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INTEGRATED NUTRIENT MANAGEMENT FOR QUALITY PRODUCTION OF CHILLI ON ACID ALFISOL

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ABSTRACT

Experiment was conducted during rabi seasons 2010-2011 Medziphema Nagaland to find out the effect of integrated nutrient management on growth, yield and quality of chilli (Capsicum annum L.) and fertility status of soil under foothill condition of Nagaland. Results revealed that the application of different levels of fertilizers, organic manures and biofertilizers either alone or in combination significantly influenced the growth, yield and quality of chilli as compared to control. The maximum plant height (105.58 cm), leaves plant^{-1} (516.4), branches plant^{-1} (104.3), leaf area (55.65 cm^2), fruit plant^{-1} (99.4), fruit weight (3.30 g), fruit length (8.90 cm), fruit diameter (1.20 cm), green fruit yield (19.47 t ha^{-1}), TSS (5.10 º Brix) and vitamin C content (247.1 mg 100^{-1}g) were recorded with the conjoint application of 50% NPK + 50% FYM + biofertilizers followed by 50 % NPK + 50 % vermicompost + biofertilizers and 50 % NPK + 50 % pig manure + biofertilizers. There was a significant build up of organic carbon in the soil after harvest of the crop with 50% NPK + 50% FYM + biofertilizers followed by 50 % NPK + 50 % pig manure + biofertilizers and 50 % NPK + 50 % vermicompost + biofertilizers. Application of 50% NPK + 50% FYM +biofertilizers also produced the highest net return of ₹ 3,16,338 ha^{-1} along with cost benefit ratio 1:4.33 followed by 50 % NPK + 50 % pig manure + biofertilizers and 50 % NPK + 50 % vermicompost + biofertilizers.

Key words: Chilli, integrated nutrient management, growth, yield, quality, economics

INTRODUCTION

Chilli (*Capsicum annum* L.) belongs to the family Solanaceae is one of the most important vegetable cum spice crop grown throughout the world for supply in the fresh market as well as for processing. It is consumed in various forms, fresh green chillies as vegetables to dried powder as spices. India is the largest producer, consumer and exporter of chilli in the world. Chilli is a rich source of vitamin C and its content is 5 times more than that of tomato. The hotness or pungency of chillies is due to presence of capsaicin and dihydrocapsaicin. Chilli being a heavy feeder and exhaustive crop responds very well to nutrient application. Among various factors responsible for low production of chilli, nutrition is of prime importance for maintaining higher yield and soil fertility. The increasing use of chemical fertilizers to increase vegetable production has been widely recognized but its long run impact on soil health, ecology and other natural resources are detrimental which affect living organisms including beneficial soil microorganism and human being. The cost of chemical fertilizers is also increasing day by day hence, adoption of integrated plant nutrient offers scope for sustainable crop production and improves soil fertility (Lal and Kanaujia, 2013). Use of organic manures in INM help in mitigating multiple nutrient deficiencies. Application of organic manures to acidic soil reduces the soluble and exchangeable Al temporarily by forming complex and provides better environment for growth and development in addition to improvement in physical, chemical and biological properties of soil (Avitoli *et al*., 2012). The role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters (Vimera *et al*., 2012). The agro-climatic condition prevailing in the low hills of Nagaland have been found to be highly favourable for chilli cultivation. But very limited information is available about the nutrient requirement of chilli in North Eastern region including acidic soils of Nagaland in particular. In view of the above, the present investigation was undertaken to find out the effect of integrated nutrient management on the growth, yield, and quality of chilli and fertility status of soil after harvest under foothill condition of Nagaland.

MATERIALS AND METHODS

A field experiment was conducted during rabi seasons of 2010 – 2011 at the Experimental Farm of SASRD, Medziphema Campus, Nagaland University, Nagaland. The field is located at the altitude of 304.8 m above mean sea level with geographical location at 20º 45' 43" N latitude and 93 º 53' 04" E longitudes. The soil of the experimental site was sandy loam having soil pH 4.6, organic carbon 19.5 g kg^{-1} and available N 290, P 17.8 and K 240 kg ha^{-1},

respectively. The experiment was laid out in a randomized block design with three replications. Plot size measured 1.8 m x 1.8 m and spacing was maintained at 45 x 30 cm. Forty five days old healthy seedlings of G-4 variety with uniform vigour and height were transplanted on 9 October, 2010. The treatments consisted of T_1 - Control, T_2 - 20 t FYM ha^{-1}, T_3 - 15 t Pig manure ha^{-1}, T_4 - 10 t Vermicompost ha^{-1}, T_5 - 100% NPK, T_6 - 75% NPK + biofertilizers, T_7 - 50% NPK + 50% FYM, T_8 - 50% NPK + 50% Pig manure, T_9 - 50% NPK + 50% Vermicompost, T_{10} - 50% NPK + 50% FYM + biofertilizers, T_{11} - 50% NPK + 50% Pig manure + biofertilizers, T_{12} - 50% NPK + 50% Vermicompost + biofertilizers. Nitrogen, P and K were applied through urea, single superphosphate and muriate of potash respectively. Full dose of P and K and half dose of N were applied at the time of transplanting and remaining half dose of N was given in two equal doses *ie*. 30 and 60 days after transplanting. Manures viz., FYM, pig manure and vermicompost were incorporated as per treatment in respective plot prior to transplanting. Seedlings were inoculated with biofertilizers (*Azospirillum* and Phosphotica) prior to transplanting. Observations on plant height, leaves plant^{-1}, branches plant^{-1}, leaf area, fruit plant^{-1}, fruit weight, fruit length, fruit diameter, green fruit yield, were recorded at harvesting. Total soluble solid was determined using hand refractometer and results expressed in ^{o}brix. Vitamin C content was determined by 2, 6-dichlorophenol indophenol visual titration method (A.O.A.C., 1984) and expressed in mg 100 $^{-1}$g. Soil samples were collected before and after harvest of the crop from different locations of the experimental plot to a depth of 15 cm with the help of screw type auger. Soil samples were analysed for pH, organic carbon, available nitrogen, phosphorus and potassium by adopting standard procedure. Economics of the treatments were calculated as per prevailing market price of input and output. Gross income was calculated by yield multiplied with whole sale rate of chilli (₹ 30,000 t^{-1}). Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment. Cost-benefit ratio was worked out by dividing net return from total cost of cultivation.

RESULTS AND DISCUSSION

Growth characters

Applications of NPK fertilizers, organic manures and biofertilizers alone or in combination were found to have significant effect on growth characters as compared to control (Table 1). Application of 50% NPK + 50% FYM + biofertilzers recorded maximum plant height (105.58 cm), leaves plant^{-1} (516.4), branches plant^{-1} (104.3) and leaf area (55.65 cm^2). The lowest values of growth characters were recorded with control. The increase in vegetative growth might be due to the role of nitrogen in promoting vegetative growth and enhancing cell division and elongation as well as greater chlorophyll synthesis and increased activity of leaf formation and development in chilli. The added FYM in integrated nutrient management would have improved the physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plant resulting better plant growth. This might be attributed to certain growth promoting substances secreted by the biofertilizers which in turn might have led to better root development, better

Table 1: Effect of integrated nutrient management on growth, yield and quality of chilli

Treatments	Plant height (cm)	Leaves plant^{-1}	Branches plant^{-1}	Leaf area (cm^2)	Fruit plant^{-1}	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit Yield (t ha^{-1})	TSS (^{0}Brix)	Vitamin C (mg 100^{-1}g)
T_1-Control	66.51	208.5	66.4	37.45	60.7	2.78	6.88	0.80	10.29	4.37	119.0
T_2-FYM 20 t ha^{-1}	88.69	453.4	89.4	50.68	96.9	3.06	7.32	1.00	17.57	4.88	226.1
T_3-Pig manure 15 t ha^{-1}	78.65	426.4	76.2	40.69	70.8	2.85	7.28	1.00	11.95	4.76	138.6
T_4-Vermicompost 10 t ha^{-1}	81.96	240.6	70.1	43.09	74.5	2.83	7.90	1.10	12.51	4.57	150.9
T_5-100% NPK (100:60:60 Kg ha^{-1})	87.88	464.6	88.0	46.69	86.1	3.16	6.92	0.90	16.12	4.76	219.3
T_6-75% NPK + biofertilizers	88.18	446.8	83.0	49.18	78.5	3.29	7.71	0.90	15.32	4.75	210.4
T_7-50% NPK + 50% FYM	83.03	358.6	67.7	42.44	84.8	2.86	7.54	1.10	13.99	4.68	169.7
T_8-50% NPK + 50% PM	83.12	323.0	73.3	42.59	80.3	2.91	6.94	0.90	13.86	4.63	159.5
T_9-50% NPK + 50% VC	87.83	456.4	82.2	45.62	78.6	3.23	7.62	1.00	15.07	4.72	197.1
T_{10}-50% NPK + 50% FYM + bio	105.58	516.4	104.3	55.65	99.4	3.30	8.90	1.20	19.47	5.10	247.1
T_{11}-50% NPK + 50% PM + bio	93.24	473.3	93.6	51.12	96.3	3.14	7.78	1.00	17.93	4.89	230.8
T_{12}-50% NPK + 50% VC + bio	96.49	492.9	100.5	53.73	93.5	3.25	8.34	0.90	18.02	4.97	235.3
SE (m)±	0.31	0.01	0.01	0.65	0.02	0.01	0.08	0.04	0.49	0.03	0.89
CD (P=0.05)	1.05	0.05	0.03	2.21	0.08	0.03	0.29	0.14	1.69	0.08	3.02

PM= Pig manure, VC= Vermicompost, bio= biofertilizer

transportation of water, uptake and deposition of nutrients. Hangarge *et al*. (2001) reported that maximum growth characters in chilli were recorded under integrated nutrient supply system. These results are in conformity with the findings of Chumyani *et al*. (2012) in tomato, Vimera *et al*. (2012) in king chilli and Chumei *et al*. (2013) in brinjal, who found maximum growth characters with 50% NPK + 50% FYM + biofertilizers.

Yield attributing characters and yield

Integrated application of chemical fertilizers, organic manures and biofertilizers alone or in combination significantly increased yield and yield attributing characters of chilli compared to control (Table 1). Application of 50 % NPK + 50 % FYM + biofertilizers recorded maximum fruit plant^{-1} (99.4), fruit weight (3.30 g), fruit length (8.90 cm) and fruit diameter (1.20 cm). Higher vegetative growth might have helped in synthesis of greater amount of food material which were later translocated into developing fruits resulting in increased fruit length and fruit diameter. In adidition, organic manures supply essential nutrient in balanced ratio and improved physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plant resulting higher value of yield attributing characters. The highest fruit yield (19.47 t ha^{-1}) was recorded in treatment of 50 % NPK + 50 % FYM + biofertilisers followed by 50 % NPK + 50 % vermicompost + biofertilizers and 50 % NPK + 50 % pig manure + biofertilizers. This might be due to higher values of yield attributes. Chumyani *et al*. (2012) in tomato, Vimera *et al*. (2012) in king chilli and Chumei *et al*. (2013) in brinjal recorded maximum yield and yield attributes with 50% NPK + 50% FYM + biofertilizers.

Table 2: Effect of integrated nutrient management on the nutrient status of the soil after harvest

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Organic carbon (g kg^{-1})	Soil pH
T_1-Control	245.5	7.2	171.2	16.0	4.78
T_2-FYM 20 t ha^{-1}	255.1	8.3	184.3	20.0	4.81
T_3-Pig manure 15 t ha^{-1}	260.7	8.1	190.4	19.4	4.83
T_4-Vermicompost 10 t ha^{-1}	270.3	7.7	178.6	19.1	4.80
T_5-100% NPK (100:60:60 Kg ha^{-1})	320.6	9.3	201.2	19.3	4.84
T_6-75% NPK + biofertilizers	295.7	9.1	195.5	19.0	4.83
T_7-50% NPK + 50% FYM	270.1	10.3	210.7	18.9	4.86
T_8-50% NPK + 50% PM	269.2	9.8	216.1	18.6	4.81
T_9-50% NPK + 50% VC	280.5	10.8	218.4	18.5	4.89
T_{10}-50% NPK + 50% FYM + bio	285.6	13.4	245.0	22.2	4.90
T_{11}-50% NPK + 50% PM + bio	283.3	12.6	224.2	20.7	4.88
T_{12}-50% NPK + 50% VC + bio	275.4	12.5	220.2	20.4	4.87
SE (m)±	1.24	0.09	4.79	0.6	0.01
CD (P=0.05)	4.20	0.32	16.31	2.0	0.02

PM= Pig manure, VC= Vermicompost, bio= biofertilizer

Quality

It is evident from table 1 that maximum values of TSS (5.10º Brix) and vitamin C (247. 1 mg 100^{-1}g) were recorded with 50 % NPK + 50 % FYM + biofertilizers. The higher level of both vitamin C and TSS may be due to application of as a result of mineral fertilizers + organic manure or with biofertilizers in manner integrated effect which in turn may activate specific enzymes for the synthesis of these compounds. These findings are in agreement with Vimera *et al*. (2012) in king chilli and Lal and Kanaujia (2013) in *Capsicum.*

Fertility status of soil

Sustainability of a cropping system is being evaluated on the basis of crop yield as well as nutrient status of the soil after harvest of the crop. Available NPK, organic carbon and pH of the soil after harvest were significantly influenced by application of NPK fertilizers, organic manures and biofertilizers alone or in combination over control (Table 2). Maximum available nitrogen (320.6 kg ha^{-1}) was recorded with 100% NPK fertilizer also reported by Vimera *et al.* (2012). On the other hand, maximum available P_2O_5 (13.4 kg ha^{-1}) and K_2O (245.0 kg ha^{-1}) were recorded with 50 % NPK + 50 % FYM + biofertilizers which might be due to reduced solubility of Al and Fe and improved the CEC of the soil and thus increased the retention of K in exchangeable form by a mass action effect. Organic carbon of soil acts as a sink and source of nutrients for microbial population, which regulates the availability of different nutrients through microbial transformation. The net increase in organic carbon was much higher with organic manures in combination with biofertilizers and fertilizers over 100% NPK alone. Application of 50% NPK + 50 % FYM + biofertilizers recorded significantly higher soil organic carbon (22.2 g kg^{-1}) and soil pH (4.90) over other treatments. This may be due to increased

microbial activities in the root zone which decomposed organic manures and also fixed unavailable form of mineral nutrients into available forms in soil thereby substantiated crop requirements and improved organic carbon level and stabilized soil pH. Chaudhary *et al.* (2005) reported that the incorporation of biofertilizers and FYM with inorganic fertilizers significantly improved the organic carbon content and available N, P_2O_5 and K_2O status of the soil in tomato. Similar results were reported by Chumei *et al*. (2013) in brinjal and Lal and Kanaujia (2013) in *Capsicum*.

Table 3: Effect of integrated nutrient management on economics of the treatments

Treatments	Fixed cost (₹)	Treatment cost (₹)	Total cost (₹)	Gross Income (₹ha^{-1})	Net income (₹ ha^{-1})	Cost benefit ratio
T_1-Control	64300	0	64300	205820	141520	1:2.20
T_2-FYM 20 t ha^{-1}	64300	10000	74300	351400	277100	1:3.73
T_3-Pig manure 15 t ha^{-1}	64300	9000	73300	238980	165680	1:2.26
T_4-Vermicompost 10 t ha^{-1}	64300	100000	164300	250240	85940	1:0.52
T_5-100% NPK(100:60:60 Kgha$^{-1)}$	64300	7424	71724	322420	250696	1:3.49
T_6-75% NPK + biofertilizers	64300	5618	69918	306480	236562	1:3.38
T_7-50% NPK + 50% FYM	64300	8712	73012	279900	206888	1:2.83
T_8-50% NPK + 50% PM	64300	8212	72512	277120	204608	1:2.82
T_9-50% NPK + 50% VC	64300	52712	118012	301320	183308	1:1.55
T_{10}-50% NPK + 50% FYM + bio	64300	8762	73062	389400	316338	1:4.33
T_{11}-50% NPK + 50% PM + bio	64300	8262	72562	358680	286118	1:3.94
T_{12}-50% NPK + 50% VC + bio	64300	53762	118062	360460	242398	1:2.05

PM= Pig manure, VC= Vermicompost, bio= biofertilizer

Economics

It is evident from table 3 that the integration of 50% NPK + 50 % FYM + biofertilizers was found to be the most profitable treatment in chilli exhibiting highest net return of ₹ 3,16,338 ha^{-1} with cost - benefit ratio of 1:4.33 followed by ₹ 2,86,118 ha^{-1} in the treatment having 50 % NPK + 50 % Pig manure + biofertilizers. This might be due to lower cost of input and higher yield. These findings are in accordance with Vimera *et al.* (2012) in king chilli, Chumyani *et al*. (2012) in tomato, Chumei *et al*. (2013) in brinjal and Lal and Kanaujia (2013) in *Capsicum.*

It can be concluded from the results that the integrated use of 50% NPK + 50% FYM + biofertilizers was found optimum for quality and production of chilli without reducing fertility status of soil. This treatment reduced 50% chemical fertilizers without any compromise on yield and quality of chilli and fertility of soil. Therefore, 50% NPK + 50% FYM + biofertilizers may be recommended for sustainable yield of chilli and to nourish the soil fertility under foothill condition of Nagaland.

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