Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Impact of integrated nutrient management on tomato yield under farmers field conditions

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Publication Info

Paper received:
31 March 2012

Revised received:
31 October 2012

Accepted:
26 December 2012

Abstract

Field trials were conducted in farmer's field of district Chandauli, Uttar Pradesh, India to assess the impact of integrated nutrient management (INM) on the performance of tomato crop during rabi (2008) and kharif (2009) season. Before conducting trials technological gap between actual and potential productivity were analyzed by interviewing growers to find out the major causes for low yield. Overall gap in use of fertilizers was recorded 64.90 % whereas overall mean gap in technology was 43.83 %. On-farm experiments on INM were conducted by applying FYM (10t ha^{-1}) + (NPK (150:80:60 kg ha^{-1}) followed by dipping seedling roots in1% *Azotobacter* solution for 15 min and foliar spray with 20 ppm ferrous ammonium sulphate after 30, 45 and 75 days of transplantation. The plant height, root length, number of primary branches, average fruit weight increased in INM plots as compared to farm practice. The increment in yield was found to be 28.84 and 33.86 % during rabi and kharif season respectively. The maximum marketable yield obtained in INM plot during kharif and rabi seasons was 1025 q ha^{-1} and 955 q ha^{-1} respectively, whereas as farm practice yielded 740 q ha^{-1} and 713 q ha^{-1} during the same seasons. The percent loss from total production was recorded 8.5 % and 8.8 % in control plot and only 4.9 % and 5.7 % in INM plot during rabi and kharif seasons respectively. The higher fruit weight and lower incidence of disease and pest were observed in INM field in comparison to farm practice. The benefit cost ratio with INM treatment was recorded 4.25 and 4.23 in rabi and kharif season respectively against the benefit cost ratio of 2.98 and 2.82 in control plot during the same respective seasons.

Key words

Azotobacter, Field trial, Integrated nutrient management, Technological gap, Tomato

Introduction

There is a big question whether the agriculture practices which are in vogue can provide food for a world population projected to exceed 7.5 billion by the year 2020. There are several indications that the highly productive fertilizer and seed introduced over the past three decades may be reaching a point of diminishing returns (Bouis and Howarth, 1993). We will have to produce 5Fs (food, feed, fodder, fibre and fuel) in future with less negative impacts on natural resources and environment. The present agriculture production system for last several decades has depleted the soil properties and environmental quality resulting in extinction of several beneficial insects, birds and microorganisms etc. Depletion of soil fertility means degradation of the environment and likewise, its improvement also leads to the better environment (Javaria and Khan, 2011).

As far as global vegetable production is concerned tomato (*Lycopersicon esculentum*) is the most popular and third most consumed vegetable in the world next to potato and sweet potato (FAO, 2002). It consist of vitamins, minerals and antioxidants which are essential for human health (Kallo, 1993). Tomato is grown in all type of soil on a small scale for family use and on a commercial scale as a cash crop by the vegetable growers. However, tomato yield in India is quite low (18 t ha^{-1}) as compared to the average yield in Asia (24.30 t ha^{-1}) and world (26.74 t ha^{-1}). The area under tomato cultivation in India is about 6.10 lakh ha and the total production of fruits is 11.00 million tone (FAO, 2002).

The majority of tomato growers do not produce good quality fruit at high yield due to lack of knowledge regarding improved production technologies including use of proper inorganic and organic fertilizers (FAO, 2003). Farmers use imbalance inorganic fertilizers and pesticides injudiciously in order to harvest good yield. The continuous use of chemical fertilizers increases the concentration of heavy metal in the soil (Arya and Roy, 2011), disturbs soil health and quality which can't support plant growth in long term basis. Tomato is heavy yielder hence requires adequate fertilizers for growth and high yield. Integrated nutrient management comprises organic, inorganic and microorganisms that are highly beneficial for sustainable crop production as it ameliorates soil environment, maintain adequate level of nutrients and provide favorable conditions for high tomato yield with divine quality (Solaiman and Rabbani, 2006; Law-Ogboma and Egharevba, 2009). In recent years despite rapid development in agrotechnological service, dissemination of agriculture technology to farmer's field is still very limited. Low level of education and insufficient training to improve agricultural knowledge of farmers in developing countries is another constraint for extension of nutrient management technology (Javaria and Khan, 2011). It was also established from survey that farmers obtained more agricultural knowledge and experience from their neighbors than from the other extension systems. In view of inconsistent, inadequate and site/soil specific results of integrated nutrient management (INM) in tomato a location specific demonstrative trial was conducted in farmers field to determine the impact of INM.

Materials and Methods

Demonstrative experiment on integrated nutrient management was conducted during rabi season 2008 and kharif season 2009 at farmers fields in two village viz. Kanta-visunpura and Amadpur of the district Chandauli (U.P.) located at 25.27°N and 83.27° E. The average precipitation recorded during study period was 1025.40mm yr^{-1}, while the maximum temperature was (38°C) in May and minimum (8°C) in January. Soil of the study area where the experiments were conducted was sandy loam with pH 7.3 and 0.80 % organic matter. Before trial, the technological gap between recommended technology and actual practice adopted by tomato growers were studied by group discussion and questionnaire method. It was observed that respondents were marginal to small holding (0.10 to 0.50 ha). Out of 100 farmers 10 were selected randomly for field trials.

The gap in use of practice was calculated by dividing the substract of recommended (kg ha^{-1}) and practice applied (kg ha^{-1}) and multiplying with 100. The mean technological gap of farmers was calculated by dividing total gap for all practices with number of practice considered and multiplying with 100.

INM module recommended by Indian Institute of Vegetable Research, India for tomato (De *et al.*, 2004) was slightly modified due to unavailability of press mud. The INM applied in the treatment was 10 t FYM + 150:80:60 kg ha^{-1} NPK followed with root dip of seedling in *Azotobacter chroccocum* solution @ 1% for 15 min and spray of 20 ppm ferrous ammonium sulphate. The full quantity of farm yard manure, phosphorus and potash and half dose of nitrogen were applied in basal and remaining half N was used in two split doses at 30 and 75 days after treatment.

Seeds of tomato variety Avinash 2 were treated with carbendazim @ 1g seed kg^{-1} sown in raised bed in line during September 2008 and June 2009 for rabi and kharif season respectively. The plants were watered as and when necessary after seed sowing. After 3 weeks, the seedling uprooted were root dipped in *Azotobacter* solution and transplanted to well prepared field and spaced 50 X 60 cm to achieve planting density of 33333 plant ha^{-1}. The plot size was 400m^2 for both treatment and farmer practice.

Plant height (cm) at maturity was determined *in situ* from five randomly sampled and tagged plants per plot. Root length was determined by uprooting five fruited plants from each plot. Matured fruits were harvested at weekly interval for assessment of number of fruit per plant, average fruit weight, and marketable yield. Fruit yield per hectare was obtained through conversion of the net plot yield. The data on disease and insect was recorded at biweekly interval. Economic parameters such as cost of production, net return and benefit cost ratio (BCR) were calculated by considering all inputs and outputs. The data collected were subjected to analysis of variance (Steel and Torrie, 1987).

Results and Discussion

The technological and managemental gap in tomato was analyzed and tabulated in Table 1. It revealed that the tomato growers of the region did not adopt recommended practices. In tomato cultivation overall technological gap of 43.83% was found whereas 64.90% gap in overall fertilizer application was recorded. It was noticed that 88.50% respondents did not adopt seed treatment and nursery sowing by line method. Though majority of farmers adopted high yielding varieties, seed rate, spacing and interculture operations recommended for the commercial cultivation of tomato. Surprisingly, it was noticed that 73.82% respondents applied more than the recommended dose of nitrogen and phosphatic fertilizers (300:200 kg ha^{-1}). Moreover, only

Table 1 : Mean technological gap among the tomato growing farmers of Chandauli, India

Attributes	Recommended technology	Mean technological gap (%)
Variety	Avinash 2, NS 815	15.26
Nursery raising	Raise bed, line sowing	88.50
Plant spacing	50 X 60 cm plant and row	8.20
Application of FYM	10 t ha^{-1}	67.72
Application of fertilizers	a. Nitrogen 150kg ha^{-1} (more/less from recommended)	49.37
	b. Phosphorus 80 kg ha^{-1}	24.45
	c. Potash 60 kg ha^{-1}	19.24
	d. Micronutrients (foliar spray ferrous ammonium sulphate @ 20 ppm at 30, 45 and 75 DAT)	72.35
	e. Biofertilizers (Root dip in *Azotobacter* @ 1 % solution)	96.30
Mean gap	**Overall fertilizer application**	**64.90**
Interculture	Irrigation, weeding earthening etc.	5.34
PP measures	Need based IPM	35.50
Total gap	**Overall mean gap in technology**	**43.83**

n=100

Table 2 : Growth and yield attributes of tomato influenced by INM

Year/Season	Treatments	Plant height (cm $plant^{-1}$)	Primary branches (no)	Root length (cm $plant^{-1}$)	Average fruit weight (g $plant^{-1}$)	No of fruits per plant
2008, Rabi	Farmers practice	82.90	6.09	28.50	73.00	55.00
	Recommended dose	90.31	7.15	32.85	94.80	52.07
	CD p=0.05	5.33	0.68	3.11	8.55	1.76
2009, Kharif	Farmers practices	88.71	6.32	33.43	74.10	56.61
	Recommended dose	99.41	7.77	40.33	96.00	55.79
	CD p=0.05	6.53	0.73	4.36	12.55	NS

32.28% respondents somehow managed to apply FYM in their field inspite all knowing the benefits of FYM on soil and plant health. The unavailability of FYM is the main constraints on its use. However, lack of knowledge was the major reasons for non adoption of micronutrient and biofertilizers in growing tomato crop which were almost lacking in practice (Table 1). Javaria and Khan (2011) also reported that small land holding and low level of education of farmers in developing countries is constraints for technological extension. According to Feder *et al*. (2004) extension module such as front line demonstration using INM can contribute to the reduction of the productivity differential with ecofriendly means by increasing the speed of technology transfer and assisting farmers in improving knowledge.

INM+*Azotobacter* application significantly increased the plant height, number of primary branches and root length as compared to control (Table 2). Growth parameter during kharif season was higher than the growth in rabi season because of the availability of favorable moisture condition which lead to higher root growth and thereby improvement in plant growth as compared to rabi season. Plant growth of control plot was reduced at higher N and P application probably due to nutrient imbalance in tomato as reported by Olasantan (1991) and Ewulo *et al*. (2008).

The average fruit weight in INM plot observed was 94.80 g $fruit^{-1}$ and 96.0 g $fruit^{-1}$ in rabi 2008 and kharif 2009 season respectively while the fruit weight in control plot was found to be 73.0 g and 74.10 g $fruit^{-1}$ in respective season (Table 2). The INM applied crop rendered less number of fruits with higher weight in both the seasons resulting in higher yield than the fruits of control plot. The highest yield of 1005 q ha^{-1} and 1087 q ha^{-1} were found in INM plot during rabi 2008 and kharif 2009 season respectively (Fig. 1). This yield noticed 28.84 % higher in rabi 2008 and 33.86 % higher in kharif 2009 than the yield of control plot received farmers technology. In the study, FYM, NPK, micronutrient and *Azotobacter* were given to plant under INM resulted into increased growth of plant and yield. This might be due to the availability of higher amount of nutrients to plant from the soil and thereby higher uptake of the essential nutrients by plant as also ascribed by Adekiya and Agbede(2009). The incorporation of *Azotobacter* in integrated nutrient module improved the supply of N to plant, leading to better growth and yield confirms the previous studies of Shahram Sharafzadeh (2012). Goyal *et al*. (1999) and Javaria and Khan (2011)

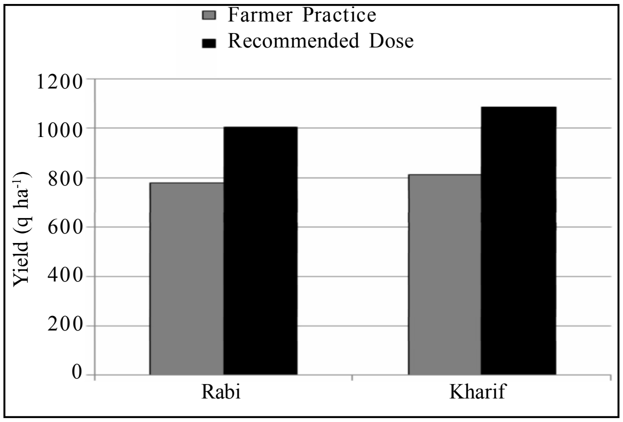

Fig. 1 : Effect of INM on yield of tomato crop

reported that microorganism work efficiently in dissolving nutrient and making them available to plant if amended with organic fertilizers. Ayoola and Adeniyan (2006) reported that nutrient from mineral fertilizers enhance the crops, while those from mineralization of OM promoted yield when both fertilizers were combined.

The marketable yield found in INM plot was 955 q ha^{-1} and 1025 q ha^{-1} in rabi 2008 and kharif 2009 season respectively. The data in Table 3 exhibits that loss of yield was due to inferior quality and diseased fruits were higher in control plot. The loss recorded was 4.9% and 5.7 % in both seasons respectively in INM crop as compared to control plot where the loss recorded was 8.0 % and 12.0 % in mentioned seasons. The higher yield loss in control was correlated with higher incidence of fruit borers, blight and leaf curl virus. The injudicious application of N and P in imbalance doses might be the major causes of higher pest infestation because these plants noticed more succulent, juiciness which attracted disease and pest maximum. Previous report of Olasantan (1991) confirms our findings that higher N reduced tomato yield due to nutrient imbalance on the inoculation of rhizomicroorganisms in plant induces the growth, nutrition and content of secondary metabolites (Hemashenpagam and Selvaraj, 2011) which helps in suppressing the incidence of pests.

The highest gross return and benefit cost ratio was obtained if integrated nutrition of inorganic fertilizer, micronutrient combined with organic manure and biofertilizer. Benefit cost ratio of 4.23 and 4.25 was calculated in INM tomato in rabi 2008 and kharif 2009 season respectively in comparison to control plot which rendered 2.98 and 2.82 benefit cost ratio in respective season and year (Table 4). The higher net return was reported in INM plot due to lower loss in yield caused by pest compared to control plot. The cost of cultivation found higher in control plot due to high cost of fertilizer and PP measures. Meena *et al.* (2012) also found that use of INM in tomato reduces the overall cost of input due to fewer incidences of insect pest and disease as compared to crop with farmers practices.

The results of the present study revealed that INM increased the fruit yield of tomato up to 33.94 % and 38.51 % during rabi and kharif season. Moreover, it reduced the yield loss due to suppression in pest infestation by maintaining plant health and improving fruit quality. In addition, the quantity of chemical fertilizer required was reduced and tomato yield enhanced, therefore saving the amount of money on chemical fertilizer and pesticides through INM system. More steps should be taken to spread awareness among the farmers to bridge the gap in

Table 3 : Yield and yield loss in INM and control plots of tomato

Year/Season	Treatments	Marketable yield(q ha^{-1})	Yield loss (%)	Incidence of disease and pest (%)		
				Leaf curl virus	Blight	Fruit borer
2008 Rabi	Farmers practice	713.0	8.50	8.00	16.00	15.00
	Recommended dose	955.0	4.90	3.00	10.00	5.00
	CD p=0.05	56.31	2.30	3.09	4.40	4.80
2009 Kharif	Farmers practice	740.0	8.80	12.00	6.00	4.00
	Recommended dose	1025.0	5.70	5.00	4.00	2.00
	CD p=0.05	83.50	2.39	4.80	1.22	1.10

Table 4 : Economic performance of tomato crop applied with INM

Year/Season	Treatments	Cost of production (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit cost ratio
2008 Rabi	Farmers practice	71660.00	142240.00	2.98
	Recommended dose	67490.00	219010.00	4.25
2009 Kharif	Farmers practice	78765.00	143235.00	2.82
	Recommended dose	72886.00	234614.00	4.23

technology and in actual practices to promote the INM to enhance the yield, quality with maximum economic benefit and most imperatively it environmental friendly nature.

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