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Influence of naphthalene acetic acid (NAA) and integrated nutrient management (INM) on yield and economics attributes of chilli (*Capsicum annuum* L.)

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Abstract: The present experiment was conducted to study the response of naphthalene acetic acid NAA and integrated nutrient management on yield and yield attributes as well as and economics of chilli (*Capsicum annuum* L.) with four levels of NAA (0 ppm, 25 ppm, 50 ppm and 75 ppm) and five levels of vermicompost (VC) along with RDF (V_0-100% Recommended dose of fertilizer *i.e.* 120:60:60 Kg N P K /ha), V_1-100% N through Vermicompost, V_2-75% N through VC + 25% (RDF), V_3-50% N through VC + 50% (RDF) , V_4-25% N through VC + 75% (RDF), having 20 treatment combinations. The results revealed that the combine application of 50 ppm NAA and 100% N through vermicompost *i.e.* P_2V_1 performed well in respect of fruit length (8.73 cm), fruit diameter (1.46 cm) and fruit weight (2.91 g) while the application of NAA 50 ppm + 50% N through vermicompost along with 50% RDF *i.e.* P_2V_3 gave significantly (P=0.05) maximum number of fruits/plant (73.86) and fruit yield per hectare (121.20 q) with higher gross income (Rs.2,66,640.00/ ha), net profit (Rs.1,98,946.00/ ha) and benefit - cost ratio (2.94). Therefore, it can be concluded that the combine effect of NAA 50 ppm along with 50 % N through vermicompost +50% inorganic fertilizers (RDF) gave better result regarding growth and yield attributes and also generated maximum gross income, net return and B:C ratio while the next best treatment was application of NAA 75 ppm alongwith 25 % N through vermicompost + 75 % inorganic fertilizers (RDF).

Keywords: Chilli, NAA, RDF, Vermicompost

INTRODUCTION

Among the solanaceous fruit vegetables chilli (*Capsicum annuum* L.) is one of the most valuable commercial vegetable as well as spice crop not only for India but also for all over the world. India is the largest producer, consumer as well as exporter of chilli in the world. In Indian cuisine it has a crucial value for imparting natural colorant and pungent taste in food stuffs. It is a rich source of vitamin A, C and E, whose role as antioxidants is well documented. Cultivation of chilli is increasing day to day due to its greater importance. Chilies one of the exhaustive crop, therefore, it needs greater amount of nutrient application. The chemical fertilizers, of course increased the vegetable production but they decreased soil fertility, harm the environment and also cause health problems for consumers. Organic manures are excellent source of plant available nutrients and their addition to soil could maintain high microbial population and their activities (Joshi and Vig, 2010). Hence, adoption of integrated use of organic and inorganic fertilizers offers scope for sustainable crop production (Lal and Kanaujia, 2013). Vermicompost has been found to be an ideal organic source of minerals, macro and micro nutrients, plant growth hormones (IAA, IBA and GA), vitamins, enzymes and many beneficial microbes and releases nutrients slowly for absorption with additional nutrients which help to increase yield (Hidalgo and Pashanasi, 1999). The increase fruit drop, decrease percentage of fruit set, more vegetative growth and delay in flowering are the major issues which lead to lower production and productivity of chilli (Erickson and Makhart, 2001) and Balraj *et al*. (2002). NAA improves the internal physiology of plants in terms of better supply of water, nutrients and other bio-compounds vital for their proper growth and development (Meena and Dhaka, 2003) and Khurana *et al*. (2004).Such efforts will be effective not only in sustaining productivity on soil health but also in curtailing a part of chemical fertilizers requirement of the crop. Keeping all the facts under consideration and visualising the paucity of information on these aspects for agroclimatic condition of Bihar. In view of the above facts, the investigation was undertaken to find out the response of NAA and integrated nutrient management on yield attributes and economics of chilli.

MATERIALS AND METHODS

The field experiment was conducted at Bihar Agricultural College, Sabour during summer season 2014-15. The

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experiment was laid out in a factorial randomized block design, replicated three times with the variety 'Jawaher Mirch 218'. The treatments used were Naphthalene Acetic acid (NAA), vermicompost (VC) as organic manure and inorganic fertilizers such as urea, single super phosphate (SSP) and murate of potash (MOP). There were four levels of NAA (P_0 - 0 ppm, P_1- 25 ppm, P_2- 50 ppm and P_3- 75 ppm) and five levels of vermicompost along with RDF (V_0-100% Recommended dose of fertilizers *i.e.* 120:60:60 Kg N P K /ha), V_1- (100% N through Vermicompost), V_2- (75% N through VC+ 25% RDF), V_3- (50% N through VC + 50% RDF) and V_4- (25% N through VC + 75% RDF) having 20 treatment combinations. The soil of the experimental plot was sandy loam in texture having pH 7.8, organic carbon (0.42%), available nitrogen (125.11 kg/ ha), phosphorus (26.28 kg/ ha) and potassium (206.18 kg/ ha) and as per the method suggested by Schofield and Taylor (1965),Piper (1950),Jackson (1963), Olsen method (1954) and Toth and Prince (1944) respectively. Treatment wise vermicompost and full dose of P_2O_5 and K_2O as well as 1/3rd dose of nitrogen were applied and mixed thoroughly and then plots were dressed for transplanting. Well-developed healthy seedling attaining an age of 35 days were uprooted from the nursery and transplanted in the evening with a spacing 50 cm x 30 cm. First top dressing of 1/3rd N as urea was done after 20 days after transplanting and 2nd top dressing was done 50 days after transplanting. The treatment wise NAA was sprayed in each plot early in the morning when dews had evaporated. The spraying was performed with the help of knapsack sprayer. First sprayed was done after 35 days after transplanting and second was at the time of flowering. Plant protection measure and other cultural practices were followed as per need of the crop. The observations were recorded on yield attributing characters like number of fruits per plant, fruit length, fruit diameter, fruit weight and fruit yield per plant and yield (fresh green fruit) q/ha.

The economics studies of the crop was done by computing the cost of cultivation and net profit in rupees per hectare on the basis of the prevailing rate of inputs and output obtained from the local market. Gross return was calculated by multiplying yield (q/ha) with average selling rate of chilli fruits. The net return (Rs/ha) was calculated by subtracting the cost of cultivation from the gross return obtained from the sale of the harvested chilli fruits. The benefit -cost ratio *i.e.* the net return per rupee investment was obtained by dividing net profit with total cost of cultivation.

RESULTS AND DISCUSSION

It is evident from the results that the NAA and integration of organic and inorganic fertilizers could bring significant result in the production and economics of chilli. The data (Table 1) showed that application of NAA at 50 ppm (P_2) gave highest number of fruits (71.33), average fruit length (8.55 cm), fruit diameter (1.41 cm), fruit weight (2.81 g), fruit yield per plant (202.53 g) and yield per hectare (108.39 q/ha) which was at par with NAA 75 ppm (P_3) except for fruit length, diameter and weight. The increase in fruit length and diameter might be attributed to increase in the number of cells as well as elongation of cells which are the characteristic action of NAA. These results are supported by Kannan *et al*. (2009) on Paprika cv. KtPl-19.They found that maximum yield attributing characters were achieved by the treatment of NAA 50 ppm during both winter and summer season.. Better performance of NAA might be also due to proper growth of plants, control of abscission layer in full bloom stage which hasten the fruit setting and increased in number of fruits, ultimately enhanced yield. These results are also in close agreement with earlier findings of Khurana *et al.* (2004), They reported that higher yield of chilli was achieved by after spray of NAA, similar results were found by Veishnav *et al.* (2012) with the foliar application of 40 ppm NAA.

Integration of organic and inorganic fertilizers augmented the yield and yield attributing characters. Treatment V_1 (100% N through VC) produced maximum fruit length (8.67 cm), fruit diameter (1.36 cm) and fruit weight (2.78 g) and found significantly superior to the rest levels of vermicompost along with RDF. This might be due to sole application of vermicompost caused shorter plant, lesser number of branches which ultimately produced less number of fruits so the synthesized food material which were later translocated into developing fruits resulting in increased fruit length, fruit diameter and fruit weight. These results are also supported by Sinha *et al.* (2010 b) reported that vermicompost improved yield parameters of Egg plant and similar results were also found by Azarmi *et al.* (2008) in tomato. However, maximum number of fruit (69.36), fruit yield per plant (184.69 g), fresh green fruit yield (102.46 q/ha) were recorded inV_3 (50% N through VC + 50% RDF). The possible reason for increased fruit yield was attributed to the solubilization effect and availability of nutrients by the addition of vermicompost (Edwards and Bohlen, 1996 and Parthasarathi, 2010). The adequate amount of inorganic fertilizers, effectively maintain the physiology of plant which reduces the fruit drop and increases the number of fruits, ultimately increase in yield. These results are in conformity with earlier finding of Sha and Karuppiah (2010). They reported that combined application of vermicompost (7.5 t/h), recommended dose of N P K (160:60:60 Kg/h) along with foliar spray of micronutrient mixture (0.25%) enhanced yield and yield parameters of chilli. Similar results were reported by Mohd Rafi *et al*. (2002) in tomato and Shashidhara (2000), Hangarge *et al*. (2002) in chilli.

Table 1. Effect of levels of NAA and vermicompost along with RDF on yield attributes of chilli during 2014-15.

Levels of NAA	Number of Fruits / Plant	Fruit Length (cm)	Fruit Diameter (cm)	Fruit Weight (g)	Fruit Yield/ Plant (g)	Fresh Yield (q/ ha)
P_0(0 ppm)	55.66	7.85	1.12	2.11	119.09	66.03
P_1(25ppm)	65.00	8.15	1.23	2.61	162.57	88.87
P_2(50ppm)	71.33	8.55	1.41	2.81	202.53	108.39
P_3(75ppm)	69.44	8.47	1.38	2.79	196.65	104.84
CD at 5%	0.61	0.08	0.01	0.03	1.80	0.95
Levels of Vermicompost along with RDF						
V_0 (100 % RDF)	58.50	7.77	1.18	2.44	147.58	76.52
V_1 (100% N through VC)	60.40	8.67	1.36	2.78	164.35	90.30
V_2 (75% N through VC + 25% RDF	66.65	8.45	1.33	2.63	178.60	97.61
V_3 (50% N through VC + 50% RDF)	69.36	8.17	1.26	2.59	184.69	102.46
V_4 (25% N through VC +75% RDF)	67.88	8.20	1.26	2.46	175.82	93.26
CV at 5%	0.76	0.09	0.01	0.03	2.25	1.19

Table 2. Combined effect of NAA and vermicompost along with RDF on yield attributes during 2014-15 of chilli.

P X V	Number of fruits/ plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit yield/ Plant (g)	Fresh yield (q/ ha)
P0V0	47.33	6.67	0.85	1.76	94.53	54.51
P0V1	52.40	8.59	1.27	2.56	107.28	60.46
P0V2	56.40	8.25	1.20	2.25	126.90	69.37
P0V3	61.80	7.98	1.16	2.18	134.72	73.64
P0V4	60.40	7.76	1.13	1.80	132.05	72.18
P1V0	52.86	7.36	1.14	2.53	127.53	69.72
P1V1	65.40	8.69	1.29	2.77	149.16	81.54
P1V2	68.40	8.37	1.30	2.62	179.21	97.96
P1V3	70.60	8.20	1.24	2.60	183.56	100.34
P1V4	67.73	8.12	1.20	2.55	173.39	94.78
P2V0	68.20	8.59	1.38	2.75	186. 04	91.20
P2V1	70.40	8.73	1.46	2.91	204.42	111.75
P2V2	71.60	8.62	1.42	2.85	208.06	113.73
P2V3	73.86	8.31	1.40	2.80	212.30	121.20
P2V4	72.60	8.49	1.39	2.76	201.83	104.08
P3V0	65.60	8.46	1.35	2.73	182.23	90.66
P3V1	69.20	8.68	1.44	2.87	196.57	107.45
P3V2	70.20	8.58	1.38	2.81	200.26	109.40
P3V3	71.20	8.19	1.35	2.78	208.19	114.66
P3V4	70.80	8.45	1.35	2.74	196.03	102.00
CD at 5%	5.31	0.65	0.13	0.25	15.64	8.29

Table 3. Combine effect of NAA and vermicompost along with RDF on economics and benefit: cost ratio of Chilli.

PXV	Yield (q/ ha)	Gross income (Rs.)	Total cost of cultivation (Rs.)	Net Income (Rs.)	B:C Ratio
P_0V_0	54.51	119922	51868	68054	1.31
P_0V_1	60.47	133034	81616	51418	0.63
P_0V_2	69.37	152614	74445	78169	1.05
P_0V_3	73.64	162008	66922	95086	1.42
P_0V_4	72.18	158796	59391	99405	1.67
P_1V_0	69.72	153384	52430	100954	1.92
P_1V_1	81.54	179388	82178	97210	1.18
P_1V_2	97.96	215512	75007	140505	1.87
P_1V_3	100.34	220748	67484	153264	2.27
P_1V_4	94.78	208516	59953	148563	2.47
P_2V_0	91.20	200640	52640	148000	2.81
P_2V_1	111.75	245850	82388	163462	1.98
P_2V_2	113.73	250206	75217	174989	2.32
P_2V_3	121.20	266640	67694	198946	2.93
P_2V_4	104.08	228976	60163	168813	2.80
P_3V_0	90.66	199452	52850	146602	2.77
P_3V_1	107.45	236390	82598	153792	1.86
P_3V_2	109.4	240680	75427	165253	2.19
P_3V_3	113.8	250360	67904	182456	2.68
P_3V_4	102	224400	60397	164003	2.71

The interaction effects between plant growth regulator (NAA) and vermicompost along with RDF levels were found to be quite superior to their individual effect. The data (Table 2) revealed that significantly maximum number of fruits (73.86), fruit yield per plant (212.30 g) and fresh yield per hectare (121.20 q) were produced by the combine application of 50 ppm NAA along with 50% N through VC + 50 % RDF *i.e.* P_2V_3 . This might be due to the fact that combine application of organic and inorganic fertilizers provide sufficient nutrients to plant for proper growth and development and plant growth regulator (NAA) reduces the fruit drop, increases the fruit setting as well as enhances the mobilization of photo assimilates at a faster rate which increase number of fruits and ultimately increase in yield. These findings are in agreement with the results of Kalshyam *et al*. (2011).Who noted; combine application of NAA and fertilizer (75 ppm NAA + 150 Kg N/h) gave higher yield and its component in chilli cv. Pusa Jwala. Similar results also were found by of Singh and Mukherjee (2002) in chilli.. The foliar application of NAA 50 ppm (P_2) + 100 % N supplied through vermicompost (V1) *i.e.* P_2V_1 gave significantly maximum fruit length (8.73 cm) and fruit diameter (1.46 cm). This might be due to the fact that the vermicompost is a rich mixture of major and minor plant nutrients and increased microbial activity, improve the availability of soil phosphorus and nitrogen to plant which help in cell division, hence increase in length and diameter of fruits.

Economics: The interaction effect between NAA and vermicompost along with inorganic fertilizers was found beneficial. The net profit per hectare ranged from Rs.51, 418.00 to Rs. 1, 98,946.00 (Table 3). The highest net profit (Rs.1,98,946.00/ ha) was obtained by the foliar application of 50 ppm NAA + 50% VC + 50% RDF (P_2V_3) while 100% N through vermicomposting the absence of NAA *i.e.* P_0V_1 gave least net profit (Rs.51,418.00). The benefit-cost ratio ranged from 0.63 to 2.93 depending upon the treatment and it was found to be highest (2.93) by the foliar application of 50 ppm NAA + 50% VC + 50% RDF *i.e.* (P_2V_3) followed by 50 ppm NAA + 25% N through VC + 75% RDF *i.e.* $P_2V_4$with 2.80 benefit - cost ratio of 2.80. Our results get support from the finding of Singh *et al*. (2015). Who obtained maximum net profit with application of NAA 50 ppm in chilli. Samsangheile and Kanaujia (2014) also found highest net

return and benefit-cost ratio with integrated nutrient management in chilli.

Conclusion

The combine application of 50 ppm NAA and 100% N through vermicompost *i.e.* P_2V_1 performed well in respect of fruit length(8.73cm), fruit diameter(1.46cm) and fruit weight(2.91g) while the application of NAA 50 ppm + 50% N through vermicompost along with 50% RDF *i.e*. P_2V_3 gave significantly (at 5%) maximum number of fruits/plant (73.86) and fruit yield per hectare (121.20q) with higher gross income (Rs.2,66,640.00/ha), net profit (Rs.1,98,946.00/ha) and benefit - cost ratio (2.94).

Hence on the basis of these finding it may be concluded that the combine effect of NAA 50 ppm along with 50 % N through vermicompost + 50% inorganic fertilizers (RDF) gave better result regarding growth yield and quality attributes and also generated maximum gross income, net return and B:C ratio where as application of NAA 75 ppm along with 25 % N through vermicompost + 75 % inorganic fertilizers (RDF) ranked 2nd in marit.

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