

SIGNIFICANCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON PRODUCTIVITY AND SHELF LIFE OF BIG ONION

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ABSTRACT

A field experiment was conducted at the College of Agriculture, Rajendranagar, Hyderabad, India, on Integrated nutrient management with biofertilizers, organic and inorganic fertilizers on productivity and shelf life of onion (*Allium cepa* L.), in a randomized complete block design with 12 treatments replicated thrice. Two organic manures (farmyard manure and vermicompost) used separately and in combination with two biofertilizers (*Azotobacter chroococcum* and *Azospirillum brasilianse*) and chemical fertilizers were tested in comparison with recommended dose of chemical fertilizers (RDF) as control, using onion cv N-53. Bulb yield and yield attributes (bulb diameter and bulb weight) and nutrient uptake were significantly increased with application of biofertilizers (*Azotobacter* or *Azospirillum*) in combination with 50% N through organic manure (VC or FYM) and 50% N and 100% PK as chemical fertilizer, and were significantly superior to all other treatments. Storage losses due to physiological loss of weight (PLW), sprouting and rotting were highest in the RDF treatment and losses were reduced with application of biofertilizers in combination with organic manure and chemical fertilizers which also increased yield by 22% over the control (RDF). Economic analysis revealed that higher net return and benefit:cost ratio (1.6) were obtained when FYM was used to replace 50% of the recommended dose of inorganic N.

KEY WORDS: Biofertilizer, Farmyard manure, Nutrient uptake, Onion (*Allium cepa*)
Shelf life, Vermicompost.

INTRODUCTION

Onion (*Allium cepa* L.) is an important bulb crop and is an essential condiment in the diet. Pandey and Bhonde (1999) have reported that the productivity of onion in India (10.62t/ha) and in Sri Lanka (12.5t/ha) are low when compared to Korea (61.9t/ha), China (61.7 t/ha) and USA (42.9t/ha). Some of the facts associated with low yield are imbalance and inadequate nutrients, poor cultural practices, pest and disease incidence and low seed quality. A crop of 35t onion removes approximately 120 kg N, 50 kg P₂O₅ and 160 kg K₂O/ha. Supply of nutrients particularly nitrogen is of paramount importance in boosting productivity, quality and shelf life of onion (Tandon, 1987). Due to increasing costs, application of chemical fertilizer is not affordable by the small and marginal farmers. On the other hand continuous use of inorganic fertilizer results in deficiency of micronutrients, poor soil physico-chemical properties and low production. Hence the necessity to test the integrated plant nutrient approach which may be cost effective in many farming systems.

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Bio-fertilizers are living organisms, which augment plant nutrient supplies in symbiotic or asymbiotic manner. Among the asymbiotic, nitrogen fixing-bacteria, *Azotobacter* and *Azospirillum* contribute significantly to improve vegetable crops yields by 15-20% while reducing the depletion of soil nutrients (Motsara et al., 1995). In addition to these beneficial effects, biofertilizers help to cut down on inorganic N fertilizers from 20-30kg/ha, due to their potential to fix N (Tilak, 1991).

Farmyard manure, a useful organic component in an integrated nutrient management system, is the decomposed mixture of dung, urine and bedding material and contains about 0.5-1.3% N, 0.3-0.8% P₂O₅ and 0.4-1.2% K₂O (Kapur and Kanwer, 1993). Vermicompost produced by using earthworms is a rich source of macro and micro nutrients, vitamins and growth promoting substances. Vermicompost is reported to improve the quality and storability of onion (Kale et al., 1992). Judicious and efficient use of chemical fertilizers in combination with organic manure and biofertilizer increased the shelf life of onion where as with higher N and reduced K doses, storability was decreased (Singh et al., 1991). This study was carried out to find out the effect of integrated nutrient management with biofertilizers, organic manure and chemical fertilizers on productivity and shelf life of onion.

MATERIALS AND METHODS

A field experiment was carried out on a sandy loam soil during *rabi* (cool season) 2001-2002 at the student farm, College of Agriculture, Rajendranagar, Hyderabad in India. The experiment was arranged in a randomized complete block design with three replications using onion cv. N-53. Spacing was 15 cm x 10 cm and plot size was 3 m x 3 m. The 12 treatments comprised two organic manures (farmyard manure and vermicompost) applied separately and in combination with two biofertilizers available as commercial inoculants (*Azotobacter chroococcum* and *Azospirillum brasilianse*) and chemical fertilizers. Recommended dose of chemical fertilizers (RDF) served as the control (Table 1).

Decomposed farmyard manure (FYM) and vermicompost (VC) were applied to the respective plots and incorporated into the soil using a hand rake. The NPK contents in FYM was, 0.56, 0.21 and 0.45%, and in VC 1.96, 1.45 and 1.16%, respectively. Quantities of FYM and VC applied to the different plots were calculated on the basis of their NPK contents.

The seedling roots were dipped in a slurry of biofertilizer (1 kg in 10L water/ha) for 20 minutes before planting. Thirty days after transplanting, the soil between the seedling rows was also treated with biofertilizers at the rate of 2 kg/ha, before irrigating. Yield and yield attributes such as average bulb diameter and bulb weight and nutrient uptake by leaf and bulb were measured. A sample of 100 bulbs with 3 replicates stored in perforated gunny bags was used to estimate shelf life by measuring physiological loss of weight, and recording bulb rotting and sprouting

The soil in the experimental site was sandy loam in texture pH=6.1, electrical conductivity=2.3 m mhos/cm, and available N,P and K contents were 204.63, 24.52 and 146.52 kg/ha, respectively. Net return and benefit: cost ratio were calculated for each treatment.

RESULTS AND DISCUSSION

Bulb yield

Yield obtained in the different treatments are given in Table 2. Highest yield (42.04 t/ha) was recorded with the application of *Azospirillum* in combination with VC and chemical fertilizers (T₁₁) and this was 22% higher than the control (RDF), but was in par with that obtained (40.69 t/ha) with *Azotobacter* + VC + chemical fertilizers (T₈). A significant yield reduction was observed when VC in the above treatment combinations (T₁₁ and T₈) was substituted with FYM (T₁₀ and T₇). Shinde *et al.*, (1992), have attributed such results to the beneficial effects of VC over FYM.

Application of only VC (T₂) gave significantly higher yield (18.80 t/ha) than with only FYM (T₁) or combined application of FYM and VC (T₃) which recorded significantly lowest bulb yield. The low yields with only FYM or FYM+VC may be due to the low availability of major nutrients in FYM when compared to that from VC (Shinde *et al.*, 1992).

Comparison between treatments with *Azotobacter* in combination with FYM and VC (T₆) and *Azospirillum* with the same combination (T₉) revealed that individual effect of *Azotobacter* and *Azospirillum* were almost similar to that reported by Jhadhav *et al.*(1998). Integrated use of both biofertilizers with organic and inorganic fertilizers was efficient in increasing yields over the exclusive application of chemical fertilizers. This could be due to the increased uptake of nutrients (Table 3) resulting in rapid synthesis and translocation of photosynthates from the leaves to the bulbs.

Bulb diameter and weight

Highest bulb diameter (6.46 cm) and bulb weight (60.3g) were recorded with application of *Azospirillum* in combination with VC and chemical fertilizers (T₁₁). Only FYM (T₁) recorded lowest bulb diameter (3.96 cm) and weight (18.37g), which were in par with the combined application of FYM and VC (T₃) with a diameter of 4.00 cm and bulb weight of 18.41g.

Application of 50% N through FYM or VC together with chemical fertilizers (T₄ and T₅) recorded significantly higher bulb diameter (5.52 and 5.56 cm, respectively) and bulb weight (54.49 g and 55.26 g respectively), than that in RDF where the bulb diameter was 5.21 cm and bulb weight 52.41 g.

Combined application of bio fertilizer, organic manure and chemical fertilizer increased

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bulb diameter by 15.1-19.9% and bulb weight by 8.2-12.2% over the exclusive application of chemical fertilizers. This could be attributed to the fact that increasing major nutrients, particular N through biofertilizer and organic manure may have accelerated the synthesis of chlorophyll and amino acids (Develin, 1973) resulting in increased translocation of photosynthates from leaves to bulb.

Uptake of Major Nutrients

Nitrogen

Maximum N uptake at harvest (154.56 kg/ha) was recorded with the application of *Azospirillum* with VC and chemical fertilizers (T_{11}) which was in par with rest of the treatments receiving biofertilizer in combination with organic manure and chemical fertilizers (Table 3) and this trend was similar to the yield increase. Significantly lowest N uptake (84.36 kg/ha) was recorded with FYM (T_1). The N uptake with recommended N dose (122.43 kg/ha) was significantly lower than that with 50% N through FYM (T_4) or VC + chemical fertilizers (T_9), which recorded 124.7 kg N/ha and 127.8 N kg N/ha, respectively.

Thus it is evident that in treatments with low N source, the leaves removed more N than the bulbs, where as in treatments with high level of N, bulbs removed more N than leaves. However, such trends were not observed in P and K uptake. The favourable effects of N in promoting growth characters such as plant height, leaf area and number of leaves, might be due to the fact that the NAR (Net Assimilation Rate) of N fed plants was accelerated by their increased chlorophyll content and the absorbed N helped the formation of food reserves due to higher photosynthetic activity and improved carbohydrate content (Kumar *et.al.*, 1998). Similar findings of higher N uptake with higher N doses through organic manure and chemical fertilizers have been reported by Amirthalingam (1988) and Mallangouda *et.al.* (1995).

The enhancement of N uptake, when biofertilizers (*Azotobacter* and *Azospirillum*) were incorporated together with other organic and inorganic components, may be due to the significant contribution of biofertilizers towards fixing atmospheric nitrogen, which has been reported to be about 20-30 kg/ha (Subba Rao, 1984). Results show that *Azospirillum* in combination with VC and chemical fertilizers (T_{11}) recorded 20.93% more total N uptake than with VC and chemical fertilizers (T_9). Hence the additional uptake of 26.75 kgN/ha could be attributed to the effect of *Azospirillum*.

Total N uptake, with the combined use of chemical fertilizers and 50% N through FYM (T_4) or with VC (T_9), increased N uptake over the control (RDF) by 1.85 and 4.40 % respectively. Hence 50% N in RDF could be replaced with FYM or VC without affecting total N uptake. It is also evident from economic analysis (Fig. 2) that application of FYM is feasible due to higher benefit cost ratio. Similar findings with FYM over VC were also reported by Reddy (2000).

Phosphorus

Phosphorus uptake values in the different treatments are given in Table 3. Leaf, bulb and whole plant uptake (11.55, 20.08 and 31.63 kg/ha, respectively) were highest with the integrated use of *Azotobacter*, VC and chemical fertilizers (T_8). Subbaiah (1994) also reported that application of bio fertilizers increased N and P uptake in onion.

Potassium

Application of biofertilizers in combination with organic manure and chemical fertilizers (T_7, T_8, T_{10} and T_{11}) registered significantly high K uptake (Table 3) compared to other treatments. Treatment with FYM alone (T_1) recorded lowest K uptake of 46.94, 51.82 and 98.76 kg/ha by leaf, bulb and total plant respectively while the control recorded 55.41, 73.00 and 131.41 kg/ha respectively, which were in par with 50% N through FYM (T_4) and inferior to 50% N through VC (T_3). Singh and Verma (2001) observed that increasing K uptake leads to increased accumulation of carbohydrates and pungency of onion.

SHELFLIFE

Physiological loss of weight (PLW)

PLW in bulbs increased with increasing storage period irrespective of treatments. During the period between 40-140 days after storage, maximum PLW (18.93%) was observed in the control and was significantly higher than in other treatments (Fig.1). After 140 days of storage, total PLW was significantly low in the organic manure only and organic manure applied in combination with biofertilizer and chemical fertilizer treatments (T_1 to T_{11}). Pandey and Pandey (1994) also reported that application of organic manures enhanced the storage period and reduced PLW. This could be due to availability of antioxidants like vitamin C and growth retarding substances, which interfere with metabolic activities within the bulb.

Sprouting losses in bulbs

The only treatment which recorded sprouting was the control, in which 140 days after storage, 3.89% sprouting losses were recorded, while bulbs in other treatments remained dormant (Fig.1). The higher sprouting losses may be due to inorganic nitrogen, which favours apical dominance and enhances the formation of auxins, which in turn promote the growth, and development of dormant bulbs by activating and enlarging cells (Pandy and Pandey, 1994). Similar findings with higher sprouting losses with inorganic fertilizer (4.10%) as compared to VC has been reported earlier (NHRDF, 1996).

Rotting of bulbs

At 80 days after storage, first incidence of rotting (2.33%) was observed in the control. At 100 days after storage, rotting of bulb in the control and in 50% N through FYM + chemical

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fertilizer (T_4) recorded 3.67 and 2.51%, respectively. At the end of the storage period (140 days), rotting of bulbs was observed in treatments T_4 , T_5 , T_{10} and T_{12} (control) and the percentage loss was 4.86, 4.03, 1.85 and 6.83, respectively (Fig. 1). Thus the integrated use of biofertilizer, organic manure and chemical fertilizers may be beneficial to enhance the storage period and reduce storage losses due to PLW, sprouting and rotting of bulbs.

Economics

Figure 2 shows that maximum net returns (Indian Rs. 49393.00/ha) were obtained in the FYM + chemical fertilizers + *Azospirillum* treatment (T_{10}), and this was in par with the corresponding *Azotobacter* treatment (T_7). Lowest net returns (Indian Rs. 5063.00) were obtained with VC (T_2) and it was significantly lower than the returns in the FYM (T_1) and FYM + VC (T_3), treatments (Indian Rs. 9298.00 and Rs. 6070.00, respectively). The control recorded a net return of Indian Rs. 39733.00 and it was in par with that received in the FYM + chemical fertilizer (T_4) and VC + chemical fertilizer (T_3) treatments (Indian Rs. 41710.00 and 38878.00, respectively).

Maximum benefit cost ratio (1.60) was recorded with application of *Azospirillum* in combination with FYM and chemical fertilizers (T_{10}) followed by the corresponding *Azotobacter* treatment (T_7) recording a ratio of 1.57, and by T_4 (1.39). The control recorded a cost benefit ratio of 1.37. The ratio was lowest in the VC treatment (T_2) with a value of 0.16. Highest benefit cost ratio with FYM could be due to the low cost of FYM as compared to VC.

CONCLUSIONS

Integrated use of bio fertilizers in combination with 50% nitrogen through vermicompost and balance NPK through chemical fertilizers produced 22% more yield than the recommended dose of fertilizers. Bulb diameter and bulb weight increased with application of biofertilizer in combination with either FYM or VC and chemical fertilizer, resulting in higher bulb yield. Highest uptake of N, P and K in leaf, bulb and total plant were also recorded in the same treatments. Hence 50% N of the recommended dose of fertilizer could be replaced by either FYM or VC. Application of bio fertilizer in combination with organic manure and chemical fertilizer improved the shelf life of onion as indicated by the low PLW, sprouting and rotting of bulbs. Application of the recommended dose of fertilizers resulted in higher PLW, sprouting and rotting. Highest bulb yield was obtained with application of bio-fertilizer in combination with VC and chemical fertilizers, but significantly highest benefit cost ratio (1.60) and net returns were obtained in bio fertilizers + FYM + chemical fertilizer, as the cost of VC is higher than FYM.

Hence, integrated nutrient management with bio-fertilizers in combination with organic manure and chemical fertilizers is beneficial and economical to in increasing onion productivity.

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Table 1. Description of the treatments.

Treatment	Materials used
T ₁	Farmyard manure (FYM)
T ₂	Vermicompost (VC)
T ₃	Farmyard manure -10 t/ha + Vermicompost- 2.5 t/ha
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 Vermicompost+ 50% recommended N and total recommended P and K through chemical fertilizers.
T ₆	Treatment 3 + <i>Azotobacter</i> (2 kg/ha)
T ₇	Treatment 4 + <i>Azotobacter</i> (2 kg/ha)
T ₈	Treatment 5 + <i>Azotobacter</i> (2 kg/ha)
T ₉	Treatment 3 + <i>Azospirillum</i> (2 kg/ha)
T ₁₀	Treatment 4 + <i>Azospirillum</i> (2 kg/ha)
T ₁₁	Treatment 5 + <i>Azospirillum</i> (2 kg/ha)
T ₁₂	Recommended NPK (150-80-100) kg/ha (control)

Table 2. Effect of organic manures, biofertilizers and chemical fertilizers on bulb yield, bulb weight, and bulb diameter of onion.

Treatment	Bulb yield (t/ha)	Bulb weight (g/bulb)	Bulb diameter (cm/bulb)
T ₁ : FYM 20 t/ha	16.85	18.37	3.96
T ₂ : VC 5 t/ha	18.80	21.47	4.28
T ₃ : FYM 10 t/ha +VC 2.5 t/ha	17.25	18.41	4.00
T ₄ : 50 % N through FYM+ 50 % N & 100 % PK (Chemical fertilizers)	35.87	54.49	5.52
T ₅ : 50 % N through VC + 50 % N & 100 % PK (Chemical fertilizers)	37.42	55.26	5.66
T ₆ : T ₃ + <i>Azotobacter</i>	24.24	29.02	4.48
T ₇ : T ₄ + <i>Azotobacter</i>	38.93	57.04	6.08
T ₈ : T ₅ + <i>Azotobacter</i>	40.69	59.51	6.38
T ₉ : T ₃ + <i>Azospirillum</i>	23.87	28.33	4.59
T ₁₀ : T ₄ + <i>Azospirillum</i>	39.42	57.86	6.10
T ₁₁ : T ₅ + <i>Azospirillum</i>	42.04	60.31	6.46
T ₁₂ : RDF (Control)	34.34	52.41	5.21
LSD at 5 %	1.48	1.72	0.27
CV(%)	12.21	11.65	10.32

FYM - Farmyard Manure

VC - Vermicompost

RDF - Recommended dose of chemical fertilizers (N.P.K-150.80:120)