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Integrated nutrient management on growth, yield and quality of paprika alike chillies (*Capsicum annuum* L.)

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Abstract

The experiment was conducted for two seasons to study the effect of organic nutrient sources and inorganic sources of nutrients combined with biofertilizers on growth, yield and quality of paprika alike chillies (indigenous germplasm of paprika). The results revealed that application of vermicompost (250 g plant^{-1}) combined with neem cake (100 g plant^{-1}) recorded higher growth parameters, yield and quality attributes, which was comparable with inorganic fertilizers at the recommended levels. Under integrated nutrient management, application of 75% N (8 g plant^{-1}) + *Azospirillum* spp. (5 g plant^{-1}) + 75% P (1.7 g plant^{-1}) + Phosphobacteria (5 g plant^{-1}) + 100% K (2.5 g plant^{-1}) improved the growth, yield and quality parameters of paprika alike chillies as compared to recommended NPK through fertilizers indicating a saving 25% of both inorganic N and P through biofertilizers.

Keywords: colour, growth characters, inorganic, organic, paprika alike chillies, yield attributes

Introduction

India is the leading producer, consumer and exporter of chillies, which is primarily used as an essential condiment in foods for imparting pungency and red color. In India, there are a few indigenous types of chillies, which are akin to paprika (exotic type having high color with less or nil pungency) and with fruits having high color and low pungency such as 'Byadagi chilli' grown in Dharwad district of Karnataka state and Warangal Chappatta (Tomato chilli) grown in Warangal and Khammam districts of Andhra Pradesh, which have the qualities of paprika types that are grown in Spain and Hungary (Shiva *et al.* 2008). These chillies are much preferred by oleoresin manufacturers for extraction of paprika alike oleoresin (John 2000). Organic sources of nutrients are key factors for improving soil fertility and sustaining yield and quality of the crop in the long run. However, organic sources for incorporation into the soil are becoming scarce. Essential elements locked up in the organic manures are slowly mineralized and made available to the crops, which helps in increasing the yield and quality (Lal 2004), besides improving the fertility of the soil. To meet the increasing demand, application of adequate

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amount of nutrients is of paramount importance to ensure high yield and quality. Use of organic manures combined with chemical fertilizers ensures sustainable and quality production with minimum adverse effect on soil health and environment. In light of the above, the present investigation was undertaken to study the influence of organic and inorganic sources of nutrients in combination with biofertilizers on growth, yield and quality of paprika alike chillies.

Materials and methods

An investigation was carried out at Experimental Farm, ICAR-Indian Institute of Spices Research, Kozhikode (Kerala). Paprika alike chillies (indigenous) line, ICBD -11 [ICBD denotes the Indigenous Collections of Byadagi Dabbi] was selected for the study. The seeds were raised in nursery and transplanted to pots after one-month under rain-shelter for two seasons (January to June). The potting media comprised of one part each of dried leaf mould, well-decomposed farm yard manure, river sand and garden soil. Two different experiments were laid out in completely randomized design with three replications. The first set of experiment consisted of seven treatments comprising of organic manures and their combinations *viz*., T_1: Vermicompost (500 g plant^{-1}), T_2: Neem cake (160 g plant^{-1}), T_3: Farm yard manure (FYM plant^{-1}) (1 kg), T_4: Neem cake (100 g plant^{-1}) + Vermicompost (250 g plant^{-1}), T_5: Neem cake (100 g plant^{-1}) + FYM (500 g plant^{-1}), T_6: Recommended NPK fertilizer (5 g N + 2.5 g P_2O_5 + 2.5 g K_2O plant^{-1}), T_7: Absolute control (without organic and inorganic).

The second set of experiment consisted of 17 treatments comprising of different levels of recommended dose of chemical fertilizer (RDF) and its combination with biofertilizers *viz*., T_1: 75% NPK; T_2: 75% N + 100% P + 100% K; T_3: 75% N + 125% P + 100% K; T_4: 75% N + (75% P + Phosphobacteria) + 100% K; T_5: 100% N + 75% P + 100% K; T_6: 100% N + 125% P + 100% K; T_7: 100% N + (75% P + Phosphobacteria) + 100% K; T_8: 125% N + 75% P + 100% K; T_9: 125% N + 100% P + 100% K; T_{10}: 125% N + 125% P + 100% K; T_{11}: 125% N + (75% P + Phosphobacteria) + 100% K; T_{12}: (75% N + *Azospirillum* spp.) + 75% P + 100% K; T_{13}: (75% N + *Azospirillum* spp.) + 100% P + 100% K; T_{14}: (75% N + *Azospirillum* spp.) + 125% P + 100% K; T_{15}: (75% N + *Azospirillum* spp.) + (75% P + Phosphobacteria) + 100% K; T_{16}: 100% (Control). The recommended dose of fertilizers (100% RDF) was 150:75:75 kg NPK ha^{-1}. Nitrogen was applied in two equal splits (first at the time of planting and second three weeks after planting). Biofertilizers, *Azospirillum* and Phosphobacteria were applied 5 g each plant pot^{-1} twice (first at the time of planting and second three weeks after planting). Uniform cultural practices were followed. The nutrient content of organic manures were analyzed and given in Table 1.

Observations on morphological parameters (days to 50% flowering, plant height, weight of pericarp, yield) were recorded from 10 pots plants^{-1} in each replication, according to IPGRI descriptor (1995). The total extractable color of the fruit pericarp was analyzed by ASTA method using a Shimadzu UV-Visible spectrophotometer at 450 nm and the color value was expressed as ASTA units (ASTA 1995). The data thus collected for two seasons were pooled and subjected to standard statistical analysis as per Gomez & Gomez (1986).

Table 1. Nutrient content (%) of organic sources used in the experiment

	N	P	K	Ca	Mg	S	Fe	Zn	Cu
Organic source	%						mg kg^{-1}		
Neem cake	3.0	0.1	1.5	1.0	0.3	0.2	2050	17	10
FYM	0.5	0.25	0.3	1.1	0.5	0.18	2700	56	29
Vermicompost	2.0	0.8	1.2	3.3	1.1	0.8	6100	45	36

Results and discussion

Analysis of variance revealed significant differences among the organic as well as inorganic sources of nutrients and their combinations for economic traits (Tables 2 & 3) indicating the influence of organic manures and chemical fertilizers on growth, yield and quality parameters of paprika alike chillies.

Effect of organic manures

There were significant differences among the treatments in the organic sources of nutrients (Table 2). Application of 100% RDF resulted in minimum number of days for flowering (55.92 days) and it was on par with neem cake + vermicompost (56.11 days). The next best treatment was neem cake + FYM, which significantly differed from neem cake + vermicompost. However, maximum number of days for flowering (65.48 days) was recorded with absolute control (without organics and inorganics). The early flowering of plant is a desirable character for early fruiting and harvest. Tallest plants were produced by the application of RDF (128.1 cm), which was comparable with neem cake + vermicompost (127.8 cm). Application of neem cake + FYM, vermicompost and neem cake produced taller plants than that of 100% RDF. The absolute control registered the shortest plants. With respect to weight of pericarp per fruit, 100% RDF recorded the maximum (6.42 g), followed by neem cake + vermicompost (6.27 g) and neem cake + FYM (6.13 g), which were on par with each other. However, minimum pericarp weight was noticed with absolute control. Weight of pericarp is an important quantitative character contributing to the yield of paprika (powder). Significantly higher fruit yield was observed with the application of 100% RDF, neem cake + vermicompost and neem cake + FYM. The lowest fruit yield was registered with absolute control. Application of neem cake coupled with vermicompost resulted in better vegetative growth, flowering, yield and quality attributes in comparison to 100% RDF, which could be due to the beneficial effects of vermicompost in soil conditioning, strong retention of nutrients (macro and micro) (Edwards 1998), presence of

Table 2. Effect of organic sources on growth, yield and quality of paprika alike chillies

Treatment	Days to 50% flowering	Plant height(cm)	Weight of pericarp fruit^{-1} (g)	Yield plant^{-1}(g)	Color value (ASTA units)
T_1: Vermicompost (500 g plant^{-1})	58.98	125.40	6.05	567.13	245.00
T_2: Neem cake (160 g plant^{-1})	59.78	124.00	5.98	554.52	252.00
T_3: FYM (1 kg plant^{-1})	59.12	121.50	5.87	551.08	262.00
T_4: Neem cake (100 g plant^{-1}) + Vermicompost (250 g plant^{-1})	56.11	127.80	6.27	585.27	276.00
T_5: Neem cake (100 g plant^{-1}) + FYM (500 g plant^{-1})	58.17	126.30	6.13	572.31	265.00
T_6: 100% RDF (Control)	55.92	128.10	6.42	602.19	280.00
T_7: Absolute control (without organic and inorganic)	65.48	114.80	5.52	546.36	204.00
SEd	0.27	0.39	0.20	0.48	1.55
CD (P<0.05)	0.53	0.79	0.42	0.97	3.12

Table 3. Effect of inorganics and biofertilizers on growth, yield and quality of paprika alike chillies

Treatment	Days to 50% flowering	Plant height(cm)	Weight of pericarp fruit^{-1} (g)	Yield plant^{-1}(g)	Color value (ASTA units)
T_1: 75% NPK	60.65	115.78	5.27	421.32	215.98
T_2: 75% N + 100% P + 100% K	60.21	117.71	5.29	425.10	218.12
T_3: 75% N + 125% P + 100% K	60.02	117.98	5.35	425.37	223.53
T_4: 75% N + (75% P + PB) + 100% K	58.93	119.12	5.39	427.12	224.14
T_5: 100% N + 75% P + 100% K	58.22	119.85	5.39	428.32	231.42
T_6: 100% N + 125% P + 100% K	57.72	121.59	5.51	435.51	239.12
T_7: 100% N + (75% P + PB) + 100% K	57.15	124.12	5.62	435.79	253.45
T_8: 125% N + 75% P + 100%	55.92	124.17	5.63	442.43	253.91
T_9: 125% N + 100% P + 100% K	55.46	126.40	5.69	451.32	261.27
T_{10}: 125% N + 125% P + 100% K	55.31	126.59	5.74	457.19	262.13
T_{11}: 125% N + (75% P + PB) + 100% K	54.72	128.72	5.75	463.31	267.32
T_{12}: (75% N + Azo.) + 75% P + 100% K	54.75	128.78	5.79	465.12	279.10
T_{13}: (75% N + Azo.) + 100% P + 100% K	53.13	128.78	5.88	472.59	280.33
T_{14}: (75% N + Azo.) + 125% P + 100% K	52.77	131.11	5.97	491.23	289.31
T_{15}: (75% N + Azo.) + (75% P + PB) + 100% K	51.28	131.65	6.12	497.17	297.11
T_{16}: 100% NPK (Control)	57.81	121.34	5.47	431.12	237.25
SEd	0.35	0.42	0.27	0.89	2.90
CD ($P<0.05$)	0.72	0.85	0.55	1.79	5.82

plant growth regulating materials such as humic acids (Atiyeh *et al*. 2002), auxins, gibberellins and cytokinins (Krishnamoorthy & Vajrabhiah 1986; Tomati *et al*. 1988), in addition to the nitrification regulative property of neem cake (Singhal & Mudgal 1982). These findings are in line with the earlier reports of Savanur (1999) in paprika and Umesha *et al*. (2011) in black night shade (*Solanum nigrum* L.).

Application of 100% RDF recorded maximum colour value (280 ASTA units), which was comparable with neem cake + vermicompost. Total extractable colour expressed as colour value is one of the most important quality attributes of paprika alike chillies. The carotenoids contribute to the chilli red colour, which is constituted by two major pigments – capsanthin (30-60%) and capsorubin (6-18%), which increases with the advanced stage of ripeness and the content depends on factors such as cultivar, maturity stage, agro-techniques adopted and growing conditions (Shiva *et al*. 2008). Vermicompost might have favoured accumulation of total carotenoids, which in turn would have increased the color value of paprika alike chillies.

Effect of chemical fertilizers and in combination with biofertilizers

Vegetative growth, reproduction, yield and its attributes and quality parameter of paprika alike chillies were greatly influenced by the inorganic sources of nutrients alone and in combination with biofertilizers (Table 3). Application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K reduced the number of days to flowering, followed by 75% N + *Azospirillum* spp. + 125% P + 100% K and 75% N + *Azospirillum* spp. + 100% P + 100% K, which were significantly different from 100% RDF (control). However, control recorded the maximum number of days for flowering. Significantly higher plant heights were recorded with 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K, 75% N + *Azospirillum* spp. + 125% P + 100% K, 75% N + *Azospirillum* spp. + 100% P + 100% K and 75% N + *Azospirillum* spp. + 75% P + 100% K, when compared to other treatments and control. Vegetative characters of paprika alike chillies were also influenced by the chemical fertilizers alone and in combination with biofertilizers. Maximum reduction in days to flowering over control was found by the application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K (11.30%), followed by 75% N + *Azospirillum* spp. + 125% P + 100% K (8.72%), 75% N + *Azospirillum* spp. + 100% P + 100% K (8.10%) and 75% N + *Azospirillum* spp. + 75% P + 100% K (5.29%), while maximum increase over control was observed with 75% NPK. In contrast, maximum increase in plant height was recorded with the application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K (8.50%) over 100% NPK (control). However, maximum reduction in plant height over control was noticed with 75% NPK (-4.58%).

Application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K resulted in maximum pericarp weight fruit^{-1}. This is followed by 75% N + *Azospirillum* spp. + 125% P + 100% K and 75% N + *Azospirillum* spp. + 100% P + 100% K, which were significantly different from each other. The control showed the lowest pericarp weight. With respect to yield fruit^{-1}, maximum yield was recorded with the application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K, which differed significantly from the second best treatment, 75% N + *Azospirillum* spp. + 125% P + 100% K. Both the treatments produced higher yield than that of control. Higher weight of pericarp fruit^{-1} could be mainly contributed to higher yield produced (Table 3). The highest color value was expressed by the application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria + 100% K. However, higher colour values were recorded with 75% N + *Azospirillum* spp. + 125% P + 100% K, 75% N + *Azospirillum* spp. + 100% P + 100% K and 75% N + *Azospirillum* spp. + 75% P + 100% K as compared to other treatments and control. Among the economic characters, maximum increase over control was observed for color value (25.23%), followed by yield plant^{-1} (15.32%) and weight of pericarp fruit^{-1} (11.88%) in response to the application of 75% N + *Azospirillum* spp. + 75% P + Phosphobacteria +

100% K RDF (8.50%). This was followed by 75% N + *Azospirillum* spp. + 125% P + 100% K, 75% N + *Azospirillum* spp. + 100% P + 100% K and 75% N + *Azospirillum* spp. + 75% P + 100% K. The maximum decrease over control was registered in colour value (8.97%) with the application of 75% NPK. The same treatment also showed maximum reduction in pericarp weight (3.66%) and yield plant^{-1} (2.27%) over control (100% NPK).

Significant improvement in the vegetative growth, flowering, yield and yield attributing characters and quality of paprika alike chillies might be attributed to the integration of biofertilizers with inorganic/chemical fertilizers. In addition to chemical fertilizers, biofertilizers *viz*., *Azospirillum* spp. exerts its significant role in root proliferation, more uptake of nutrients and water, higher number of leaves, more photosynthesis and enhanced food accumulation, while Phosphobacteria enhances the availability of P in the rhizosphere. Thus, the biofertilizers facilitates the continuous availability of nutrients during the entire life cycle of the plant. These nutrients are important constituents of nucleotides, protein, chlorophyll and enzymes involved in various metabolic activities and have direct impact on vegetative and reproductive phases of the plants. The favourable response of biofertilizers in combination with organics/inorganics was also reported by Khan & Chattopadhyay (2009) in chilli and Savanur (1999) in paprika.

From the present study, it is concluded that among the organic nutrient sources, application of neem cake coupled with vermicompost resulted in better vegetative growth, flowering, yield and quality attributes in comparison to 100% RDF. Under integrated nutrient management, application of 75% N + 75% P + 100% K RDF along with biofertilizers improved the growth, yield and quality parameters of paprika alike chillies.

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