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Original Research Paper

Effect of Integrated Nutrient Management on Nutrients Uptake and Productivity of Onion

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ABSTRACT

A field experiment was conducted during Rabi season (2009) to find out the effect of integrated application of organic manures (FYM and vermicompost), inorganic fertilizers and biofertilizers (PSB and *Azotobacter*) on growth, yield and nutrient uptake by onion (*Allium cepa* L.). There were six treatments comprised of varied levels of FYM, vermicompost, chemical fertilizers, PSB and *Azotobacter*. The experiment was laid out under randomized block design (RBD) and the treatments were triplicated during the experiment. Significantly higher yield of onion (74.85 q ha^{-1}) was observed in the plots received 50% N through vermicompost +25% N through urea + PSB + *Azotobacter* (T_6) as compared to other treatments. Similar significant effect was observed on nutrient content (N, P, K and S) and nutrient uptake (N, P, K and S). On the basis of results obtained it can be concluded that the integrated use of organic manures (vermicompost and FYM) along with chemical fertilizers and biofertilizers (PSB and *Azotobacter*) can substitute the nitrogen requirement of plant to the extent of 25% and increased the yield, content and uptake of N, P, K and S by onion significantly over the sole use of chemical fertilizers.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India and it belongs to family Alliaceae. Onion is an indispensable item in every kitchen as vegetable and condiment, therefore commands, an extensive internal market. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil 'allyl propyl disulphide'- an organic compound rich in sulphur. Onion bulb is a rich source of minerals like phosphorus, calcium and carbohydrates. It also contains protein and vitamin C. It is being used in several ways as fresh frozen and dehydrated bulbs. Dehydrated onion is in great demand which reduces transport cost and storage losses. Onion has got good medicinal value. It contains several anticancer agents which have shown to prevent cancer in animals.

India is the second largest producer of onion in the world, next to China, accounting for 26.38 per cent of the world area and 19.25 per cent of the world production. In India, onion is being grown in an area of 1.04 million hectares with production of 15.75 million tonnes and the productivity is 15.1 tonnes per hectare which is low in 2011-12. Maharashtra is the leading onion growing state and other important states are Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu. In Karnataka, onion is cultivated in an area of 1.65 lakh hectares with production of 30.32 lakh tonnes and the average productivity is 18.40 tonnes per hectare which is low compared to world average. On the productivity front (as reported by FAO, 2009), compared to Korean Republic at 66.67 MT/ha followed by USA with 56.56 MT/ha, Spain (53.53 MT/ha) and Netherlands (48.81 MT/ha), China (22.21 MT/ha) average onion productivity in India is just 15-16 MT/ha although India is the second largest onion producer in the world. Thus, there is a wide gap between yields obtained in India and other developed countries, reflecting the huge scope to increase yields in India. Among the many constraints for low productivity in onion, unbalanced nutrition is the main limiting factor. The continuous and unbalanced use of fertilizers is adversely affecting the sustainability of agricultural production besides causing environmental pollution. Greenland (1975) suggested that for a sustainable crop production system, chemical nutrients removed by the crop must be replenished and physical conditions of the soil maintained. Integrated nutrient management (INM) provides excellent opportunities to overcome all the imbalances besides sustaining soil health and enhancing crop production. This optimizes the benefit from all possible sources of plant nutrients in an integrated manner. There are several indigenously available sources of nutrients of organic origin, in which FYM is widely used as organic manure but the availability of FYM is not adequate so, it becomes necessity of present day situation to look forward to another organic manurial source and probably, India has a very high potential of manurial resource and organic wastes (Ramaswami 1999). Vermicomposting has proved to be an efficient technology for converting waste material into quality manure (Sharma et al. 2004). These organic manurial sources not only enhance the availability of macronutrient as well as micronutrient (Pandey et al. 2007) but also reduce the use of chemical fertilizer and sustain soil health and productivity in the long run (Mohanty et al. 1992). Biofertilizers are generally used as microbial inoculants, which may help in increasing crop productivity by enhancing efficiency of natural biological nitrogen fixation, solubilization of insoluble form of nutrients and stimulating plant growth. Biofertilizers have been developed for large number of vegetable crops and their use enhance the 8-21% yield of above ground crops and 25-50% yield of underground crops as well as increased nutrient use efficiency by 12-36% of N, 18-29% of P, 9-15% of K and 16-18% of S (AINP on Biofertilizer Res. Report, 2004-2007 IISS, Bhopal). Use of biofertilizers like *Azotobacter* enhances the N use efficiency. The N fixing potential of *Azotobacter* varies soil to soil depend upon a number of environmental and ecological factors (Alexander 1977). *Azotobacter* inoculation also has been found effective in increasing nitrogen content in the plant dry matter (Badgire & Bindu 1976). Inoculation with efficient strains of *Azotobacter* contributes about 15-20 kg N per hectare in different crops and integrated use of P solubilising bacteria with contributes 30-35 kg P_2O_5 ha^{-1} in natural to slightly alkaline soils. However, there is a lack of information regarding the integrated performance of vermicompost, *Azotobacter* and PSB in relation to productivity and fertility status of soil under vegetable based cropping system. Hence, this investigation was planned to identify a suitable integrated nutrient management package for onion.

MATERIALS AND METHODS

Site description and field experiment: The field experiments were conducted at the research farm of the Department of Agricultural Chemistry and Soil Science, Udai Pratap Autonomous College, Varanasi, during 2009-10, followed by laboratory analysis of the post harvest soil and plant samples. The Geographical situation of the farm lies of 25°8' North latitude and 88°03' East longitudes and 128.93 m above the mean sea level. The initial physico-chemical properties viz. bulk density (1.51 g cm^{-3}), particle density (2.59 g cm^{-3}), texture (Sandy clay loam), pH (1:2; 7.85), EC (0.32 dSm^{-1}), organic C (0.42%), available N (192.8 kg ha^{-1}), available P (10.60 kg ha^{-1}), available K (168.7 kg ha^{-1}) and available S (6.8 kg ha^{-1}) of experimental the plot are given in parentheses.

Experiment design and treatment details: The experiment was laid out in Randomized Block Design (RBD) during rabi seasons with six treatments and three replications. The details of various treatments applied to onion crop along with the symbols used are as:

T_1 = Control plot

T_2 = 100% Recommended dose of N, P, K (100: 50: 50)

T_3 = 50% N through FYM + 50% N through urea

T_4 = 50% N through vermicompost + 50% N through urea

T_5 = 50% N through FYM+ 25% N through urea + PSB + *Azotobacter*

T_6 = 50% N through vermicompost + 25% N through urea + PSB + *Azotobacter*.

Field was prepared by cross harrowing followed by transplanting of seeding. Full care was taken to level the plots uniformly and grasses were removed from the plots. 35 days old onion seeding of cultivar N-52 were transplanted at spacing of 15 × 10 cm in the plots having net plot area of 7 m^2. Recommended doses of nitrogen, phosphorus and potassium i.e. @ 100, 50 and 50 kg ha^{-1} respectively, were applied to onion as 100 kg of nitrogen ha^{-1} was considered as 100 per cent of nitrogen. Nitrogen was applied through urea, uniform based application of phosphorus and potassium was made through single super phosphorus and mureate of potash, respectively to all plots. Vermicompost and farm yard manure were obtained from agriculture research farm of Udai Pratap Autonomous College, Varanasi and analysed for their elemental composition. The elemental composition of vermicompost (3% N; 1.5% P_2O_5; 2% K_2O) and FYM (0.5% N, 0.2% P_2O_5; 0.5% K_2O) so obtained had been used to supplement the nitrogen requirement of onion crop. Intercultural operations were done to ensure normal growth of the crop. There was no infestation of insects, pests and diseases in the field, therefore, no control measures were applied for insects, pests and diseases. Plant heights from marked plants were recorded in each plot as different growth stages. Five plants are marked randomly and tagged in each replicate plot and the height was measured from the base of the plant to the upper most fully stretched leaf. The average of all the observation of each plot were worked out and designed as mean plant height. The crop was harvested on 5th May 2009. Yield and yield contributing data were recorded at the harvest. The diameter of onion bulb obtained by dividing the circumference of onion bulb by the factor 3.14 (p=3.14). After harvesting, the weight of onion bulb was recorded. Plant samples drawn at harvesting were dried in shade and chaffed into pieces and then kept in oven at 70°C for 12 hours to make free from moisture. After that, the dried samples were ground in a grinder. After mixing well the ground samples were digested in diacid mixture prepared by sulphuric acid and perchloric acid in the ratio of 9:1. The digested samples used to determine the nitrogen, phosphorus, potash and sulphur content by following the standard procedures.

Statistical analysis: Data were assessed by Duncan's multiple range tests (Duncan 1955) with a probability P=0.05. Least significant difference (LSD) between the mean values was evaluated by using SPSS version 10.0.

RESULTS AND DISCUSSION

Plant height: The plant height of onion crop increased continuously with crop age up to harvest under all treatments. Integration of organic manures and chemical fertilizers with biofertilizers gave a significant effect on the plant height of onion crop. The addition of 50% N vermicompost + 25% N through urea + PSB + *Azotobacter* (T_6) and 50% N through FYM + 25% N through urea + PSB + *Azotobacter* (T_5) in onion plots have shown a significant increase in plant height at all growth stages over control (T_1) and 100% urea N treated plots (T_2). The treatment T_5 (50% FYM N + 25% urea N + PSB + *Azotobacter*) has shown a significant increase in the plant height of onion crop to the extent of 38.7% and 22% over control (T_1) and 100% urea N treated plots (T_2), respectively. The treatment T_6 (50% vermicompost N + 25% urea N + PSB + *Azotobacter*) has also shown more superior effect on the plant height to the extent of 44.6% and 27% over control plot (T_1) and 100% urea N (T_2) plots, respectively. The increase in plant height due to the addition of FYM and vermicompost with PSB (phosphorus solubilizing bacteria) and *Azotobacter* was found to be statistically significant over control at all stages of growth. Organics are known to contain micronutrients apart from major nutrients. Besides this, vermicompost has been reported to contain several plant growth promoters, enzymes, beneficial bacteria and mycorrhizae (Gupta 2005). Therefore, the availability of higher quantity of nutrients might be responsible for improvement in the physical properties of soil and increased activity of microbes with higher levels of organics might have helped in increasing plant height, number of leaves and other growth attributes. Similarly, significantly higher plant height in onion with application of organic manures was reported by Reddy & Reddy (2005).

Bulb weight and bulb equatorial diameter: Application of 50% N through vermicompost + 25% N through urea + PSB + *Azotobacter* (T_6) was recorded significantly higher bulb weight of onion followed by T_5 (50% N through FYM + 25% urea N + PSB + *Azotobacter*), T_4 (50% N through vermicompost + 50% N through urea), T_3 (50% N through FYM + 50% N through urea) and T_2 (100% N through urea). The treatment T_6 (50% N through vermicompost + 25% N through urea + PSB + *Azotobacter*) increased bulb weight in respect of T_1 (control) and T_2 (100% N through urea) plots by 176% and 96% where as the treatment T_5 also recorded significantly higher bulb weight of onion to the extent of 141% and 71% over T_1 (control) and T_2 (100% N through urea) treatments, respectively (Table 1).

Like bulb weight, highest bulb equatorial diameter was recorded in case of the treatment consisting with vermicompost and FYM. Maximum bulb equatorial diameter was recorded in T_6 (7.87 cm) followed by T_5 (7.38 cm), T_4 (7.30 cm), T_3 (7.13 cm), T_2 (6.22 cm) and T_1 (5.55cm). The differences in values among various treatments were found to be statistically significant.

Higher bulb weight was recorded in the plots received vermicompost and FYM might be due to larger bulb diameter and plant height in this treatments. Similarly, increased bulb equatorial diameter with the application of integrated use of organics with inorganics (Chowdappan 1972, Thimmaiah 1989, Singh et al. 1993, Mallanagouda et al. 1995, Varu et al. 1997 and Baghali et al. 2012), might be attributed to the fact that the organic manures reduced bulk density thus increases porosity and resulted in the better development of physical condition of soil for better growth of bulb of onion plant.

Yield of onion: Significantly higher yield of onion (74.85 q ha^{-1}) was recorded with the application of 50% N through vermicompost + 25% N through urea + PSB + *Azotobacter* (T_6) followed by 50% N through FYM + 25% N through urea + PSB + *Azotobacter* (T_5; 62.13 qha^{-1}), 50% N through vermicompost + 50% N through urea (T_4; 55.41 qha^{-1}), 50% N through FYM + 50% N through urea (T_3; 43.61 qha^{-1}) and 100% N through urea (T_2; 32.41 qha^{-1}) (Table 1). The increase was much higher in the case when equal amounts nitrogen applied through vermicompost in place of FYM. The application of treatments T_6 (50% N through vermicompost + 25% N through urea + PSB + *Azotobacter*) and treatments T_5 (50% N through FYM + 25% N through urea + PSB + *Azotobacter*) increased the yield of onion by 130% and 92% under respective treatments over 100% N through urea (T_2). These results can help in concluding the superiority of vermicompost over farmyard manure.

The higher yield of crops with the use of vermicompost in comparison to FYM might be ascribed to higher nutrient concentration of vermicompost and beneficial effect on physical environment of soil. The beneficial effect of organic manures on yield might be due to the additional supply of plant nutrients as well as improvement in overall soil's

Table 1: Effect of integrated use of organic manures, inorganic fertilizers and biofertilizers on plant height, bulb weight, bulb equatorial diameter and yield of onion.

Treatments	Plant height (cm)			Bulb Weight (gm)	Bulb Equatorial Diameter (cm)	Yield of onion (q/ha)
	30 DAT	60 DAT	At harvest			
T_1	17.1e	26.2d	35.9e	66.0e	5.55e	17.14f
T_2	22.2d	30.7c	40.8d	88.3d	6.22d	31.42e
T_3	24.3c	33.5bc	43.6c	127.3cd	7.13c	43.61d
T_4	26.2bc	36.5b	46.5b	140.0c	7.30bc	55.41c
T_5	27.6b	40.1a	49.8a	154.3b	7.38b	62.13b
T_6	30.5a	40.6a	51.9a	177.0a	7.87a	74.85a
Level of Significance	*	*	*	**	**	**

Means with different alphabets indicate significant difference between treatments by Duncan's multiple range test at $p \leq 0.05$.*, ** significantly different at 0.05 and 0.01 probability levels, respectively. N.S: not significant.

Table 2: Effect of integrated use of organic manures, inorganic fertilizers and biofertilizers on nutrients content (%) and total nutrients uptake (kg ha^{-1}) onion.

Treatment	Nutrients Content (%) in onion				Nutrients uptake (kg ha^{-1}) by onion.			
	N	P	K	S	N	P	K	S
T_1	1.28f	0.190d	0.86d	0.21d	22.13f	3.23f	14.84f	3.53f
T_2	1.37e	0.223c	0.98cd	0.26c	46.62e	7.31e	30.48e	8.27e
T_3	1.48d	0.253bc	1.02c	0.31bc	59.71d	11.82d	44.68d	13.41d
T_4	1.57c	0.270b	1.05c	0.34b	86.23c	13.93c	57.45c	18.49c
T_5	1.75b	0.306ab	1.18b	0.35b	109.81b	19.31b	74.59d	21.28b
T_6	1.98a	0.323a	1.32a	0.41a	148.02a	24.31a	98.98a	30.61a
Level of Significance	*	*	*	*	*	**	**	**

Means with different alphabets indicate significant difference between treatments by Duncan's multiple range test at $p \leq 0.05$.*, ** significantly different at 0.05 and 0.01 probability levels, respectively. N.S: not significant.

physico-chemical and biological properties (Datt et al. 2003). It could also be attributed to the fact that after decomposition and mineralization, the applied manures supplied available nutrients directly to plant and also had solubilizing effect on fixed form of nutrients (Singh et al. 2001). Similar improvement in yield of onion due to integrated use of vermicompost and FYM with chemical fertilizer (Sharma et al. 2005), Sharma et al. 2009) and Baghali et al. 2012).

Nutrients content in onion bulbs: Integrated use of organic manures (Farmyard Manure and vermicompost) and inorganic fertilizers in combination with biofertilizers (phosphorus solubilizing bacteria and *Azotobacter*) increased the N, P, K and S contents in onion bulbs significantly (Table 2). Highest content of N, P K and S was recorded in the treatment consisting of 50% N through vermicompost + 25% N through urea + PSB + *Azotobacter* (T_6) followed by the treatments T_5 (50% N through FYM + 25% N through urea + PSB + *Azotobacter*), T_4 (50% N through vermicompost + 50% urea N), T_3 (50% N through FYM + 50% N through urea), T_2 (100% N, P, K) and T_1 (control).

The higher content of N, P, K and S in onion bulbs due to application of vermicompost with PSB and *Azotobacter* may be ascribed as the decomposition and mineralization of manures ensures better supply of available N, P, K and S directly to the plants and solubilizing effect on fixed form of mineral nutrient and also provide better soil physical environment (Sreenivas et al. 2000). The substantial improvement in nutrient uptake indicates the requirement of integration of nutrient supply sources for onion crop and also for overall improvement in soil's physico-chemical properties and biological environment (Sharma et al. 2003 and Sharma et al. 2009).

Nutrients uptake by onion: The nutrients uptake by the onion crop increased significantly with the addition of organic manures and chemical fertilizers along with biofertilizers over control (Table 2). Nutrients uptake was significantly higher in the plots treated with vermicompost or farmyard manure and chemical fertilizer along with PSB and *Azotobacter*. The application of 50% N through vermicompost + 25% N through urea + PSB + *Azotobacter* (T_6) increased the N uptake by 34.7%, 71.6%, 147% and 217% over the treatments T_5 (50% N through FYM + 25% N through urea + PSB + *Azotobacter*), T_4 (50% N through vermicompost + 50% N through urea), T_3 (50% N through FYM + 50% N through urea), T_2 (100% N, P, K) treatments, respectively. The corresponding values increases in case of P uptake were 25.98%, 76.6%, 105% and 245% over T_5, T_4, T_3 and T_2 treatments, respectively. Desai et al. (2009) has noticed that application of PSB effective in uptake of phosphorus, if used with the combination of organic manures. In case of K uptake, the corresponding increase was 32.7%, 72.28, 121% and 224% under T_6 over T_5, T_4, T_3 and T_2 treatments, respectively. Similarly, the S uptake has increased significantly under T_6 by 43.8%, 65.5%, 128% and 270% over T_5, T_4, T_3 and T_2 treatments, respectively.

CONCLUSION

On the basis of these results it can be concluded that the integrated use of organic manures (vermicompost and FYM) along with chemical fertilizers and biofertilizers (PSB and *Azotobacter* can substitute the nitrogen requirement of plant to the extent of 25% and increased the yield, content and uptake of N, P, K and S by onion significantly over the sole use of chemical fertilizer. The plots which had received vermicompost or FYM and chemical fertilizers with biofertilizers showed significant have showed significant improvement in residual soil fertility. It could also be concluded that the application of vermicompost with biofertilizers has good performance over the FYM with same biofertilizers. In general, the use of PSB and *Azotobacter* with vermicompost or FYM increases the yield and reduces the dose of inorganic nitrogen source by one-fourth**.**

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