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Effect of Integrated nutrient management on growth, yield and nutrient uptake by soybean (*Glycine max*)

ATUL SHALIGRAM BONDE AND S.N. GAWANDE

Department of Agricultural Chemistry and Soil Science, Shri Sivaji Agriculture College, Amravati (MS)-444603

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ABSTRACT

A field experiment was conducted at Amravati (Maharashtra) during kharif season of 2010 and 2011 to study the effect of integrated nutrient management on growth, yield, quality and nutrient uptake by soybean [(Glycine max L) Merril]. The experiment was conducted in randomized block design with three replications and twelve treatments. The results revealed that increasing levels of NP increased the growth, yield attributes and seed and straw yields of soybean upto 100% NP over control. Application of 75% NP + 4 t FYM ha^{-1} + PSB also improved the yield and uptake of P by the crop. But the growth and yield attributing characters of soybean were maximum with the application of 75% NP + 4 t FYM + 5 kg Zn ha^{-1}. Application of 75% NP + 4 t FYM + 25 kg S ha^{-1} produced the highest seed (29.59 q ha^{-1}) and straw (4.49 q ha^{-1}) yield which were 50.2 and 50.8% more than that of control. The uptake of N, P, K and S by soybean seeds and straw was the highest at 75% NP + 4t FYM + 25 kg S ha^{-1} and the lowest in control. The Zn uptake by soybean seed grain (32.9 g ha^{-1}) and straw (24.2 g ha^{-1}) was highest at 75% NP + 4t FYM + 5 kg Zn ha^{-1} treatment. The crop quality in respect of protein content, oil content and yield increased significantly with conjoint use of fertilizers and FYM and maximum values were recorded with 75% NP + 4t FYm + 25 kg S ha^{-1} treatment.

Keywords: Nutrient management, yield, nutrient uptake, quality, soybean.

INTRODUCTION

Soybean (Glycine max L) is an important oil seed crop that is widely grown as a valuable source of protein and oil for human nutrition in the world. It has highest content of lysine, which is limiting factor in cereals. It is used in manufacturing of antibiotics in pharmaceuctical industries and for producing soymilk and soya protein in food industry. In spite of its high yield potential, soybean productivity is much lower than developed countries mainly due to sub-optimal application of fertilizers. In plant nutrition, organic matter of a soil is the key property that decides the availability status of essential nutrients. Integrated nutrient management system through efficient use of organic matter can substantially enhance crop production. The use of FYM is the tool to improve the physical, chemical and biological properties of the soil. Farmyard manure being the source of all essential elements, improves soil organic matter and humus part of soil. FYM also plays an important role inhabitating beneficial bacteria thus making the nutrients available to crop. Zinc is the important micronutrient for crops as it play major role in synthesis of tryptophan, which is precursor of indole acetic acid. Zinc catatyzes the process of oxidation in plant cells and plays a vital role in transformation of carbohydrates, regulates the consumption of sugar and increases the source of energy for the production of chlorophyll. Response to applied zinc for better growth and yield of soybean has also been reported (Singh, 2017). Sulphur improves the quality of grain, synthesis of amino acid and is involved in the metabolic and enzymatic processes of all living cells. Combined application of organic manure and fertilizers is very effective in realization of high yield and high response to nutrients (Singh *et al.* 2013). PSB can prove to be an effective low technology for the farmers as expense on costlier fertilizer can be lowered down. There is a need to improve the nutrient supply system in terms of integrated nutrient management involving the use of fertilizers in conjunction with organic manures and biofertilizers. Therefore, the present experiment was undertaken to study the effects of nutrient management options on the crop growth, yield, nutrient uptake by soybean.

MATERIALS AND METHODS

The experiment was conducted at the Sri Shivaji Agriculture College, Amravati (22° 42’ latitude, 77° 42’ E longitude with an elevation of 315 meters above mean sea level), Maharashtra, India during rainy season of 2010 and 2011. Amravati has subtropical climate with an annual rainfall of about 824mm which is mainly confined to south-west monsoon extending from June to September in the region. The sunface soil (0-15cm) was alkaline in reaction (pH 7.7), low in organic carbon (4.1 g kg^{-1}) and available N (202 kg ha^{-1}) medium in available P (18 kg ha^{-1}) and high in K (366 kg ha^{-1}). It contained 11.6 kg S ha^{-1} and 0.56 mg kg^{-1} Zn. There were 12 treatments namely, T_1 control, T_2 50% recommended dose of N and P, T_3 75 RD of NP, T_4 50% NP + 4t FYM ha^{-1}, T_5 - 50% NP + 4t FYM + 25 kg S ha^{-1}, T_6-50% NP + 4t FYM + 5 kg Zn ha^{-1}, T_7-50% NP + 4t FYM + PSB, T_8-75% NP + 4t FYM ha^{-1}, T_9-75% NP + 4t FYM + 25 kg S ha^{-1}, T_{10}-75% NP + 4t FYM + 5 kg Zn ha^{-1}, T_{11}-75% NP +4t FYM + PSB and T_{12} 100% RD of NP.The treatments were laid out in a randomized block design with 3 replications. Recommended doses of 30 kg N and 75 kg P_2O_5 ha^{-1} were applied through urea and triple superphosphate, respectively. Sulphur and zinc were applied at sowing through elemental sulphur and zinc oxide, respectively. Well decomposed FYM (0.65% N, 0.25% P and 0.55% K) was added to the plots as per treatments one week before sowing. The seeds of soybean var. JS-335 treated with PSB were sown in lines at 45cm apart using a seed rate of 75 kg ha^{-1} in July of both the years. Pendimethalin (Stomp 30EC) herbicide @ 0.45 kg ha^{-1} was applied using 500 litres water on the same day of sowing followed by one hoeing (4 weeks after sowing in both the years to control weeds). Data on growth and yield attributes were recorded at the time of harvesting. Data on seed and straw yield were also recorded. The seed and straw samples were analysed for their N, P, K, S and Zn by adopting standard procedures (Jackson 1973) Protein and oil content were determined by standard methods. The uptake of nutrients was calculated by multiplying the nutrient concentration values with the yield data. The data were statistically analysed using standard procedures of ANOVA at 5% level of significance.

RESULTS AND DISCUSSION

Crop growth and yield

Significantly taller plants were recorded with the application of 100% NP compared to 50 and 75% NP levels. The positive effect of inorganic fertilizers on plant height may be due to poor status of N and P in soil (Tripathi 2007). Plant height also improved significantly over control with 50 and 75% NP alongwith 4t FYM and 25 kg S ha^{-1}. This treatment was statistically at par with 75% NP + 4t FYM + 5 kg Zn ha^{-1}. The maximum values of plant height (62.3 cm) were recorded with 75% NP + 4t FYM + 25 kg S ha^{-1}. This treatment was statistically at par with 75% NP + 4t FYM + 5kg Zn ha^{-1} and 100% NP alone in respect of plant height. Adequate and continous availability of nutrients with recommended NP or combined use of FYM with NP might have improved the plant height of soybean (Singh *et al.* 2013).Higher values of pods/plant (54.1), pods weight/plant (21.7g), seed yield/plant (14.49 g) and 100 seeds weight (13.13g) were also recorded with the application of 75% NP + 4t FYM + 25kg S ha^{-1} over other treatments, owing to higher growth in terms of plant height with this treatment. Application of 75% NP + 4t FYM + 25kg S ha^{-1} being at par with 75% NP + 4t FYM + 5kg Zn ha^{-1} showed a positive and significant effect on these yield attributes over most of the treatments. This might be due to balanced use of fertilizers in soil which increased their availability in soil. This could also be attributed to slow decomposition of FYM resulting in release of nutrients in synchrony with crop demand and their continuous availability in soil for higher number of pods and seeds/ pod. Similar results were reported by Najar *et al.* (2011) and Ram *et al.* (2014).

Table 1: Effect of various treatments on growth, yield attributes and yield of soybean (mean of 2 years)

Treatment	Plant height (cm)	Pods/ plant	Pods weight/ plant (g)	Seed yield / Plant (g)	100 seeds weight (g)	Yield (q ha^{-1})	
						Grain	Straw
T_1 Control	48.1	47.6	17.5	12.46	11.81	19.69	28.94
T_2 50% NP	51.2	49.4	18.5	13.20	12.03	21.79	32.62
T_3 75% NP	54.1	50.7	20.0	13.37	12.24	23.87	35.84
T_4 50% NP +4t FYM ha^{-1}	57.0	50.1	19.1	13.30	11.99	23.74	34.13
T_5 50% NP +4t FYM + 25kg S ha^{-1}	58.5	52.9	21.0	14.07	12.67	25.90	38.47
T_6 50% NP +4t FYM + 5kg Zn ha^{-1}	58.0	52.3	20.8	14.13	12.61	25.82	38.09
T_7 50% NP +4t FYM + PSB	55.2	52.2	20.6	13.97	12.58	24.93	35.81
T_8 75% NP +4t FYM ha^{-1}	58.7	52.0	20.1	14.03	12.68	27.00	39.78
T_9 75% NP +4t FYM + 25kg S ha^{-1}	62.3	54.1	21.7	14.49	13.13	29.59	43.49
T_{10} 75% NP +4t FYM + 5kg Zn ha^{-1}	62.0	53.9	21.5	14.30	13.07	29.14	42.03
T_{11} 75% NP +4t FYM + PSB	60.5	53.4	21.3	14.17	12.72	28.61	42.10
T_{12} 100% NP	62.0	53.6	20.9	13.69	12.53	27.09	40.38
SEm $\pm$	7.45	0.83	0.79	0.33	0.39	1.05	2.20
CD (P=0.05)	3.19	1.83	1.74	0.72	0.85	2.30	4.82

Increase in seed yield of soybean over control (19.69 q ha^{-1}) was 21.2 and 37.6 percent due to addition of 75 and 100% NP, respectively (Table 1). The corresponding increase in straw yield was 23.8 and 39.5 per cent. Higher response to the applied N and P was expected on this N and P deficient experimental soil. The seed and straw yield of soybean were significantly influenced by different combinations of organic and inorganic fertilizers. Application of 75% NP + 4t FYM + 25 kg S ha^{-1} recorded the highest mean seed (29.59 q ha^{-1}) and straw (43.49 q ha^{-1}) of soybean which were 50.2 and 50.8 per cent higher over control. This may be attributed to better growth and higher yield attributes due to addition of FYM and fertilizer (Ram *et al.* 2014, Arbad and Ismail, 2011). Combined application of 75% NP + 4t FYM + 5kg Zn ha-1 increased the seed and stover yields of soybean significantly over control. The increase in yield caused by FYM in presence and absence of added Zn could be attributed partly due to presence of Zn in FYM itself and also to the chelation effect of organic acids formed during decomposition of both native and applied Zn (Singh, 2017). Similarly, application of S increased the mean seed and stover yield from 19.69 to 29.59 q ha^{-1} and from 28.94 to 43.49 q ha^{-1}, respectively which may be attributed to low sulphur status of soil. Similar results were reported by Najar *et al.* (2011). Inoculation of PSB alongwith 75% NP + 4t FYM ha-1 also improved the yield over control as reported by Sarawgi *et al.* (2008).

Quality

Seed protein and oil content are important parameters which govern the quality of soybean. There was significantly higher percentage of protein in seed under all the treatments as compared to control. The protein content in seeds ranged from 37.37 to 40.62%, the minimum being in control. Application of 100% NP and 75% NP + 4t FYM + 25kg S ha^{-1} being at par proved significantly superior to other treatments in respect of protein content in seeds. This may be due to accumulation of more nitrogen with these treatments and ultimately showing more protein percent (Singh, 2011). Application of 75% NP + 4t FYM + 5kg Zn ha^{-1} also improved the protein content in seeds. The effect of inoculation of seeds with PSB alongwith FYM and NP fertilizer was non significant on protein percent. The protein yield ranged from 735.8 to 1201.9 kg ha^{-1}. The minimum protein production was noted under control which may be attributed to lower seed yield of soybean. Protein production significantly increased with increasing levels of NP fertilizers and maximum value was recorded with 100% NP. Addition of NP levels with 4t FYM ha^{-1} enhanced the protein production over chemical fertilizer alone. Application of both S and Zn coupled with 4t FYM + 50 or 75% NP also improved the protein yield and maximum value of protein yield (1201.9 kg ha^{-1}) was recorded under 75% NP + 4t FYM + 25 kg S ha^{-1} showing the beneficial effect of combined application of chemical fertilizers and FYM (Najar *et al.* 2011, Ram *et al.* 2014).

Table 2: Effect of various treatments on quality of soybean (mean of 2 years)

Treatment	Seed Protein content (%)	Protein yield (kg ha^{-1})	Oil Content (%)	Oil yield (kg ha^{-1})
T_1 Control	37.37	735.8	19.35	382.2
T_2 50% NP	38.12	830.6	19.60	428.8
T_3 75% NP	38.81	923.4	19.88	476.2
T_4 50% NP +4t FYM ha^{-1}	38.62	916.8	20.23	482.2
T_5 50% NP +4t FYM + 25kg S ha^{-1}	39.00	1010.1	21.01	546.2
T_6 50% NP +4t FYM + 5kg Zn ha^{-1}	39.00	1006.9	21.04	545.1
T_7 50% NP +4t FYM + PSB	38.62	962.8	20.35	507.1
T_8 75% NP +4t FYM ha^{-1}	39.75	1073.2	20.40	551.3
T_9 75% NP +4t FYM + 25kg S ha^{-1}	40.62	1201.9	21.10	625.2
T_{10} 75% NP +4t FYM + 5kg Zn ha^{-1}	40.50	1188.2	21.07	614.8
T_{11} 75% NP +4t FYM + PSB	40.00	1144.4	20.50	585.6
T_{12} 100% NP	40.19	1088.7	19.92	542.1
SEm $\pm$	0.45	37.50	0.15	13.07
CD (P=0.05)	0.98	82.12	0.33	28.62

The oil content in soybean ranged from 19.35 to 21.10 per cent. The effect of NP fertilizers on oil content was observed to be beneficial (Singh, 2011). Application of NP levels alongwith 4t FYM + 25 kg S ha^{-1} significantly improved the oil content. Similarly NP + FYM + 5kg Zn ha^{-1} improved the oil content over control. Addition of Zn might have activated the enzymes responsible for the production of oil and raised the oil content in seed (Dhawan *et al.* 2006). Among the treatments studied, 75% NP + 4t FYM + 25kg S ha-1 appeared to be the best in respect of oil content in soybean seeds (Najar *et al.* 2011). All the three levels of N and P fertilizers improved the oil yield over control which may be attributed to higher seed production (Singh, 2011). The oil yield of soybean was further improved when both levels of NP (50 and 75%) fertilizers were added in combination with FYM. Application of 25kg S ha^{-1} alongwith FYM and 75% NP produced higher yield of oil. Application of Zn along with FYM and NP levels also improved the oil yield but S was more effective in improving the oil yield than that of zinc. Dhawan *et al.* (2006) also reported similar results. Inoculation with PSB was not effective in increasing the oil yield of soybean. The maximum (625.2 kg ha^{-1}) and minimum (382.2 kg ha^{-1}) oil yields were recorded under 75% NP +4t FYM + 25 kg S ha^{-1} and control, respectively. The results indicated the beneficial effect of integrated use of plant nutrients in the soybean crop.

Uptake of nutrients

Nitrogen uptake by soybean increased significantly with different treatments over control (Table 3). The mean increases in N uptake were from 117.7 to 174.2 kg ha^{-1} and 8.9 to 17.8 kg ha^{-1}, respectively by seed and straw with increase in the level of NP from control to 100% NP. The highest N uptake by soybean was recorded with the application of 75% NP + 4t FYM + 25 kg S ha^{-1} or 5 kg Zn ha^{-1}. This increase in N uptake may be attributed to increased seed and straw production (Arbad and Ismail 2011). Inoculation with PSB also improved the uptake of N by the crop (Sarawgi *et al.* 2008). The P uptake by seed and straw ranged from 9.6 to 17.4 kg ha^{-1} and 4.6 to 11.7 kg ha^{-1}, respectively. Application of NP levels increased the uptake of P by soybean crop which may be ascribed to increased seed and straw production and improvement in P content in the crop (Tripathi, 2007 and Singh 2011). Combined application of NP levels + Zn + FYM and NP levels + FYM + S also improved the P uptake by the crop over control. Sulphur proved more beneficial than that of zinc in improving P uptake by soybean crop. Application of NP + FYM + PSB also enhanced the utilization of P by soybean crop (Sarawgi *et al.* 2008). This may be due to more availability of P from soil due to the solubility action of PSB. Addition of NP fertilizers proved beneficial in increasing K uptake by soybean seed and straw which may be attributed to higher production of seed and straw. The higher yields of seed and straw under 50 or 75% NP levels coupled with 4t FYM ha^{-1} absorbed large quantities of K from the soil thus depleting the soil more K consequently showing its higher uptake in plants (Arbad and Ismail 2011). Application of NP levels + 4t FYM + 25 kg S ha^{-1}

or 5 kg Zn ha^{-1} also improved K uptake by the crop. The positive influence of S fertilization on nutrient content of the crop seems to be due to improved nutritional environment both in the rhizosphere and the plant system (Dhawan *et al.* 2006), inoculation of PSB alongwith FYM and NP levels also improved the K uptake by the crop. The maximum amounts of K by seed (16.6 kg ha^{-1}) and straw (77.8 kg ha^{-1}) were utilized under 75% NP + 4t FYM + 25kg S ha^{-1}. Moreover, higher amount of K was utilized by straw than seed, it was merely because of higher content of K in straw of the crop. All the treatments proved beneficial in increasing the uptake of S by soybean seed and straw over control (Table 3). The minimum (7.9 kg ha^{-1}) and maximum values (17.5 kg ha^{-1}) were recorded under control and 75% NP + 4t FYM + 25kg S ha^{-1}, respectively. Application of NP levels alone and in combination with FYM also improved the S uptake which may be attributed to increased availability. S as a result of its addition. Similar results were reported by Najar *et al.* (2011). Zinc uptake by soybean seed and straw ranged from 11.6 to 32.9 g ha^{-1} and 8.4 to 24.2 g ha^{-1}, respectively. Application of NP levels alongwith FYM improved the utilization of zinc by the crop over control. The maximum uptake of Zn by soybean seed and straw was recorded under 75% NP + 4t FYM + 5kg Zn ha^{-1} (Arbad and Ismail, Singh 2017).

It may be concluded that the combined application of 75% NP + 4t FYM +25kg S ha^{-1} and 75% NP + 4t FYM + 5 kg Zn ha^{-1} were found to be beneficial in increasing the production of soybean and uptake of nutrients by the crop. The quality in terms of protein and oil content was also improged with integrated use of chemical fertilizers and FYM. Zinc and sulphur are also limiting nutrients in Amravati region of Maharashtra and need to be included in fertilizer schedule.

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