AU DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/1978-1982 Agriculture Update
Volume 12 | TECHSEAR-7 | 2017 | 1978-1982
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RESEARCH ARTICLE :

Assessment of integrated nutrient management on yield, quality and economics of chilli (*Capsicum annuum* L.)

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ARTICLE CHRONICLE :
Received :
19.07.2017;
Accepted :
03.08.2017

SUMMARY : This study was aimed to assess the effects of integrated nutrient management on yield, quality and economics of chilli (*Capsicum annuum* L.). The present study was carried out during 2012 *Rabi* season at Research Farm, J.N.K.V.V. College of Agriculture, Tikamgarh, (M.P.), India with 10 treatment combinations (V_1I_1. V_1I_2, V_1I_3, V_1I_4, V_1I_5, V_2I_1, V_2I_2, V_2I_3, V_2I_4, V_2I_5, wheres V_1- Pusa Jwala, V_2- Garima -12 and INM facors, I_1- recommended dose of fertilizer (RDF) or Control (100:50:50 kg NPK ha^{-1}), I_2- RDF + FYM (10 t ha^{-1}), I_3 – RDF + Vermicompost (2.5 t ha^{-1}), I_4 – RDF + Vesicular arbuscular mycorrhiza (VAM) @ 2 kg ha^{-1}, I_5 – RDF + *Azospirillum* in Factorial Randomized Block Design with 3 replications. Application of RDF + Vermicompost 2.5 tonnes ha^{-1} showed significant increase in fruit yield $plant^{-1}$ (271.5 g) and fresh fruit yield of 6816 kg ha^{-1}.Significantly the lowest fruit yield $plant^{-1}$ and fresh fruit yield of chilli (227.8 g and 4218 kg ha^{-1}, respectively) was noticed in recommended dose of fertilizer (RDF) or Control (100:50:50 kg NPK ha^{-1}). Combined application of RDF + Vermicompost 2.5 tonnes ha^{-1} showed significant increase in ascorbic acid content (190.8 mg $100g^{-1}$) and in terms of benefit cost ratio was economical with highest net returns (181607 Rs. ha^{-1}) and B:C (3.19). However lowest ascorbic acid content (170.8 mg $100g^{-1}$) and minimum net returns (95194 Rs. ha^{-1}) was noticed in control (100:50:50 kg NPK ha^{-1}) while, minimum B:C ratio (3.19) with I_2.

KEY WORDS :
FYM, Vermicompost, VAM, Azospirillum, Chilli, Ascorbic acid

How to cite this article : Chouhan, K.S., Baghel, Satish Singh , Mishra, Kashyap, Singh, Ajeet Kumar and Singh, Vijay (2017). Assessment of integrated nutrient management on yield, quality and economics of chilli (*Capsicum annuum* L.). *Agric. Update*, **12**(TECHSEAR-7) : 1978-1982; **DOI: 10.15740/HAS/AU/12.TECHSEAR(7)2017/1978-1982.**

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BACKGROUND AND OBJECTIVES

Chilli (*Capsicum annuum* L.) is an important spice cum vegetable crop cultivatedextensively in India.Area under chilli during the year 2011-12 in India was 805,000 ha, production 1276,000 MT and productivity was 1.6 MT/ha (Anonymous, 2013).It has different types of protein, vitamin, and ascorbic acid contents and is a good source of medicinal potential.Chillis are consumed in both fresh as well as dried form. It is good choice for generating higher profit. It can be cultivated in many types of soils, well drained loamy soil having rich organic matter are best suited for its cultivation. Chilli production has to be increased primarily from enhancing the productivity with a combination of high yielding plant types, standard agronomic practices and balanced plant nutrition attained through integrated nutrient management (INM). After the green revolution, increase in production was achieved at the cost of soil health. It has been proved that indiscriminate use of inorganic fertilizers results in decrease in soil fertility and increase in soil acidity with depletion of organic humus content in addition to poor crop quality. Since chemical fertilizer alone will not be able to sustain the productivity, integrated use of all potential sources of plant nutrients seems to be the only option to maintain soil fertility and crop productivity (Paul *et al*., 2013). It is truth that use of organic manures alone cannot fulfill the crop nutrients requirement. There is a proper ratio between the organic and chemical sources and it should be worked out to derive the best combination of the inputs for attaining quantity and quality as well as economical point of view of chilli production. Organic manures improve the soil physical, chemical and biological properties and also improves the moisture holding capacity of soil, thus resulting in enhanced crop productivity along with better quality of crop produce (Premsekhar and Rajashree, 2009).Use of Experimental findings of Jayanthi *et al*. (2014) showed positive influence on soil quality, yield and quality characters of chilli with combined application of vermi fertilizer along with recommended dose of chemical fertilizer (RDCF). Further, the vermi fertilizer reduces 50% of the RDCF to the crop and enhances the soil quality, yield and quality of chilli than chemical fertilizer alone. Further the combined use of organics (farmyard manure, vermicompost, biofertilizers, panchagavya) along with the inorganic fertilizers increased the nutrient use efficiency, apparent nutrient recovery and the available nutrient status of the soil (Naidu *et al.*, 2009).The integrated supply and use of plant nutrients from chemical fertilizers and organic manures has been shown to produce higher crop yields than when they are applied alone. This problem can be managed through adoption of integrated nutrient management. Present investigation is carried out to identify / screening suitable genotype with better management practices for getting good quality fruits and higher fruit yield of chilli for getting maximum profit.

RESOURCES AND METHODS

The present investigation was carried out at Research Farm, J.N.K.V.V. College of Agriculture, Tikamgarh (M.P.) during 2012with an objective to study the effect of varieties and integrated nutrient management on growth and fruit yield of chilli. The experimental site was clay loam, low in available N (266 kg N ha^{-1}) and high in available P_2O_5 (25.9 kg ha^{-1}) and K_2O (255 kg ha^{-1}). The experiment was laid out in Factorial Randomized Block Design with three replications comprised of 10 treatment combinations *viz*., V_1I_1, V_1I_2, V_1I_3, V_1I_4, V_1I_5, V_2I_1, V_2I_2, V_2I_3, V_2I_4, V_2I_5 where's, V_1- Pusa Jwala, V_2- Garima -12 and INM facors, I_1- recommended dose of fertilizer (RDF) or Control (100:50:50 kg NPK ha^{-1}), I_{2-} RDF + FYM (10 t ha^{-1}), I_3 – RDF + Vermicompost (2.5 t ha^{-1}), I_4 – RDF + Vesicular arbuscular mycorrhiza (VAM) @ 2 kg ha^{-1}, I_5 – RDF + Azospirillum. Organic manures were applied (on equal N basis) as per the treatment and incorporated into the soil before sowing. 1/3 nitrogen were given to the plot before sowing as basal dose. Remaining 2/3 quantity of nitrogen was applied in two split doses *i.e.*, 30 and 60 DAT. The seedlings were planted in the plots with spacing of 60×45 cm^2. Five plants were randomly selected from each treatments and replication for the study. Immediately after harvesting their fresh yield was recorded. The weight of each picking was added to get the total green chilli yield. Observations were recorded on fruit yield plant^{-1} (g) and fresh green fruit yield (kg ha^{-1}) and ascorbic acid content. Ascorbic acid content in chilli green fruits at 90 DAT was estimated by using 2,6-dichlorophenol indophenol titration method. The required amount of N, P and K fertilizers was applied through urea, DAP and muriate of potash, respectively. Other cultural operations and plant protection measures were followed as per the recommendations.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Effect of INM on yield and ascorbic acid content of chilli :

The data pertaining to fruit yield (plant^{-1} and ha^{-1}) and quality characters like ascorbic acid (mg 100^{-1} g fruit) as influenced by different varieties and integrated nutrient management treatments was statistically analyzed and presented in Table 1. Integrated nutrient management practices exerted significant influence on fruit yield during the years of investigation.The significantly highest fruit yield plant^{-1} (259.6 g) and total fresh fruit yield of 6193 kg ha^{-1}was obtained with genotype Garima-12 over the genotype of Pusa Jwala. Among the integrated nutrient management treatments, RDF (100:50:50 kg NPK ha^{-1}) + Vermicompost 2.5 tonnes ha^{-1} recorded significantly higher fruit yield plant^{-1}and yield ha^{-1} (271.5 g and 6816kg ha^{-1}, respectively) while, significantly lowest fruit yield plant^{-1} and yield ha^{-1} (227.8 g and 4218 kg ha^{-1}, respectively) was recorded with control.Interaction due to treatments and varieties for total green fruit yield was found non-significant.Fruit yield plant^{-1} and interaction was found significant and highest fruit yield plant^{-1} (282.2 g) was recorded under the treatment combination of RDF + Vermicompost 2.5 tonnes ha^{-1} with variety Garima-12 and was closely followed by combination of RDF + FYM 10 tonnes ha^{-1} with variety Garima-12 (255.7 g) (Table 1). The increase in fruit yield with application of RDF + Vermicompost @ 2.5 t ha^{-1} (I_3) may be attributed to better growth in terms of plant height and number of branches, which reflected into improved yield components *viz.*, number of fruits plant^{-1}, fruit length, fruit girth and fruit yield plant^{-1} as compared to other INM treatments. The increased yield in I_3 was due to significantly more number of fruits plant^{-1} and fruit yield plant^{-1} respectively. These parameters also showed the similar trend as that of final green fruit yield. Increase in number of fruits plant^{-1} is due to production of more number of flowers, higher percentage of fruit set and reduced shedding of flowers and fruits and resulted in increased fruits.Similar increase in fruit yield was observed in gangetic alluvial plain soils with 50% nitrogen received from vermicompost and 50% from urea (Pariari and Khan, 2013). Improved growth components under application of RDF + Vermicompost @ 2.5 t ha^{-1} (I_3) may be attributed to increasing in availability of nutrients for longer period and continuous supply of nutrients.This might have attributed to more availability and subsequent nutrient uptake by the crop, thus increasing the yield. The reasons for increased fruit yield in chilli was attributed to the increased solubilization effect and availability of nutrients by the addition of vermicompost and increased physiological activity leading to the build-up of sufficient food reserves for the developing sinks and better portioning towards the developing fruits. This higher translocation was possible perhaps due to better sink capacityas indicated by the higher number of fruits and weight of fruits per plant. The results are in accordance with the findings of Patil *et al.* (2004). Similar results were also reported by Subbaiah *et al.* (1982) in Chilli. In the present study increase in growth and morphological parameters in the early stages of crop growth, indicate the efficiency of the plant to trap the available solar radiation efficiently which resulted in the increased rates of assimilates which inturn used in the fruit formation, thus ultimately increased the yield per unit area. The results of the present investigation are in conformity with the findings of Swamy and Subbarao (1992).

The significant difference in ascorbic acid content was noticed due to integrated nutrient management treatments and varieties, whereas, the interaction effect was found to be non-significant (Table 1). Among the genotypes, ascorbic acid content was significantly higher in Pusa Jwala (184.4 mg 100g^{-1}) over Garima-12 (181.7 mg 100g^{-1}). Among the treatments, RDF + Vermicompost 2.5 tonnes ha^{-1} recorded significantly higher ascorbic acid content (190.8 mg 100g^{-1}) over all other treatments, followed by RDF + FYM 10 tonnes ha^{-1} (187.1 mg 100g^{-1}), whereas, lower ascorbic acid content was recorded in control (170.8 mg 100g^{-1}).The organically managed crop has usually higher ascorbic acid than the conventional fertilized crop because when a plant exposed with more N, it increases protein production and reduces carbohydrates synthesis. Since ascorbic acid and acidity is synthesized from carbohydrates, its levels are also reduced. In case of organically managed soil plants is generally exposed with comparatively lower amount of N and several plant nutrients are released slowly over time. Therefore, organic crop would be expected to contain higher value of these quality traits and carbohydrates and less protein. Furthermore, soil micro-organism affects soil dynamics and plant metabolisms and ultimately results in plant composition and nutrition quality. Worthington (2001) and Bahadur *et al.* (2003) are also of the similar view. Increased in ascorbic acid content of fruit in these treatments could be attributed to combined application of organic, inorganic fertilizers which helped in better uptake of NPK nutrients including micronutrients which inturn influence the quality traits in chilli. The results are in conformity with the findings of

Grimstand (1990) and Asano (1994) in cucumber.

Effect of INM on economics of chilli :

The data pertaining to economic in terms of cost of cultivation, gross monetary return (GMR), net monetary return (NMR) and benefit cost ration (B:C) are summarized in Table 2. It is evident from the data that the cost of cultivation of Rs. 46680 ha^{-1} among different chillies varieties was same as inputs used and cultural operations performed were similar in all varieties.The perusal of data in Table 2 reveals that the highest gross monetary return (GMR) ha^{-1} of Rs. 248675 was obtained by the combination V_2 I_3 *i.e.*, Garima-12 x RDF+ Vermicompost (2.5 t ha^{-1}) whereas it was lowest in V_1 I_1 and V_1I_2 (Rs. 144305). It is evident that net monetary return (NMR) was recorded the highest (Rs. 191739) with the treatment combination of V_2I_3(Garima-12 x RDF + Vermicompost) while, the least net return (Rs. 91869) was calculated from V_1 x I_1(Pusa Jwala x Control). The highest B: C ratio of 3.37: 1 was recorded under combination of V_2I_3 (Garima 12 x RDF + Vermicompost @ 2.5 t ha^{-1}) while it was minimum (1.75: 1) with the V_1 I_1 (Pusa Jwala x Control). This might be due to lower yield and higher cost of cultivation compared to other treatments.The economic analysis of combined use of different fertility levels such as vermicompost in present investigation showed that maximum gross return was obtained under V_2 I_3 might be attributed due to highest fruit yield of chilli and get maximum net profit as well as B: C ratio is due to the increase in the yield of the total fruit yield (Singh and Teena, 2012).

Conclusion :

Integrated nutrient management treatments rendered their significant effect on yield and quality characters as well as fruit yield of chilli. Treatment consisted of 100% RDF of NPK + Vermicompost @ 2.5 t ha^{-1} recorded maximum performances with respect to almost all the characters. Treatment (control) was the lowest performer for the results of the said characters. So, keeping view on yield sustainability, balance in ecosystem, soil health improvement and good health of human beings and getting maximum profit it may be suggested that vegetable growers may supplement through the judicious and efficient use of inorganic fertilizers or FYM, vermicompost and poultry manure, alone or in combinations.

Further, if the cost of vermicompost is reduced by

Table 1 : Effect of INM on yield and ascorbic acid content of chilli

Treatments	Yield and ascorbic acid content of chilli								
	Fruit yield (g $plant^{-1}$)			Fresh fruit yield (kg ha^{-1})			Ascorbic acid content (mg $100g^{-1}$)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
I_1	210.2	245.5	227.8	4123.00	4313.00	4218.00	173.3	168.2	170.8
I_2	240.2	255.7	247.9	6315.00	6819.00	6567.00	188.5	185.8	187.1
I_3	260.9	282.2	271.5	6526.00	7105.00	6816.00	191.9	189.6	190.8
I_4	220.7	235.9	228.3	5813.00	6217.00	6015.00	183.3	181.7	182.5
I_5	251.4	279.0	265.0	6177.00	6510.00	6344.00	185.1	183.4	184.2
	236.6	259.6		5791.00	6193.00		184.41	181.7	
	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
Variety (V)	0.44	1.32		47.2	141.2		0.32	0.96	
Treatment (I)	0.70	2.09		74.6	223.2		0.51	1.52	
Interaction (V x I)	0.99	2.95		105.43	NS		0.72	NS	

NS=Non-significant

Table 2 : Effect of INM on economics of chilli

Treatments	Cost of cultivation (Rs./ha)			Gross monetary return (Rs./ha)			Net monetary return (Rs./ha)			B:C ratio		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
I_1	52436	52436	52436	144305	150955	147630	91869	98519	95194	1.75	1.88	1:1.82
I_2	59436	59436	59436	144305	229845	225435	161589	170409	165999	2.72	2.87	1:2.79
I_3	56936	56936	56936	228410	248675	238543	171474	191739	181607	3.01	3.37	1:3.19
I_4	52896	52896	52896	203455	217595	210525	150559	164699	157629	2.85	3.11	1:2.98
I_5	53136	53136	53136	216195	227850	222023	163059	174714	168887	3.07	3.29	1:3.18

its indigenous preparation by farmers themselves, then the integrated application of vermicompost with fertilizers in equal proportion is beneficial.

Acknowledgement :

The authors acknowledged the contributions of Dr. R.C. Tiwari and Dr. Yogranjan for donating their time, critical evaluation, constructive comments, and invaluable assistance toward the improvement of this manuscript. We are thankful to Dr. P.K.Tyagi for his technical help in carrying out the experiment and his assistance in the statistical analysis of the obtained data.

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