6 and 71.8% over no irrigation, respectively. One time irrigation can contribute considerably towards chlorophyll content and root development due to more absorption of water from from the soil. These findings indicate that application of irrigation to pea crop favours root development and promotes crop growth. Beneficial effect of irrigation on growth parameters have also been reported by Singh *et al.* (2007).

Table 1: Effect of irrigation, nitrogen and varieties on growth characters of pea

Treatments	Plant height (cm)	Primary branches	Dry matter accumulation (g)	Length of root (cm)	Weight of root (g)	Nodules $plant^{-1}$	Weight of nodules $plant^{-1}$ (g)
Irrigation							
No irrigation	22.48	3.42	26.45	11.62	0.144	22.15	0.028
One irrigation	26.52	4.16	29.37	13.50	0.262	24.73	0.048
SEm±	0.65	0.11	0.58	0.36	0.025	0.52	0.004
C.D. (P=0.05)	2.93	0.50	2.61	1.62	0.113	2.34	0.018
N (kg ha^{-1})							
0	20.75	3.40	26.54	11.73	0.141	22.25	0.031
15	26.30	3.96	28.54	12.95	0.233	24.02	0.041
30	26.42	4.01	28.68	13.00	0.235	24.05	0.042
SEm±	0.62	0.10	0.56	0.35	0.021	0.48	0.003
C.D. (P=0.05)	1.91	0.31	1.72	1.08	0.065	1.48	0.009
Varieties							
Aparna	25.06	3.93	28.96	12.75	0.212	24.32	0.042
Pant P-13	23.94	3.65	26.88	12.37	0.194	22.56	0.034
SEm±	0.60	0.93	0.52	0.35	0.024	0.46	0.002
C.D. (P=0.05)	NS	0.27	1.54	NS	NS	1.37	0.006

The data (Table 1) clearly indicated that increasing levels of N increased all growth characters up to highest levels of N (30 kg N ha^{-1}) over control, but this was found statistically at par with 15 kg N ha^{-1} in respect of growth characters. This might be due to vital role of nitrogen in the plant. It is a constituent of protoplasm, chlorophyll “a”, “b” and nucleic acids. One of the main functions of nitrogen is the initiation of meristematic activity of plant. The cell division and enlargement are also accelerated by ample supply of nitrogen. Thus, the growth of plant by and large depends on nitrogen. The present findings are in consonance with those of Pandey *et al.* (2005).

Variety Aparna produced significantly higher number of primary branches, dry matter accumulation $plant^{-1}$, nodules $plant^{-1}$ and weight of nodules $plant^{-1}$ than that of Pant P-13. The differential behavior of the cultivars in respect of growth parameters could explain solely by their genetic constitution and adaptability of soil and climatic conditions. However, variety Aparna had higher plant height, length of root and weight of root and these were found 4.7, 3.1 and 9.2% respectively more than Pant P-13.These results are in conformity with the findings of Jan *et al.* (2007). The effects of varieties on plant height, length of root and weight of root were not found significant.

Yield attributes

The data (Table 2) showed that the application of irrigation significantly increased the yield attributing characters of pea over no irrigation. The yield attributing traits viz. pods $plant^{-1}$, weight of pods $plant^{-1}$, length of pod, grains $plant^{-1}$, weigh of grains $plant^{-1}$ and grains pod^{-1} increased with one irrigation by 17.3, 18.7, 21.7, 25.5, 19.7 and 7.0% respectively over no irrigation. Irrigation did not affect the weight of grains pod^{-1} and test weight significantly. However, relatively higher weights of grains pod-1 and test weight were obtained with one irrigation. This might be due to the adequate availability of soil moisture for prolouged period.Similar effect was also seen by De *et al.* (2009).

Data revealed that N application had significant influence on yield attributes of pea over control. Application of 30 kg N ha^{-1} recorded higher pods $plant^{-1}$, weight of pods $plant^{-1}$, grains $plant^{-1}$, and grains pod^{-1} over 15 kg N ha^{-1} and control. But both the levels of N were at par in these respects. Data further revealed that maximum length of pod was obtained with 15 kg N ha^{-1} and this was found significantly superior over 30 kg N ha^{-1} and control. Application of 15 kg N ha^{-1} also recorded higher weight of grains $plant^{-1}$ and weight of grains pods $^{-1}$, which was found at par with 30 kg N ha^{-1}. Adequate supply of N helps in the increased production of larger dark green leaves due to proper meristematic activities in the cell. This turn helped the maximum utilization of sunlight and other growth factors which ultimately resulted in production of more photosynthates and translocation from leaves to reproductive parts. Yadav et al.(2012) reported similar results.Harvest Index (HI) denotes the proportion of economically produced part to the above ground biomass and varied significantly with nitrogen level.Application of 15 kg N ha^{-1} increased the harvest index by 3.0 and 3.4% over 30 kg N ha^{-1} and control, respectively. Similar results have been also reported by Yadav *et al.* (2012). The yield attributing characters of pea were significantly affected with pea varieties. Variety Aparna gave significantly higher pods $plant^{-1}$, weight of pods $plant^{-1}$, length of pod, grains $plant^{-1}$, weight of grains $plant^{-1}$, weight of grains pod^{-1} and number of grains pod^{-1} by 9.7, 10.1, 10.0, 18.6, 9.2, 8.6 and 3.1 % than that of Pant P-13, respectively. This result agrees with those of Shukla *et al*. (2009). Pea varieties did not affect the harvest index significantly. However, variety Aparna recorded higher harvest index (34.37%) than Pant P-13 (33.07 %).

Table 2: Effect of irrigation, nitrogen and varieties on yield attributes of pea

Treatments	**Pods $plant^{-1}$**	**Wt. of pods $plant^{-1}$**	**Length of pod (cm)**	**Grains $plant^{-1}$**	**Wt. of grains $plant^{-1}$ (g)**	**Wt. of grains pod^{-1} (g)**	**Grains pod^{-1}**	**Test weight**
Irrigation								
No irrigation	18.38	23.88	4.34	60.14	21.50	1.24	3.27	203.60
One irrigation	21.56	28.34	5.28	75.46	25.74	1.18	3.50	211.18
SEm±	0.61	0.85	0.18	2.25	0.65	0.04	0.05	6.48
C.D. (P=0.05)	2.75	3.83	0.81	10.13	2.92	NS	0.22	NS
N (kg ha^{-1})								
0	18.52	25.03	4.40	59.35	22.52	1.14	3.30	205.18
15	20.55	27.62	4.98	71.41	25.06	1.25	3.43	212.23
30	20.84	28.64	4.05	72.64	24.28	1.24	3.43	206.03
SEm±	0.58	0.82	0.15	2.18	0.64	0.03	0.04	5.16
C.D. (P=0.05)	1.79	2.53	0.46	6.72	1.97	0.09	0.12	NS
Varieties								
Aparna	21.42	27.36	5.04	73.58	24.66	1.26	3.24	209.18
Pant P-13	19.52	24.86	4.58	62.02	22.58	1.16	3.14	206.59
SEm±	0.56	0.80	0.14	2.15	0.62	0.03	0.04	4.58
C.D. (P=0.05)	1.66	2.38	0.42	6.38	1.84	0.09	0.10	NS

Yields

The data (Table 3) revealed that application of irrigation, nitrogen and varieties significantly increased yields (biological, grain and straw) of pea. The maximum yields (biological, grain and straw) were obtained with one irrigation (I_1). This treatment was also found significantly superior to no irrigation with respect of yields of pea. The biological, grain and straw yields increased by 25.9, 22.5 and 27.8% with irrigation over no irrigation, respectively. All the yield attributing characters might be held responsible for higher yield of pea with one post sowing irrigation. Similar results were reported by Singh *et al*. (2007). The data (Table 3) indicated that the biological and straw yield increased significantly with the application of 15 kg N ha^{-1} over control. Although maximum biological and straw yield were obtained with 30 kg N ha^{-1} but this was found statistically at par with 15 kg N ha^{-1}. Grain yield of pea showed significant improvement with successive increase in nitrogen level only up to 15 kg N ha^{-1}. Application of 15 kg N ha^{-1} caused 13.9, 10.2 and 21.3% increase in biological, straw and grain yield, respectively over control. Increased grain yield due to N application could be ascribed to increased biomass production, improved harvest index and increased seed set with N fertilization. This increase in grain and biological yields due to N application may be attributed to the fact that N is main yield limiting plant nutrient is semi-arid region ehere the soils are deficient in nitrogen. Applied N is reported to enhance the absorption of native as well as added N, P and K and there by improves over all growth and development of plants and ultimately the grain and straw yield. Positive effect of nitrogen on yields was reported by Singh *et al*. (2007) and Yadav *et al.* (2012).

Table 3: Effect of irrigation, nitrogen and varieties on yields of pea

Treatments	Biological yield ($q\ ha^{-1}$)	Grain yield ($q\ ha^{-1}$)	Straw yield ($q\ ha^{-1}$)	Harvest index (%)
Irrigation				
No irrigation	45.54	15.22	30.32	33.42
One irrigation	54.82	18.64	36.18	34.00
SEm±	1.76	0.52	1.05	1.02
C.D. (P=0.05)	7.92	2.34	4.73	NS
N ($kg\ ha^{-1}$)				
0	45.48	15.03	30.45	33.05
15	51.80	18.24	33.56	35.21
30	53.26	17.52	35.74	32.90
SEm±	1.70	0.47	0.98	0.73
C.D. (P=0.05)	5.24	1.45	3.02	2.25
Varieties				
Aparna	51.59	17.73	33.86	34.37
Pant P-13	48.77	16.13	32.64	33.07
SEm±	0.92	0.45	0.85	0.40
C.D. (P=0.05)	2.74	1.34	NS	1.28

There were significant variations in biological, straw and grain yields between the two varieties of pea. Variety Aparna produced significantly more biological, grain and harvest index by 13.0, 9.9 and 1.3 % than that of Pant P-13, respectively. The difference in yields between pea cultivars may be due to variation in their production capacity of grain and biological yield. In pea variety Aparna, increased root volume and chlorophyll content could be major contributor towards an increase in yields. These results confirm the findings of Shukla *et al.* (2009). Pea varieties did not affect the straw yield significantly; however, higher straw yield was noted with variety Aparna which was 3.7% more than Pant P-13. Based on the study, it is concluded that Aparna genotype of pea should be grown with one irrigation and 15 kg N ha^{-1} for greater growth and productivety in alluvial soil of Agra region.

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EFECT OF FYM AND POTASSIUM ON YIELD, NUTRIENT UPTAKE AND ECONOMICS OF WHEAT IN ALLUVIAL SOIL

YOGESH KUMAR, S.P.SINGH AND V.P.SINGH

Department of Agricultural Chemistry and Soil Science Raja Balwant Singh College Bichpuri, Agra (u.p.)-283105
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ABSTRACT

An experiment was conducted at Bichpuri (Agra) during rabi seasons of 2008-09 and 2009-10 to study the impact of FYM and potassium on yield, nutrient uptake and economics of wheat in alluvial soil of Agra.The experiment was laid out in factorial randomized block design with four levels of FYM (0,2.5,5.0 and 10 t ha^{-1}) and four levels of potassium (0,30,60 and 90 kg K_2O ha^{-1}).The grain and straw yield increased significantly up to 10 t FYM ha^{-1} and 90 kg K_2O ha^{-1} over absolute control. The increased in grain yield with 2.5, 5.0 and 10 t FYM ha^{-1} were recorded to the tune of 8.6, 14.0 and 15.7% and 4.1, 8.5 and 13.6%, over control in first and second year, respectively. The corresponding increases in yield due to 30, 60 and 90 kg K_2O ha^{-1} over control were 5.3, 14.9 and 25.2%, 11.0 and 19.9 and 31.4%. The levels of FYM and K applied together in different combinations increased the yield significantly more than those with their individual application. Significantly higher nitrogen, phosphorus and potassium uptake n wheat crop was recorded with FYM and potassium application. Magnesium uptake increased with the lower levels of potassium followed by decrease with each higher levels of K. The maximum net returns (₹. 47997.7 ha^{-1}) and B:C ratio (2.42) were obtained with 90 kg K_2O ha^{-1}.

Key words: Potassium, FYM, yield, nutrient uptake, economics, wheat.

INTRODUCTION

Wheat occupies a prominent place as an important cereal crop contributing 40% in the total food grain production. Wheat had high nutritive value (65-70% carbohydrates and 13-15% protein) and also serves as a good source of roughage to cattle. Wheat production in India is low as comparison to global level. The vaeious factors are responsible of low productivity such as poor fertilization and improper soil management of which poor fertilization is main facyor for poor productinity of wheat. The organic matter is a most valuable nourishment organic compound, as it improves physical, chemical and biological properties of soil and sustains fertility and productivity of cultivated land.It is well known that addition of organic manures has shown considerable increase in crop yield and helps in enhancing nutrient availability both from applied and native sources. Potassium is the most important essential nutrient after nitrogen and phosphorus and plays a vital role in plant cell sap, support enzymatic activity, photosynthesis, and transportation of sugar, synthesis of protein and starch but doesn't bounds with carbon or oxygen (Hoeft et al. 2000). It also develops tolerance to draght condition and enhances plant ability to resist attacks of pest and diseases. Supply of plant nutrients in balanced and sufficient quantity is essential to sustain the productivity of crops. Plants require potassium in large quantity. In general, 40-60 kg K_2O ha-^{1} is recommended which is far less than the amount of K removed by cereals like wheat. As a result most of the crops are running with negative K balance. Yet increased intensity of cropping and introduction of high yielding varieties resulted in considerable mining of potassium from the soil. Integration of K with FYM will not only sustain the crop production but also will be effective in improving soil fertility. As information is lacking on the effect of K and FYM on crop productivity in Agra region of Uttar Pradesh, the present study was therefore, planned to assess of the integrated use of FYM and potassium on productivity of wheat.

MATERIALS AND METHODS

Field experiment was conducted at Agriculture Research Farm, R.B.S. College,Bichpuei, Agra during 2008-09 and 2009-10 on sandy loamy soil.The experimental field had EC 0.49 dS m^{-1},pH 8.0, organic carbon 3.4 g kg^{-1},$CaCO_3$ 5.0 g kg^{-1},S available N 177, P 9, K 143 kg ha^{-1}, available S 8.5 mg kg^{-1}, exchangeable Mg 1.75 cmol (p^+) kg^{-1} and DTPA extractable zinc 0.55 mg kg^{-1}. The experiment was laid out in randomised block design with four level of potassium (control, 30, 60 and 90 kg K_2O ha^{-1}) and four levels of FYM (control, 2.5, 5.0 and 10t / ha) with three replications. The recommended doses of N and P @ 150 and 60 kg P_2O_5 ha^{-1}, respectively were applied through diammonium phosphate and urea. Potassium and FYM were supplied through muriate of potash (KCI) and well dicomposed FYM as per treatments. The wheat variety PBW-343 was shown on November 25, 2008 and November 27 2009 and irrigated at the proper time as judged by the appearance of soil and crop. The weeds were cradicated time to time from the crop. The crop was harvested on maturity. The grain and straw samples were processed for nutrient analysis and N content was determined by Kjeldahl method (Jackson 1973). Grain and straw samples of wheat were digested in di acid (HNO_3, $HClO_4$) and the digest were subjected to analysis of phosphorus by vanado molyblophosphoric acid yellow colour method, K by flame photometer Ca and Mg by versenate titration using ammonium purpurate and eriochrome black T (EBT) as indicator for Ca and Ca + Mg, respectively (Jackson 1973). The uptake of nutrients was calculated using the yield datd in conjunction with their respective contents. The economics of treatments was calculated on the basis of prevailing market price of inputs and produce.

RESULTST AND DISCUSSION

Yield

The Results indicate that the yield of grain and straw of wheat enhanced significantly with FYM application. The each increasing levels of FYM significantly increased grain and straw yield of wheat and increases in grain yield due to 2.5, 5.0 10t FYM ha^{-1} were 8.6, 14.0 and 18.7% and 4.1, 8.5 and 13.6% respectively over control in first and second year of study. The straw yield also followed similar trend. The beneficial effect of FYM on yield was also reported by Chandel et al. (2013) and Kumar and Singh (2013). This increase might be due to steady decomposition of FYM and release of nutrients throughout the crop growth period coupled with better assimulation of nutrients (Singh et al. 2013). The grain and straw yields of wheat increased significantly with the addition of potassium over control in both years. The increases in grain yield due to 30, 60 and 90 kg K_2O ha^{-1} over control were 5.3, 14.9 and 25.2% and 11.0, 19.9 and 31.4%, respectively during first and second year of experimentation. As potassium is essential for grain development, the favourable effect of high doses of K on growth and yield attributes of wheat was mainly responsible for higher grain and straw yields. The results are in close conformity with those of Singh and Singh (2009).

Table 1: Effect of FYM and potassium levels on grain, straw yield and economics of wheat

Levels	Grain yield (q ha^{-1}) 2008-09	Grain yield (q ha^{-1}) 2009-10	Straw yield (q ha^{-1}) 2008-09	Straw yield (q ha^{-1}) 2009-10	Net return (₹. ha^{-1})	B:C ratio
Potassium levels (kg ha^{-1})						
0	45.88	38.82	47.83	46.86	34785.2	1.81
30	46.83	43.12	53.35	52.48	38754.7	1.98
60	50.40	46.55	58.29	56.90	43265.0	2.21
90	32.00	51.03	63.12	62.37	47997.7	2.42
CD (P=0.05)	2.77	1.92	1.98	1.49		
FYM Level (t ha^{-1})						
0	41.09	48.50	52.71	52.04	37890.4	2.07
2.5	44.63	49.77	54.58	53.22	40187.4	2.08
5.0	46.85	52.00	56.57	55.45	42342.3	2.13
10.0	48.78	53.88	58.73	57.91	44292.2	2.15
CD (P=0.05)	2.77	1.92	1.98	1.49		

Interaction

The levels of FYM and potassium applied in different combinations increased the yield significantly more than with their individual application (Table 2). The highest grain and straw yields were recorded with combined application of 90 kg K_2O ha^{-1} and 10t FYM ha^{-1} during 2008-09 and 2009-10.

Table 2: Interaction effect of FYM and potassium on yield of wheat

Potassium (kg ha^{-1})	FYM (t ha^{-1}) 0	2.5	5.0	10	0	2.5	5.0	10
	2008-09				2009-10			
Grain yield (q ha^{-1})								
0	37.55	40.32	43.66	45.88	36.06	38.00	39.74	41.51
30	39.75	43.14	44.66	46.85	40.25	42.60	43.85	45.80
60	42.00	46.00	48.08	50.40	43.72	45.10	47.22	50.17
90	45.05	49.14	51.00	52.00	48.50	49.77	52.00	53.88
CD (P=0.05)	4.54				3.84			
Straw yield (q ha^{-1})								
0	45.06	46.80	48.79	50.66	44.34	45.60	47.69	49.81
30	50.51	52.19	54.04	56.68	49.91	51.55	53.06	55.42
60	54.26	57.34	59.87	61.71	53.77	55.02	57.61	61.21
90	61.00	62.00	63.60	65.88	60.14	60.72	63.44	65.19
CD (P=0.05)	3.96				2.98			

Nutrients uptake

The data (Table 3) clearly indicated that the increasing levels of FYM and potassium application significantly enhanced the nitrogen uptake by grain and straw of wheat. Nitrogen uptake by wheat grain and straw increased from 85.6 to 111.1 and 25.8 to 36.1 kg ha^{-1}, respectively as the levels of FYM increased from 0 to 10t ha^{-1}. The increase in N uptake was mainly due to greater production of grain and straw. Higher uptake of N with FYM levels may be due to mineralization of N from FYM which sufficiently meet the nutritional requirement of the crop. Singh and Tomar (1991) and Singh et al. (2013) also recorded similar results. The additional doses of K significantly enhanced N uptake in grain and straw of wheat from 89.6 kg ha^{-1} at the control to 112.6 kg ha^{-1} with 90 kg K_2O ha^{-1}. The minimum value of N uptake by wheat crop was recorded with control. Shivay (2002) and Kulkarni et al. (2005) also reported similar results. The data (Table-3) showed a significant increase in P uptake with increasing FYM levels as compared to control. The effect of FYM application in increasing P uptake may be associated with physiological stimulation of plant rather than increase ramification of root system (Chandel et al. 2013). The uptake of P by wheat grain and straw signicantly increased with increasing levels of K and maximum values were noted with 90 kg K_2 ha^{-1}. Thus, K had synergistic effect on P nutrition of the crop. These results are in agreement with those of Kulkarni *et al.* (2005) and Singh (2009). The uptake of potassium significantly improved with FYM and K addition. The each enhancing does of FYM increased significantly potassium uptake by wheat grain and straw over control. The higest K uptake was obtained under 10.0 t FYM ha^{-1} and minimum in control. The increasing levels of K had significantly higher K uptake in grain and straw over control. The application of 90 kg K_2O ha^{-1} increased the uptake of K in grain and straw by wheat over 60 kg K_2Oha^{-1}. These finding supported the results obtained by Singh and Tomar (1991) and Singh and Singh (2009). Magnesium uptake by wheat grain and straw significantly increased with addition of FYM and increase was positively marked up to 10t FYM ha^{-1} .The potassium application increased the average Mg uptake in grain and straw of wheat up to 30 kg K_2O ha^{-1}. Each higher levels of applied K had an adverse effect on Mg uptake by wheat crop. The results showed an antagonistic effect of K addition on Mg uptake by plants. Similar results were reported by Singh and Pathak (2002).

Table 3: Effect of FYM and potassium levels on grain, straw yield and economics of wheat

Levels	Nitrogen		Phosphorus		Potassium		Magnesium	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Potassium levels (kg ha^{-1})								
0	89.8	26.7	12.5	6.1	23.7	94.3	10.5	10.1
30	96.3	29.2	13.4	7.0	26.5	107.9	11.1	10.2
60	103.9	31.5	14.6	8.0	29.7	117.1	10.9	10.5
90	111.1	33.8	15.8	8.9	32.3	129.8	10.7	10.0
CD (P=0.05)	6.66	2.57	1.10	1.12	2.17	5.04	0.96	0.81
FYM (t ha^{-1})								
0	86.9	25.5	11.6	5.9	24.5	100.5	8.7	8.55
30	97.1	28.4	13.4	7.0	27.0	108.5	10.1	9.65
60	103.9	32.1	14.9	7.9	29.1	115.9	11.5	10.7
90	113.1	35.2	16.4	9.1	31.7	124.3	12.7	11.9
CD (P=0.05)	6.66	2.57	1.10	1.12	2.17	5.04	0.96	NS

Economics

From the economics point of view, each successive increase in K levels from 0 ti 60 K_2O ha^{-1} and FYM levels from 0 to 10t FYM ha^{-1} increased the values of net returns and B:C ratio (Table-1). The maximum net returns (₹. 47997.7 ha^{-1}) and B:C ratio (2.42) was obtained with 90 kg K_2O ha^{-1}. From FYM application perspective, the maximum net returns (₹. 44292.2 ha^{-1}) and B:C ratio (2.15) were obtain with 10 t FYM ha^{-1}. This means that the higher quantity of potassic fertilizer and FYM required for obtaining higher yield resulted in higher net return and B:C ratio.

From the results, it may be concluded that the wheat crop responded significantly up to the application of FYM and K and magnitude of response was more marked with combined use of FYM and potassium. FYM and potassium had significant effect on the quality, uptake of nutrients and economics of the crop.

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Short Communication

RESPONSE OF SUMMER MUNGBEAN TO PHOSPHORUS AND BIOFERTILIZERS IN EASTERN UTTAR PRADESH

SHISHU PAL SINGH, ADESH KUMAR, RAM BHASOSE AND SURESH KUMAR

Department of Soil Science, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) 224 229
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Mungbean (*Vigna radiata* L.) is one of the most important legume crops. It enhances the soil fertility through nitrogen fixation with the help of symbiotic microbial association. The productivity of mungbean in Uttar Pradesh was 577 kg ha^{-1} in 2010-11 (Anonymous, 2011). The productivity of mungbean of the country as well as state is very low as compared to other countries. Mungbean is capable of fixing atmospheric nitrogen through *Rhizobium* species living in root nodules, *Rhizobium* spp. invades the root hairs of mungbean and results in the formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils help to improve nodulation, N_2-fixation solicit crop growth and yield of leguminous crops**.** *Rhizobium* inoculation has been provided as a cheapest source of nitrogen fertilizer input for better crop yield particularly in legumes. Phosphorus plays a vital functional role in energy transfer and metabolic regulation and it is an important structural component of many molecules. Application of P along with *Rhizobium* inoculants has been reported to influence nodulation, N_2 fixation, and specific nodule activity (Zahran, 2000, Rana *et al* 2011). On the other hand, P fertilization usually result in enhanced nodule number and mass, as well as greater N_2 fixation activity per plant (Seraj and Gyamfi, 2004) as nodules is strong sink for P, reaching concentrations.Both phosphorus status and P-fixing capacity of soil strongly influences the phosphorus availability. Phosphorus solubilizing bacteria (PSB) has been proved as the cheapest source of phosphorus particularly in legumes that enhance the availability of phosphorus and productivity of crops (Tagore *et al.* 2013). The ability of phosphorus solublizing bacteria (PSB) to convert insoluble forms of phosphorus to an accessible form is an important trait in sustainable farming for increasing plant yields. However, meager information is available on the sole and combined effect of *Rhizobium* and phosphorus in summer mungbean under agro-ecological conditions of Uttar Pradesh for maintaining higher productivity and soil fertility. Thus keeping the importance of *Rhizobium*, PSB and phosphorus, the present study was designed to evaluate the effect of *Rhizobium* inoculation alone and in combination with PSB and phosphorus on mungbean production.

The field experiment was conducted during *summer* season, 2012 at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The twelve treatment combinations comprised with three levels of phosphorus (0, 20 and 40 kg ha^{-1}) and biofertilizers (*Rhizobium* and PSB with and without) in randomized block design replicated as thrice. The variety Narendra Munng-1 was taken as a test crop. The soil had pH (1:2.5) 8.2, EC 0.36 dSm^{-1}, organic carbon 2.9 g kg^{-1}, available N 145, P_2O_5 17 and K_2O 214 kg ha^{-1}. The uniform recommended doses (20 kgN and 40 kg K_2O ha^{-1}) were applied through urea and Muriate of potash respectively. The phosphorus was applied as basal through single super phosphate. The strain of *Rhizobium* specific to mung bean was applied as seed treatment using 200 g for 10 kg seed.

The data (Table 1) revealed that the yield attributes increased with the inoculation of *Rhizobium* and PSB along with increasing levels of P up to 40 kg P_2O_5 ha^{-1}. The maximum plant height (64.85 cm), numbers of branches (8.12), pods $plant^{-1}$ (46.93), grain $plant^{-1}$ (11.85) were recorded with inoculation of *Rhizobium* and PSB + 40 kg P_2O_5 ha^{-1} followed by *Rhizobium* + 40 kg P_2O_5 ha^{-1} and minimum values in control. The significant higher yield of grain (13.50 q ha^{-1}) and straw (42.90 q ha^{-1}) were obtained with *Rhizobium* and PSB inoculation along with 40 kg P_2O_5 ha^{-1} over with and without inoculation of *Rhizobium* and PSB along with rest lower levels of phosphorus. This might be due to synergistic effect of the two types of microorganisms for biological nitrogen fixation and better availability of phosphorus that resulted in increased growth, yield attributes and yields as against their individual application. The results are in line with the findings of Bhat *et al.* (2005), Vikram *et al.* (2008), Rana *et al* 2011 and Tagore *et al.* (2013). The maximum value of harvest index (23.9 %) was recorded with the inoculation of *Rhizobium* and PSB

Corresponding author e-mail: adeshkumar1977@gmail.com

Table 1: Effect of biofertilizers and phosphorus on growth, yield attributes, yield and economics of summer mung bean

Treatments	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Grains pod^{-1}	Test weight (g)	Grain yield (qha^{-1})	Straw yield (qha^{-1})	Harvest index (%)	Gross return (₹. ha^{-1})	Net return (₹. ha^{-1})	B:C ratio
Control	49.0	5.6	35.1	7.13	28.4	8.10	26.58	23.3	31286.4	16008.4	1.04
$R_0 B_1 P_0$	52.8	4.3	37.2	8.85	29.1	9.38	30.25	23.7	36188.0	19830.0	1.21
$R_0 B_0 P_{20}$	54.1	6.3	38.2	9.17	30.4	9.70	31.23	23.9	37418.4	22060.4	1.43
$R_0 B_1 P_{20}$	58.1	6.8	44.0	9.49	32.9	10.98	35.69	23.5	42383.2	25677.2	1.53
$R_0 B_0 P_{40}$	59.4	7.0	44.4	9.68	33.3	11.26	36.59	23.5	42663.2	26225.2	1.59
$R_0 B_1 P_{40}$	56.0	6.5	42.2	9.30	31.9	10.35	33.43	23.6	39934.4	21800.4	1.20
$R_1 B_0 P_0$	55.8	6.4	40.9	9.23	31.2	10.08	32.66	23.6	38900.8	21114.8	1.18
$R_1 B_1 P_0$	57.0	6.8	43.0	9.30	32.3	10.80	34.56	23.8	41644.8	22430.8	1.16
$R_1 B_0 P_{20}$	60.3	7.2	44.95	9.96	33.4	11.28	37.49	23.1	43319.2	26533.2	1.58
$R_1 B_1 P_{20}$	62.1	7.7	45.52	10.69	35.2	12.60	40.50	23.7	48608.0	30394.0	1.66
$R_1 B_0 P_{40}$	63.4	7.4	45.12	10.23	34.1	12.00	38.79	23.6	46303.2	28437.2	1.59
$R_1 B_1 P_{40}$	64.8	8.1	46.93	11.85	36.7	13.50	42.90	23.9	52032.0	32738.0	1.69
SEm±	1.75	0.22	1.29	0.32	0.98	0.33	1.18	0.71			
C.D (P 0.05)	5.15	0.66	3.77	0.95	2.88	0.97	3.4	2.08			

along with 40 kg P_2O_5 ha^{-1} followed by inoculation with *Rhizobium* + 40 kg P_2O_5 ha^{-1}. This might be due to partitioning of dry matter towards sink. These results corroborated with the findings of Prasad *et al.* (2014). The data (Table 2) revealed that the maximum net return of ₹. 32738 ha^{-1} and cost benefit ratio (1.69) were obtained with inoculation of *Rhizobium* and PSB along with phosphorus 40 kg P_2O_5 ha^{-1} followed by *Rhizobium* + PSB + 20 kg P_2O_5 ha^{-1} and minimum net return of ₹. 16000.40 ha^{-1} and cost benefit ratio (1.04) were received with control. The similar findings were reported by Kumawat and Kumawat (2009).

On the basis of results, it may be concluded that the growth and yield of mungbean was obtained with inoculation of *Rhizobium* and PSB along with 40 kg P_2O_5 ha^{-1} which was statistically at par with *Rhizobium* and PSB along with 20 kg P_2O_5 ha^{-1}. Hence, inoculation of *Rhizobium* and PSB along with 20 kg P_2O_5 ha^{-1} may be recommended for better performance as well as economics.

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Short Communication

RESPONSE OF RICE TO INTEGRATED NITROGEN MANAGEMENT UNDER SRI METHOD OF CULTIVATION

SANDEEP KUMAR TIWARI, SURESH KUMAR TIWARI, S.F.A. ZAIDI AND VED PRAKASH

Department of Soil Science and Agricultural Chemistry, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad 224 229 (U. P.)
Received: October, 2014; Revised accepted: January 2015

Rice (*Oryza sativa* L.), is the prince among the cereals as a premier food crop not only in India but also in the world. Uttar Pradesh is the largest rice growing state after West Bengal in the country, in which rice is being grown over an area of 6.69 m ha with production and productivity of 11.80 m tonnes and 2073 kg ha^{-1}, respectively. The system of rice intensification (SRI) is a new methodology, which has been used to increase yield and reduce water and mineral fertilizer consumption. The yield of SRI method relies on early transplant, wetting and drying of soil rather than the prolonged flooding practice in conventional rice system. Most SRI studies so far have involved small field trials comparing SRI methods with conventional method of rice cultivation. Yield differences between the SRI and conventional system are highly variable and potential of SRI method, which can increase yield by 50-100% (Termel *et al.* 2011). Nitrogen is one of the major nutrients which determine the growth and development of rice. It is an important constituent of many organic compounds and is known to improve the various morphological attributes in the rice because of higher synthesis of protoplasmic proteins and nucleic acid. It is also responsible for more leaf area and dry matter production due to higher rate of photosynthesis. The nitrogen management modules envisage use of FYM and green manures along with chemical fertilizers and opportunity to achieve long term sustainability in crop production systems (Reddy *et al.*, 2003). Green manuring and farmyard manuring may help in reducing the deleterious effects of rice cultivation on soil physical properties. Therefore a study was initiated to assess the effect of integrated use of nitrogen on rice under SRI method of cultivation.

A field experiment was conducted during *Kharif* season of 2012 at Instructional Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.). The soil of the experimental field was silty loam in texture having pH 8.3, organic carbon 2.4 g kg^{-1}, avail N 149, P13 and K 263 kg ha^{-1}. The seven treatments *viz.* T_1, Control, T_2, 100% N as fertilizer, T_3, 75% N as fertilizer+25% N as FYM, T_4,75% N as fertilizer + 25% N as green manure (Sesbania), T_5,50% N as fertilizer+25% N as FYM+25% N as green manuring, T_6,50% N as fertilizer+50% N as FYM and T_7, 100% N as FYM were tested in randomized block design with three replications. Nitrogen was applied as urea, FYM and green manure as per treatment. Phosphorus and potassium were applied in each plot @ 60 kg ha^{-1} through single superphosphate and muriate of potash respectively. The crop was planted on 12 July, 2012 at a spacing of 25 x 25 cm and it was raised under SRI method (early seedling and alternate drying and wetting condition). The grain and straw yields were recorded at harvest. Nitrogen content in grain and straw was determined by Kjeldahl method. Phosphorus and potassium were determined in di acid digest by vandomolybdophosphoric acid yellow colour method and flame photometer, respectively. The protein content in grain was worked out by multiplying the nitrogen content in grain with factor 6.25. The nutrient uptake was computed by multiplying the nutrient content in grain and straw with yield in respective treatments. The soil organic carbon and bulk density in post harvest soil was determined by adopting standard procedures.

The data (Table 1) revealed that the grain and straw yields were significantly increased with the combined application of inorganic fertilizer with green manure over application of FYM alone or combination with inorganic fertilizer. The highest grain (64.32 q ha^{-1}) and straw (81.00 q ha^{-1}) yield was recorded with 75%N as fertilizer + 25% N as green manure which was at par with 100% N as urea and significantly superior over the control , 75% N as fertilizer +25% N as FYM, 50%N as fertilizer + 25% N as FYM + 25% N as green manuring , 50% N as fertilizer + 50% N as FYM and 100% N as FYM. This might be due to improved physical condition of the soil by the application of green manure thereby improving the utilization of native as well as applied nutrients which ultimately improved the yield of the crop. These results corroborated with the findings of Premi and Kalia (2003). The minimum grain and straw yields were observed with control. The hulling and milling quality was influenced with combined application of organic and inorganic N.

Corresponding author e-mail: skumarpubs@gmail.com

Table 1: Effect of INM on yield and qualities of rice under SRI method cultivation

Treatment	Yield (qha^{-1})		Quality parameters			
	Grain	Straw	Hulling (%)	Milling (%)	Protein (%)	Protein yield ($kg\ ha^{-1}$)
T_1. Control	41.88	56.13	69.3	66.0	7.00	293.1
T_2. 100 % N as fertilizer	60.98	80.17	71.6	66.6	8.18	498.8
T_3. 75 % N as fertilizer+25 % N as FYM	58.63	77.23	72.2	67.3	8.12	476.0
T_4. 75 % N as fertilizer+25 % N as GM	64.32	81.00	73.3	67.4	8.31	534.4
T_5. 50 % N as fertilizer+25 % N as FYM + 25 % N as GM	52.60	68.67	75.1	68.8	8.00	420.8
T_6. 50 % N as fertilizer +50 % N as FYM	48.00	65.91	75.4	69.4	7.87	377.7
T_7. 100 % N as FYM	45.64	60.73	76.3	70.2	7.12	324.9
SEm±	1.72	7.12	0.55	0.78	--	-
CD (P=0.05)	5.30	2.31	1.64	2.32	--	-

The maximum hulling (76.36%) and milling (70.25%) were observed with 100% N through FYM which was significantly superior over control. This might be due to higher accumulation of dry matter content resulting improved grain quality. The result is in close conformity with the findings of Premi and Kalia (2003).The protein content in grain was influenced with various treatments. The maximum protein content (8.31%) and yield (534.4 kg ha^{-1}) were recorded with 75% N through fertilizer + 25 % N as green manuring followed by 100% N as fertilizer. The minimum protein content (7.00%) and yield (293.1 kg ha^{-1}) were obtained with the control. This might be due to higher content of nitrogen by crop. Similar findings were observed by Dixit and Gupta (2000) and Rajeshwar and Khan (2008).

Table 2: Effect of INM on soil properties and nutrients uptake under SRI method cultivation

Treatments	Org. carbon ($g\ kg^{-1}$)	N		P		K	
		Grain	Straw	Grain	Straw	Grain	Straw
T_1. Control	2.4	46.9	20.7	12.9	8.4	27.2	67.9
T_2. 100 % N as fertilizer	2.5	79.8	36.0	20.7	13.6	45.7	101.0
T_3. 75 % N as fertilizer+25 % N as FYM	2.8	76.2	33.2	19.3	13.1	45.1	95.7
T_4. 75 % N as fertilizer+25 % N as GM	2.9	85.5	37.2	22.5	14.5	49.5	102.0
T_5. 50 % N as fertilizer+25 % N as FYM + 25 % N as GM	3.0	67.3	28.8	16.8	10.9	36.8	81.7
T_6. 50 % N as fertilizer +50 % N as FYM	3.0	60.4	27.6	15.3	10.5	32.1	79.0
T_7. 100 % N as FYM	3.3	52.0	24.2	13.6	9.1	27.3	71.0
SEm±	0.1	3.13	1.17	1.16	0.48	1.48	2.52
CD (P=0.05)	0.3	9.34	3.59	3.50	1.45	4.46	7.76

It is obvious from the data that the highest uptake of N,P and K in grain and straw were computed under the treatment receiving 75% N through fertilizer + 25% N through GM which was significantly superior over control. This might be due to enhanced contents of nitrogen, phosphorus and potassium as well as improved grain and straw yields. These results are in close conformity with the findings of Dixit and Gupta (2000), Bindra and Thakur (1994) and Dasog *et al.* (2010). On the other hand, minimum N, P and K uptake was recorded under control due to lower yields.

Organic carbon was also influenced with combined application of organic and inorganic fertilizer. The maximum buildup of organic carbon (3.3 g kg^{-1}) was recorded with 100%N as FYM and minimum with control. This might be due to enhanced root growth leading to accumulation of more organic residues in the soil. These results are in close conformity with the findings of Kumar *et al.* (2001) who also reported that the application of FYM alone improved the organic carbon content in soil and reduced the bulk density of soil.

On the basis of results, it could be concluded that by substitution of 25% N as green manure or FYM was most effective in enhancing grain yield, nutrient uptake and maintaining the soil organic carbon in SRI method of rice cultivation.

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Short Communication

TERMINAL RESIDUES OF PENDIMETHALIN IN SOIL AND RADISH

A SIREESHA, P.C.RAO AND CH. S. RAMALAKSHMI

All India Coordinated Research Project on weed contect, Andhra Pradesh araice Research Institute and Regional Agricultural Reseach Station Maruteru, West Godavari (A.P.)
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In the modern day agriculture, a large number of agricultural chemicals are being used to control a wide variety of weeds, pests, diseases and parasites. A judicious and cautious use of these chemicals helps in sustaining the productivity while their indiscriminate use leads to serious ecological imbalances. Among all the chemicals use of herbicides for the control of weeds has become imminent especially in the irrigated agriculture for a wide variety of reasons like non availability of labour, high labour cost, unfavorable climatic conditions for weeding etc. Pendimethalin was found effective for the control of annual weeds as pre-emergence in leguminous and other vegetable crops which are consumed as daily food product in raw or cooked form (Lin *et al*., 2007; Tsiropoulos and Miliadis, 1998; Sinha *et al.*, 1996; Sondhia and Dubey, 2007).After application of these herbicides to soil, they undergoe decomposition and a part of them may be taken by plants accumulating in the edible parts, which are found to be toxic in nature. The residual activity of herbicides depends upon the soil type, soil moisture and temperature (Dharumarajan *et al.*, 2008).Application of recommended dose of herbicides may not pose serious problem for environmental pollution (Adachi *et al.*, 2007).However quantitative determination of herbicide residues helps in understanding the degradation pattern in the soil. Hence, an experiment was undertaken to study degradation pattern of pendimethalin in soil and their residues in edible parts of raddish.

A field experiment was conducted on an Alfisol at College Farm, College of Agriculture, Rajendranagar during 2007-08. The soil was sandy clay loam in texture with pH 6.57, E.C 0.16 dS m^{-1} and 5.30 g kg^{-1} of organic carbon content. Radish crop was grown with the pre emergence application involving two doses of Pendimethalin @ 0.5 and 0.75 kg a.i./ ha. Initial soil samples from surface layer (0-15 cm) and soil samples were collected at 0, 15, 30 and 45 days after application of pendimethalin for the analysis of residues by gas chromatograph. The edible parts were also collected at the time of harvest for analysis of residues by gas chromatograph. Shimadzu GC 2010 with Electron Capture Detector (ECD) with Ni 63. A ZB-5 column with 30 m length ID 0.53 mm, film thickness 1.50 um was used to detect pendimethalin residues in soil and vegetables. The carrier gas used was Nitrogen with flow rate 53.6 ml/min. Injector temperature was 240^0C and detector temperature was 260^0C with injector split ratio 1:10. The retention time and peak area of the samples and standard were recorded and pendimethalin in the samples was quantified. 10 g sieved soil /5 g edible parts were extracted with 150 ml of acetone: hexane. The samples were kept over night and filtered through buchner funnel and again the samples were rinsed with another 50 ml of acetone: hexane and the extract was evaporated. To a chromatographic column (2 mm i.d.) fitted below with cotton, 4 g of florosil followed by 10 g of anhydrous sodium sulphate was added. The concentrated extract was diluted to 10 ml with 10% acetone in hexane. Then the solution was transferred to florosil column. Container was rinsed with hexane and transferred to column. The column was eluted with about 5 ml/min. Florisil elute is concentrated to 1 ml. The extract is used for the determination of herbicide residues by GLC on ECD.

Table 1: Residues (mg kg^{-1}) and dissipation of pendimethalin in radish soil

Treatment	Days after application				Half life
	0	15	30	AH	
Pendimethalin @ 0. 5 kg a.i.ha^{-1}					
I season	0.206	0.138	0.084	BDL	6.45 days
II season	0.209	0.115	0.068	BDL	
Average	0.207	0.126	0.076	-	
		(56.10)	(73.87)	(100.00)	
Y=0.2593+0.0466x					
Pendimethalinn@ 0.75 kg a.i.ha^{-1}					
I season	0.304	0.248	0.085	BDL	10.03 days
II season	0.312	0.237	0.052	BDL	
Average	0.308	0.242	0.068	-	
		(21.43)	(77.92)	(100.00)	
Y=0.3194+0.03001x					

The recovery studies for pendimethalin wascarried out at 2, 1 and 0.5 ppm. Percent recovery of pendimethalin for radish varied from 85 to 94 per cent. Standard solutions of pendimethalin were prepared by dissolving 105.8 mg of respective technical grade herbicides in 100 ml of hexane. From this 100 µg mL^{-1} solution, 1 µg mL^{-1} solution was prepared and injected to GC. The peaks by their retention time were identified and the peak area was measured. The amount of residues of herbicide was calculated. Pendimethalin eluted a peak at 10.77 minutes. At harvest in both the seasons more than 98% of initial deposit of pendimethalin was dissipated. The observed residues of pendimethalin average of two seasons were 0.207 mg kg^{-1}, 0.126 mg kg^{-1} and 0.076 mg kg^{-1} at 2, 15 and 30 days after application of pendimethalin @0.5 kg a.i ha^{-1} .Where as pendimethalin applied @ 0.75 kg a.i ha^{-1}, the observed residues were 0.308 mg kg^{-1}, 0.242 mg kg^{-1} and 0.068 mg kg^{-1} at 2, 15 and 30 days after application. However at harvest, the residues of pendimethalin were below detectable limits in both the treatments. It showed that with the passage of time pendimethalin residues decreased in the soil radish field successively.

Soil and vegetable samples were collected from pendimethalin-treated plots at maturity to determine harvest time residues of pendimethalin. At harvest, 0.008, 0.001, and 0.014 µg/g residues of pendimethalin were found in tomato, cauliflower, and radishes, respectively (Sondhia, 2013). Low pendimethalin residues were found in plant samples. 0.025, 0.015, <0.001 µg g^{-1} residues of pendimethalin were found in chick pea grains at 750, 350 and 185 g a.i. ha^{-1} treatments, respectively (Sondhia, 2012). The residues of pendimethalin decreased during summer season as compared to winter season (Table 1). This may be attributed to physical parameters like temperature, wind velocity and moisture level. Comparatively faster rate of degradation of herbicides in the summer season in the present study could be attributed to higher day temperature and relative humidity. High rainfall during summer season (122.0 mm for April, May and June) which appears to have cause very rapid loss of herbicide residues by leaching and run off, as the herbicide was sprayed on surface only. Photodecomposition might be another factor for the loss of these herbicides from soil the high temperatures during summer as compared to *rabi* season were may also helped in faster degradation of herbicides in soils. Similar observations were also reported by Kalpana *et al* (1999) for the dissipation of pendimethalin and fluchloralin in soil; Guha *et al*,(1992) for the dissipation of fluchloralin in kharif paddy under West Bengal Agriculture conditions; Goutam and Ashim, 1994 for residue and persistence of pendimethalin on groundnut. The observed half life of pendimethalin in radish field was 6.45 days and 10.03 days applied @ 0.5 and 0.75 kg ha^{-1} respectively. Triantafyllidis *et al.,* (2005) reported residues of pendimethalin up to 129 days after the treatment in the top soil of tobacco field with a half life of 23-27 days. Sondhia (2012) found that dissipation of pendimethalin in the chickpea field soil conditions followed first order kinetics showing a half-life of 11.23 days.

Table 2: Residues of pendimethalin in edible parts of raddish

Treatment	Residue (mg kg^{-1})	
	Winter	Summer
Pendimethalin @ 0.5 kg ha^{-1}	0.0026	0.0027
Pendimethalin @ 0.75 kg ha^{-1}	0.0063	0.0056

The detected residues of pendimethalin in radish tubers were 0.0026 mg kg^{-1} and 0.0063 mg kg^{-1} during winter season and 0.0027 mg kg^{-1} and 0.0056 mg kg^{-1} during summer when pendimethalin applied at 0.5 and 0.75 kg a.i. ha^{-1} respectively. However, the detected residues of pendimethalin were below the maximum residue limits (MRL values) (0.05 µg g^{-1}). Sondhia (2012) studied terminal residues of pendimethalin in plant samples under field conditions and found 0.025, 0.015, <0.001 µg g^{-1} residues in chickpea grains at 750 to 185 g ha^{-1} treatments. Sharma and Mehta (1989) reported 0.103 µg g^{-1} residues in onion at harvest when the pendimethalin treatment was 2.0 kg ha^{-1}. Tsiropoulos and Miliadis (1998) reported 0.054 µg g^{-1} residues in onions treated at 2.0 kg ha^{-1}. A high level of persistence in the soil during the initial days of the crop growth would ascertain effective weed control during the most critical period of crop-weed competition and safety to rotational crops as the residues dissipate to a very low level of activity by the time of harvest of crop. As a part of applied herbicides were adsorbed to soil, a part may be leached down to deeper layers and the initial deposits were dissipated with time are the factors contributed to lower levels of herbicides in edible parts of radish.

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Short Communication

STUDIES ON RISK MANAGEMENT IN JUTE CULTIVATION THROUGH JUTE AND PULSE STRIP CROPPING IN EASTERN U.P.

M.V.SINGH, BHAGWAN SINGH AND VED PRAKASH

Crop Research Station, Bahraich -271 801 (U.P.)
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Pulses can be inter cropped with jute and give better utilization of resources i.e. soil moisture, nutrients, sun light etc. Pulses grow very vigorously and cover the ground surface, hence they suppress the weeds while do not get favorable conditions for producing seeds thus, the multiplication of weeds is checked. The protein need of Indian people is mostly met by pulses, the cheapest source of protein, apart from the human diet being leguminous, the pulse plants are important for maintaining the fertility status of soil. Considering the importance and possibilities to save precarious input like nutrients, water etc. without hampering the yield and better utilization of land, the present investigation was undertaken to study the feasibility of different pulse crops as intercrop with jute as the main crop.

The experiment was conducted at Crop Research Station, Bahraich (U.P.) during year of 2012-13 and 2013-14. The soil was sandy loam having pH 7.5 organic carbon 2.2 g kg^{-1} available N, P, K 210, 12.5, 215 kg ha^{-1}, respectively. Seven treatments viz. T_1 – Jute sole crop T_2 – green gram sole crop (variety RMG-62), T_3 – green gram sole crop (variety pant moong-5), T_4 – black gram sole crop (variety Pant U31), T_5 – Jute + green gram, pant moong 5 (9:9), T_6 – Jute + green gram (9:9), RMG-62, T_7 –Jute + black gram Pant U31(9:9) were tried in randomized block design with 3 replications. Jute variety JRC-212 was sown in the last week of April and pulse crops were sown just after sowing of jute crop according to treatments. All the recommended package of practices was followed as per requirement of jute and pulse crops. The growth and yield contributing characters were noted and yield was recorded at harvest of crop. The economics was calculated on the basis of market prices of input of the produce. Sole crop of jute produced the highest amount of fibre significantly as compared to jute inter cropped with the component crops in view of the higher plant population compared with the inter cropping ones. Among the different intercropping systems, the highest yield of fibre was recorded under jute +black gram as roots provide more synergetic effect to develop jute plants. Black gram being leguminous crop, supplied atmospheric nitrogen through biological nitrogen fixation, Mung bean and black gram also helped to suppress the weeds as they grow vigorously and covered the ground surface since the beginning of growth of jute crop. The maximum plant height (324 cm) and basal diameter (1.53 cm) was recorded from jute sole crop which was found significantly superior over other treatments.

Table 1: Effect of cropping systems on plant growth, yield and economics of jute and pulse crop (mean of two years)

Treatments	Plant height (cm) Jute	Plant height (cm) Puls Crop	Basal diameter of jute (cm)	Grains /pod of pulse crop	Fibre yield of jute (q ha^{-1})	Grain yield (q ha^{-1})	Jute equivalent yield (q ha^{-1})	Net profit (₹ ha^{-1})
T_1 – Jute (sole crop)	324.00	-	1.53	-	26.86	-	26.86	34533
T_2 – Green gram (sole crop) variety RMG-62	-	52.4	-	8.0	-	6.75	21.87	33071.5
T_3 – Green gram (sole crop) Pant mung -5	-	56.6	-	6.75	-	6.60	23.94	31857.5
T_4 – Black gram Pant U31 as (sole crop)	-	45.75	-	5.9	-	5.45	19.35	24087.5
T_5 – Jute + green gram Pant mung -5 (9:9) row ratio	313.45	49.74	1.59	5.9	15.16	5.09	31.84	48016.5
T_6 – Jute + Green gram RMG-62 (9:9) row ratio	306.85	52.2	1.49	6.1	15.05	5.2	31.35	49666.5
T_7 –Jute + Black gram Pant Urd -31(9:9) row ratio	316.85	48.75	1.61	7.0	15.88	4.51	30.86	44850
CD (P=0.05)	3.57	2.24	0.28	0.03	0.045	0.039	0.75	

Corresponding author e-mail: mvsinghbrh2013@gmail.com

The height of jute plant was significantly lower when it was inter cropped with black gram and mungbeanm. The highest basal diameter of (1.61 cm) was recorded under jute + black gram which was found significantly superior over other treatments. This might be due to synergetic effect of mungbean on jute crop by which jute crop gain more basal diameter. Result indicated that highest plant height (56.6 cm) was noted under sole crop of green gram variety pant moong-5 followed by sole crop of green gram variety RMG-62.Number of pods per plant was recorded with sole crop of mung bean and it was significantly higher over inter cropping of mung bean with jute. The numbers of seeds/pods were significantly higher in case of sole mung bean in comparison to its intercropping system. The highest grain yield (8.0 q ha^{-1}) was noted under green gram sole crop. Similar finding were also reported by Singh *et al.* (2012), Mandal and Majumdar (2010).

The higest value of jute equivalent yield (63.83 q ha-^{1}) was recorded under .jute + green gram 9:9 cropping pattern. The lowest jute equivalent yield (19.35 q ha^{-1}) was recorded under black gram sole crop which might be due to lowest yield of black gram. The highest net income of ₹ 49666 ha^{-1} was recorded under (jute +green gram variety RMG-62). It may be due to both of jute and green gram yield under same treatment. The lowest net returns of ₹ 24087 ha^{-1} was noted under sole crop of black gram. The results revealed that higher fibre yield (26.86 q ha^{-1}) was recorded under sole crop of jute and higher jute equivalent yield of 31.83 q ha^{-1} was noted under jute + green gram (9:9) row ratio. The higher net profit of ` 49666 ha^{-1} was noted under (Jute + green gram in 9:9 row ratio.

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