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Integrated Nutrient Management in Onion (*Allium cepa* L.)

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ABSTRACT*. A field experiment was conducted at students farm, College of Agriculture, Rujendranagar, Hyderabad, India to study the Integrated Nutrient Management with biofertilizers in onion (Allium cepa L.). The experiment was laid out in a randomized block design with 12 treatments replicated thrice. Two kinds of organic manures, Farm Yard Manure (FYM) and Vermicompost (VC), alone and in combination with two biofertilizers (Azotobacter chroococcum and Azospirillum brasilianse) and chemical fertilizers were tested in comparison with recommended dose of fertilizer (control) using onion cv N-53. Growth of onion as indicated by plant height, number of leaves per plant, dry matter accumulation in bulb, yield, yield attributes such as bulb diameter, bulb weight and quality of the bulb, were significantly increased with application of biofertilizers (Azotobacter or Azospirillum) in combination with 50% N through organic manure (VC or FYM) while the other 50% of recommended N and 100% PK were supplied through chemical fertilizer. This treatment was significantly superior to the application of 50% of recommended N through organic manure with other 50% N and 100% PK supplied through chemical fertilizer as well as application of chemical fertilizer alone or application of organic manure alone. The latter three treatments were also significantly different from each other. Application of biofertilizers, organic manures and chemical fertilizers increased yield by 22% over the control. Economic analysis revealed higher net return and benefit : cost ratio when FYM used as an organic source replacing the 50% of the recommended dose of inorganic nitrogen.*

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important bulb crops cultivated all over the world on commercial scale both for local consumption and export. China is the largest producer of onion (0.451 million ha and 10.03 million tones) while India ranks the second producing 0.405 million ha and 4.3 million tones (Pandey and Bhonde, 1999).

Onion is a heavy feeder of mineral elements. It was reported that a crop of 35 tones of onion removes approximately 120 kg of N, 50 kg of P_2O_5 and 160 kg of K_2O ha^{-1}. An adequate and uniform supply of nitrogen is essential for plant growth, bulb yield and good quality (Tandon, 1987).

A major constraint in increasing crop yield is the supply of nutrients particularly the nitrogen. On the other hand with the adoption of improved technology for obtaining higher yields per unit area, the requirement of the nutrients has increased by many folds. Continuous use of inorganic fertilizers has resulted in deficiency of

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micronutrients, imbalance in soil physico-chemical properties and unsustainable crop production. Use of organic manures in combination with chemical fertilizers in an appropriate proportion improves the soil health for sustainable production. Therefore, integrated nutrient management is a viable strategy for advocating judicious and efficient use of chemical fertilizers with matching addition of organic and biofertilizers.

Biofertilizers refer to living organisms, which augment plant nutrient supplies in symbiotic or asymbiotic manner. Among the asymbiotic, nitrogen fixing-bacteria, *Azotobacter* and *Azospirillum* contribute significant improvement in yield of vegetable crops by 15 – 20% while reducing the depletion of soil nutrients (Motsara *et al.*, 1995). In addition to these beneficial effects, biofertilizer saves inorganic N fertilizers from 20–30kg ha^{-1}, as they possess tremendous potentiality in nitrogen fixation (Tilak, 1991).

There is a great scope in improving the yield, quality and shelf life of onion (Gupta *et al.*, 1999) with integrated nutrient management using organic fertilizer. Keeping in view, the significance of integrated nutrient management in maintaining the soil health and improvement of the productivity of the crops, this study was carried out to find out the effect of integrated nutrient management with biofertilizers on growth, yield and quality of onion (*Allium cepa* L.).

MATERIALS AND METHODS

A field experiment was carried out on sandy loam soil during *rabi* (cool season) 2001-2002 at students farm, college of Agriculture, Rajendranagar, Hyderabad in India. Soil pH of the experimental site was 6.2 and electrical conductivity was 2.3 mmhos cm^{-1}. Textural class was sandy loam and the available N, P and K were recorded as 204.63, 24.52 and 146.52 kg ha^{-1} respectively.

The experiment was conducted in a randomized complete block design with three replications using onion cv, N-53. Spacing adopted was 15 cm x 10 cm and gross plot size was 3 m x 3 m (9 m^2). In the 12 treatments two types of organic manures, Farm Yard Manure (FYM) and vermicompost (VC), alone and in combination with two biofertilizers as commercial inoculants (*Azotobacter chroococcum and Azospirillum brasilianse*) and chemical fertilizers were tested. Recommended dose of chemical fertilizers (RDF) served as the control (Table 1).

Well-decomposed FYM and VC (source of organic fertilizers) were applied to respective treatment plots and incorporated with a hand rake. The amounts of FYM and VC applied to different plots were calculated on the basis of the results of analysis of FYM and VC for NPK.

Roots were dipped into the slurry of biofertilizer (1 kg in 10 L of water ha^{-1}) for 20 minutes before planting. Thirty days after transplanting in biofertilizer treated plots the soil between the seedlings rows was treated with the respective biofertilizer at the rate of 2 kg ha^{-1}.

The field was irrigated and growth characters such as plant height, number of leaves per plant, dry matter accumulation in bulb were recorded at 20 days intervals. Bulb diameter and weight and quality of bulbs were measured after harvesting as yield and yield attributes. Economic analysis was performed to calculate net return and the benefit : cost ratio with respect to each treatment

Table 1. Description of the treatments.

Treatment No	Treatment
T_1	Farm Yard Manure 20 t ha^{-1}
T_2	Vermicompost 5 t ha^{-1}
T_3	FYM 10t ha^{-1} + VC 2.5t ha^{-1}
T_4	50% recommended N through FYM + 50% recommended N and total recommended P and K through chemical fertilizers
T_5	50% recommended N through VC + 50% recommended N and total recommended P and K through chemical fertilizers.
T_6	Treatment 3 + *Azotobacter* (2 kg ha^{-1})
T_7	Treatment 4 + *Azotobacter* (2 kg ha^{-1})
T_8	Treatment 5 + *Azotobacter* (2 kg ha^{-1})
T_9	Treatment 3 + *Azospirillum* (2 kg ha^{-1})
T_{10}	Treatment 4 + *Azospirillum* (2 kg ha^{-1})
T_{11}	Treatment 5 + *Azospirillum* (2 kg ha^{-1})
T_{12}	Recommended NPK (150-80-100) kg ha^{-1} (control)

RESULTS AND DISCUSSION

Plant height

Data presented in the Table 2 indicates a progressive increase in plant height with the age of the crop. The highest values at 100 days after transplanting (DAT) were recorded in treatments *Azotobacter chroococcum* in combination with FYM and chemical fertilizers (T_7) and VC and chemical fertilizer (T_8). Plant heights recorded in these two treatments were 61.07 cm and 60.95 cm, respectively. An additional increase of 14.3% plant height was observed in the plant receiving *Azotobactor chroococcum* in combination with FYM and chemical fertilizers when compared to recommended dose of fertilizers (RDF) which recorded a plant height of 52.4 cm at 100 DAT. The increase in plant height by the application of biofertilizers, i.e. *Azotobacter chroococcum* and *Azospirillum brasilianse* is probably due to their high efficiency in fixing atmospheric N and synthesis of growth promoting substances and vitamins as reported by Rao (1984).

Number of leaves per plant

Among the different types and levels of fertilizers, application of *Azotobacter* in combination with VC and chemical fertilizer (T_8) and *Azospirillum* with same combination (T_{11}) recorded the maximum average number of leaves $plant^{-1}$ with 16.2 leaves at 100 days after transplanting (Table 3). These treatments were followed by those receiving *Azotobacter* and *Azospirillum* in combination with FYM and chemical fertilizer i.e., T_7 and T_{10}, which produced 16.1 and 15.8 leaves $plant^{-1}$ respectively. The lowest number of leaves per plant was recorded with only FYM (14.2) and VC (14.4) or both (14.2) and these treatments were significantly inferior to the remaining treatments.

Table 2. Average plant height (cm) as influenced by different organic manures, biofertilizers and chemical fertilizers at different stages of crop growth in onion.

Treatments	Days after transplanting				
	20	40	60	80	100
T_1	17.5[a]	22.1[a]	30.4[a]	36.3[a]	38.5[a]
T_2	19.2[b]	26.3[a]	32.5[b]	37.1[a]	40.1[b]
T_3	20.5[b]	24.5[b]	33.1[b]	37.5[a]	40.4[b]
T_4	21.6[b]	39.5[e]	46.3[d]	49.5[b]	53.3[c]
T_5	21.5[b]	41.0[c]	47.8[d]	50.4[b]	54.2[c]
T_6	20.4[b]	29.0[d]	43.1[c]	46.7[b]	49.8[c]
T_7	22.2[b]	49.3[f]	54.8[e]	58.5[c]	61.1[d]
T_8	22.4[b]	48.5[f]	54.1[e]	58.3[c]	60.9[d]
T_9	20.5[b]	29.1[d]	42.5[c]	48.1[b]	51.1[c]
T_{10}	22.6[b]	49.3[f]	54.9[e]	58.2[c]	60.6[d]
T_{11}	24.6[c]	49.5[f]	55.1[e]	58.5[c]	60.7[d]
T_{12}	21.4[b]	40.4[e]	46.5[d]	50.9[b]	52.4[c]
SE	0.7	0.6	0.9	0.6	0.7
LSD at 5 %	1.5	1.3	1.9	1.4	1.6

The production of greater number of leaves can be due to higher metabolic activity because of the higher N supply resulting in higher production of carbohydrates and phytohormones which were manifested in the form of enhanced growth as explained by Govindan and Purushottam (1984). Vermicompost is reported to be a very good source of macro and microelements, growth hormones, vitamins and microflora. Production of growth promoting substances and vitamins by vermicompost and biofertilizers and their favorable influences in increasing the leaf number and height has been reported by several workers (Bhavelker, 1991; Subbiah, 1994; Motsara *et al.*, 1995).

Bulb dry matter production

Application of *Azospirillum* in combination with VC and chemical fertilizer (T_{11}) and *Azotobacter* with the same combination (T_8) recorded the maximum bulb dry matter production (4571.2 and 4569.5 kg ha^{-1}, respectively) which were significantly higher than those receiving *Azotobacter* with FYM and chemical fertilizers (T_7) and *Azospirillum* with same combination (T_{10}) which recorded a bulb dry matter yield of 4526.3 and 4535.7 kg ha^{-1} respectively (Table 4). The above four treatments (T_{11}, T_8, T_7 and T_{10}) were significantly higher in bulb dry matter production as compared to the remaining treatments. The increased dry matter accumulation in bulb from 60-100 DAT was due to rapid bulb growth because of more translocation of photosynthates from leaves (source) to bulb (sink) (Ramana, 1991).

Table 3. Average number of leaves per plant as influenced by different organic manures, biofertilizers and chemical fertilizers at different stages of crop growth in onion.

Treatments	Days after transplanting				
	20	40	60	80	100
T_1	3.8 [a]	6.3 [a]	8.3 [a]	10.5 [a]	14.2 [a]
T_2	4.3 [a]	6.4 [a]	8.4 [a]	11.3 [b]	14.4 [a]
T_3	4.0 [a]	6.3 [a]	8.2 [a]	11.1 [b]	14.2 [a]
T_4	4.3 [a]	7.0 [b]	9.3 [c]	12.8 [d]	15.3 [b]
T_5	4.4 [a]	7.1 [b]	9.7 [d]	13.0 [d]	15.5 [b]
T_6	4.1 [a]	7.0 [b]	8.8 [b]	11.7 [c]	14.7 [a]
T_7	4.5 [a]	7.6 [b]	10.0 [e]	14.9 [e]	16.1 [b]
T_8	4.7 [b]	7.4 [b]	10.2 [e]	15.1 [e]	16.2 [b]
T_9	4.2 [a]	7.1 [b]	8.9 [b]	11.9 [c]	14.5 [a]
T_{10}	4.7 [b]	7.8 [b]	11.2 [e]	15.1 [e]	15.8 [b]
T_{11}	5.0 [c]	7.9 [b]	11.5 [e]	15.3 [e]	16.2 [b]
T_{12}	4.3 [a]	7.1 [b]	9.4 [c]	13.0 [d]	15.2 [b]
SE	0.1	0.1	0.1	0.1	0.1
LSD at 5 %	0.2	0.2	0.2	0.3	0.3

Bulb yield

The highest bulb yield (42.0 t ha^{-1}) was obtained by the application of *Azospirillum* in combination with VC and chemical fertilizers (T_{11}), which was on par with the bulb yield (40.7 t ha^{-1}) recorded with *Azotobacter* in the same combination of fertilizers (T_8).

Application of *Azospirillum* or *Azotobacter* in combination with FYM and chemical fertilizers i.e., T_{10} and T_7 recorded lower bulb yield (39.4 and 38.9 t ha^{-1} respectively) than the above treatments (T_{11} and T_8) but were not significantly different (Table 5).

Application of 50% N of RDF through VC (T_5) has produced significantly higher bulb yield (37.42 t ha^{-1}) than the 50% N provided with FYM (T_4) treatment (35.9 t ha^{-1}). On the other hand, treatment with RDF (control) recorded a bulb yield of 34t ha^{-1}, which was significantly lower to the above organic amendments combined with chemical fertilizers (T_4 and T_5). Increase in yield may be due to the application of biofertilizetrs and their direct role in nitrogen fixation and the production of phytohormone like substances and increase in nutrient uptake (Govindan and Purushottam, 1984).

Bulb diameter and weight

Among the treatments (Table 5) *Azospirillum* with VC and chemical fertilizer (T_{11}) recorded maximum bulb diameter (6.5 cm), which was not significantly different with bulb diameter (6.4 cm) recorded by the *Azotobacter* with the same combination of fertilizers (T_8).

Table 4. Bulb dry matter production (kg ha^{-1}) as influenced by different organic manures, biofertilizers and chemical fertilizers at different stages of crop growth in onion.

Treatments	Days after transplanting					
	20	40	60	80	100	120
T_1	18.2^a	71.5^b	542.4^a	1446.3^a	1884.6^a	1978.4^a
T_2	21.8^b	74.5^b	563.6^c	1510.0^c	1963.4^c	2018.8^c
T_3	22.2^b	73.6^b	557.4^b	1460.8^b	1899.1^b	1983.8^b
T_4	33.7^d	157.0^e	1003.4^e	2640.9^f	3961.9^g	4079.9^g
T_5	38.3^e	161.4^f	1063.4^g	2658.5^g	4007.0^h	4097.0^h
T_6	31.1^e	102.5^c	710.4^d	1790.4^e	2535.3^d	2632.5^d
T_7	40.8^f	184.5^g	1112.3^h	2883.7^i	4321.3^i	4526.3^i
T_8	42.9^f	196.3^j	1254.8^i	3137.3^j	4392.3^j	4569.5^j
T_9	29.3^c	109.3^d	712.9^d	1753.4^d	2567.2^e	2665.8^e
T_{10}	43.0^f	188.5^h	1256.3^i	3142.7^k	4397.1^j	4535.8^i
T_{11}	43.2^f	191.6^i	1265.7^j	3168.6^t	4430.8^k	4571.2^j
T_{12}	34.3^d	157.5^e	1048.5^f	2671.8^h	3880.3^f	3997.6^a
SE	0.9	0.8	1.2	1.3	3.6	4.4
LSD at 5 %	2.1	1.7	2.7	2.8	7.8	9.8

The onion crop receiving *Azospirillum* with FYM and chemical fertilizers (T_{10}) and *Azotobacter* with same component of fertilizers (T_7) recorded similar average bulb diameters of 6.1cm recording significantly superior values than control (5.2 cm).

Plants supplied with *Azospirillum* in combination with VC and chemical fertilizers (T_{11}) recorded the highest bulb weight (60.31g), which was on a par with those receiving *Azotobacter* in the same combination of fertilizers (T_8), which recorded a bulb weight of 59.5 g. *Azospirillum* in combination with FYM and chemical fertilizer (T_{10}) and *Azotobacter* with same combination (T_7) recorded a bulb weight of 57.9 and 57.0 g respectively, and was on a par with each other. These four treatments were significantly superior to the other treatments studied.

Integrated use of biofertilizer, organic manure and chemical fertilizers increased the bulb weight by 8.1 to 12.2% and bulb diameter by 15.0 to 19.9% (Table 4) over the application of chemical fertilizer (control). It could be attributed to the fact that increasing major elements particularly N level through biofertilizer and organic manure might have accelerated the synthesis of chlorophyll and amino acids (Develin, 1973) resulting more translocation of photosynthate from leaves to bulb causing increased bulb weight and diameter (Singh *et al.*, 1997). These results indicated that integrated use of biofertilizer, organic manure and chemical fertilizer was beneficial in improving yield attributes.

Bulb quality

Application of *Azotobacter* with VC and chemical fertilizers (T_8) produced bulbs with highest TSS (11.9%) which was on par with T_7, T_{10}, T_5 and T_4 and significantly superior to the control (10.3 %). The highest total sugars (10.1 %) was recorded with *Azospirillum* in combination with VC and chemical fertilizer (T_{11}) followed by those receiving *Azotobacter* with the same combination (T_8) and *Azospirillum* with the same combination (T_{10}) (Table 6). All these treatments were on par with one another. The maximum vitamin C content of 12.2 and 12.3 mg $100g^{-1}$ were recorded with the application of *Azotobacter* and *Azospirillum* with VC and chemical fertilizer, (T8 and T_{11}), respectively.

Table 5. Bulb yield (t ha^{-1}), bulb weight (g) and bulb diameter (cm) as influenced by different organic manures, biofertilizers and chemical fertilizers in onion.

Treatments	Bulb yield (t ha^{-1})	Average weight(g)/bulb	Average diameter (cm)/bulb
T_1	16.9^a	18.4^a	4.0^a
T_2	18.8^b	21.5^b	4.3^b
T_3	17.3^a	18.4^a	4.0^a
T_4	35.9^e	54.5^e	5.5^d
T_5	37.4^f	55.3^e	5.7^d
T_6	24.2^c	29.0^c	4.5^b
T_7	38.9^g	57.0^f	6.1^e
T_8	40.7^g	59.5^g	6.4^f
T_9	23.9^c	28.3^c	4.6^b
T_{10}	39.4^g	57.7^g	6.1^e
T_{11}	42.0^g	60.3^g	6.5^f
T_{12}	34.3^d	52.4^d	5.2^c
SE	0.7	0.8	0.1
LSD at 5 %	1.5	1.7	0.27

The improvement in the bulb quality of onion in the present study with the application of organic and biofertilizers is probably due to higher availability and uptake of nutrients which in turn might have led to more nitrogenous compounds in plant tissues and ultimately resulting in increased metabolism.

Improvement in the quality of onion bulbs through application of VC and FYM has been earlier reported by Gupta *et al.* (1999), which is in conformity with the findings of this study.

Economics

Economic analysis revealed that the highest net return (Indian Rs.49393.00 ha^{-1}) and highest benefit : cost ratio (1.6) were obtained from the treatment with the application of *Azotobacter* in combination with 50% N through FYM and rest of N, P and K through chemical fertilizer.

Table 6. Bulb quality as influenced by different organic manures, biofertilizers and chemical fertilizers in onion.

Treatments	TSS (%)	Total sugars (%)	Vitamin C mg 100 g^{-1}
T_1	10.0^a	8.3^a	10.4^a
T_2	10.3^a	8.2^a	10.5^a
T_3	10.5^a	8.6^a	10.6^a
T_4	11.4^a	9.7^a	11.5^a
T_5	11.4^a	9.7^a	12.1^a
T_6	10.5^a	9.6^a	11.2^a
T_7	11.9^a	10.0^a	12.3^a
T_8	11.9^a	10.0^a	12.4^a
T_9	10.7^a	9.5^a	11.2^a
T_{10}	11.7^a	9.9^a	12.3^a
T_{11}	11.5^a	10.1^a	12.3^a
T_{12}	10.3^a	8.3^a	10.5^a
SE	0.5	0.5	0.3
LSD at 5 %	0.9	0.9	0.6

CONCLUSIONS

In this study all the growth characters, yield and quality of the onion registered higher values with the application of biofertilizers in combination with organic manure and chemical fertilizer in Integrated Nutrient Management system. It was possible to obtain a yield increase of 22% over control with the above combinations of fertilizers. Highest net return and highest benefit cost ratio was obtained with biofertilizers in combination with FYM and chemical fertilizers. Hence, the application of biofertilizer (*Azospirillum* or *Azotobacter*) in combination with 50% N through FYM or VC and rest of N and 100% P, K through chemical fertilizer could be used in order to obtain optimum yield in sandy loam soil with onion cv N-53.

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REFERENCES

Bhavalkar, U.S. (1991). Vermiculture Biotechnology for LEISA Seminar on Low External Input Sustainable Agriculture, Amesterdam, Netherlands pp 1-6.

Develin, R.M. (1973). Plant Physiology India. Ed. Affiliated East West Press Private Ltd. pp 446.

Govindan, M. and Purushottam, D. (1984). Production of phytohormones by the nitrogen fixing bacteria *Azospirillum*. Agricultural Research Journal, Kerala 22(2): 133-138.

Gupta, R.P., Sharma, V.P., Singh, D.K. and Srivastava, K.J. (1999). Effect of organic manures and inorganic fertilizers on growth yield and quality of onion variety. Agrifound Dark Red NHRDF News Letter XIX (2&3) : 7-9.

Motsara, M.R., Bhattacharya, P. and Srivastaba, B. (1995). Biofertiliser, Technology, marketing and usage. Fertilizer Development Consultation Organization, New Delhi pp. 183.

Pandey, U.B. and Bhonde, S.R. (1999). Onion Export NHRDF News Letter XIX (4): 1-6.

Ramana, P.V. (1991). Studies on growth features, quality and nutrient uptake in some onion (*Allium cepa* L) cultivars. M.Sc. (Hort) Thesis submitted to Acharya N.G. Ranga Agricultural University, Hydrabad.

Rao, S.N.S. (1984). Biofertilizers in Agriculture, Oxford and IDH Publishing Company, India.

Subbaiah, K. (1994). Effect on N, P and biofertilizers on yield and nutrient uptake in chilli and Bellary onion. Madras Agricultural Journal 81 (5): 277-279.

Singh, L. Bhonde, S.R and Mishra, V.K. (1997). Effect of Different organic manures and inorganic fertilizers on yield and quality of *rabi* onion. News letter NHRDF 17(3): 1-3

Tandon, H.L.S. (1987). Fertilizer recommendation for horticultural crops. A guide book, Fertilizer Development and Consultation Organization, New Delhi.

Tilak, K.V.B.R. (1991). Bacterial fertilizers, Publication of Indian Council of Agricultural Research, New Delhi. pp 65.