



Effect of organic and inorganic nutrient sources on productivity, profitability and soil fertility in onion (*Allium cepa*) under Entisol

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ABSTRACT

Field experiment was conducted for two consecutive winter (*rabi*) seasons of 2014–15 and 2015–16 at Panwari village, Agra, Uttar Pradesh to find out the best combination of organic manures and inorganic fertilizers for increasing productivity, profitability and soil fertility in onion (*Allium cepa* L.) under Entisol. The experiment was laid out in randomized block design with eight treatments and three replications. The results revealed that the fresh weight of onion bulb, and bulb yields increased on application of 100% NPK. The yields of onion bulbs were significantly lower with the suboptimal dose of NPK fertilizers (75% RDF). An additional bulb yield of 7.25 t/ha was realized with 75% NPK+15 t/ha FYM over 75% NPK alone. Application of 75% RDF+6 t/ha vermicompost increased bulb yield by 29.4% over 75% RDF alone. Application of 75% RDF+15 t/ha FYM+20 kg/ha S and 75% NPK+6 t/ha vermicompost+20 kg/ha S increased the bulb yield by 38.5 and 43.8% over 75% RDF, respectively, indicating the superiority of vermicompost over FYM. The maximum content of protein (7%) was recorded with 75% NPK+15 t/ha FYM+20 kg/ha S, but maximum value of protein yield (481 kg/ha) was recorded with 75% NPK+6 t/ha vermicompost+20 kg/ha S. Application of 75% NPK+20 kg/ha S also improved the yield (29.92 t/ha), quality, and uptake of nutrients by onion bulbs but proved inferior compared to vermicompost and FYM. The uptake of NPK and S was highest with 75% NPK+6 t/ha vermicompost+20 kg/ha S and lowest in control. Net returns (₹ 1,44,375/ha) and B:C ratio (3.20) were also highest with 75% NPK+6 t/ha vermicompost+20 kg/ha S. Use of organic manures decreased soil pH and their combined use with fertilizers built up organic carbon and available NPK and S in post-harvest soil.

Key words: Entisol, Inorganic Fertilizers, Onion, Organic manure, Productivity, Profitability, Soil fertility

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops grown in India. It has culinary, dietary and medicinal value and is also a major vegetable crop to gain foreign currency. In India, the productivity of onion is very low due to lack of manuring and imbalanced fertilization. Among the various agronomic practices, use of sub-optimum and imbalanced fertilization is responsible for low productivity of onion. Use of optimum fertilization is the key factor for increasing productivity, it can be realized by judicious application of plant nutrients to onion crop (Singh *et al.* 2015, Pal *et al.* 2016). The continuous use of NPK fertilizers increases the production but simultaneously brings about problems related to sulphur deficiencies in soil. Sulphur has many physiological functions including synthesis of sulphur containing amino acids that improve quality of bulbs, synthesis of carbohydrates, protein, vitamins and flavour compounds. Response to applied

sulphur for better growth and yield of vegetable crops has been reported from almost all corners of the country (Verma and Singh 2012). Judicious use of farmyard manure and vermicompost alone and in combination with chemical fertilizers improves soil's physical, chemical and biological properties, and crop productivity. Organic manures also help to overcome deficiencies of macro, secondary and micronutrients, and make fertilizer use economical and efficient. Integration of organics with inorganics has been found to be promising for maintaining higher productivity and greater stability in crop production. In view of shrinkage of land resources for cultivation, short supply and escalating cost of chemical fertilizers, environmental pollution and ill effects on soil, animal and human health, there is a need to use organic manures with chemical fertilizers for achieving the objective of environmentally and ecologically sustainable agriculture (Verma *et al.* 2014). Limited studies have been conducted to work out the optimum dose of organic manures and mineral fertilizers for vegetable crops in Agra region of Uttar Pradesh. Field experimentation of organic manures in vegetable crops is important as the farmers are diversifying from cereals. The present investigation was, therefore, carried out to study the effect of integrated use of organic

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manures and chemical fertilizers on yield, nutrient uptake and quality of onion under entisol.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons (winter) of 2014–15 and 2015–16 at Research farm RBS College Bichpuri, Agra (UP). The experimental site is characterized by semi-arid climate with extreme temperature during summer (45–48°C) and very low temperature during winter (2°C). The average rainfall is about 650 mm, most of which is received from June to September. The experimental soil was sandy loam with pH 7.9, organic carbon 3.1 g/kg, available N 152 kg/ha, P 9.5 kg/ha, K 106 kg/ha and S 15 kg/ha. The experiment was laid out in randomized block design with three replications. The experiment included eight treatments, viz. T₁ control, T₂ 75% RD of NPK, T₃ 75% NPK+15 t/ha FYM, T₄ 75% NPK+6 t/ha vermicompost (VC), T₅ 75% NPK+20 kg/ha S, T₆ 75% RD of NPK+15 t/ha FYM+20 kg/ha S, T₇ 75% RD of NPK+6 t/ha VC+20 kg/ha S, T₈ 100% NPK (150 kg N + 100 kg P₂O₅+50 kg K₂O per ha). Potassium in the form of muriate of potash was applied at planting; the crop received nitrogen in two splits, half as basal and half at 60 days after planting. Phosphorus was applied as triple superphosphate at planting. Sulphur was applied as elemental sulphur at the time of planting. Well decomposed farmyard manure (0.51% N, 0.20% P and 0.55% K) and vermicompost (1.55% N, 0.62% P and 0.75% K) were applied as per the treatments one week before planting. The seedlings of onion, cv. Nasik red N-53 were planted in mid-December during both the years. The spacing adopted was 20×10 cm. Onion was irrigated after planting, and later as and when required. Crop was harvested at physiological maturity and yield data were recorded. Onion bulbs were oven dried at 70°C to a constant weight to calculate the dry matter yield of bulbs. Processed bulb samples were analyzed for their nutrient content by digesting the samples using di-acid mixture of HNO₃: HClO₄ (10:4). Phosphorus, Potassium and Sulphur were determined by vanadomolybdophosphoric yellow colour method, flame photometer (Jackson 1973), turbidimetric method (Chesnin

and Yien, 1951), respectively. Nitrogen content in bulbs was estimated by modified Kjeldahl method, and protein content was calculated by multiplying with 6.25. The uptake of nutrients was obtained as product of their concentrations and dry matter yield of onion bulbs. After harvesting the crop, soil samples were collected and analyzed for organic carbon, available N (0.32% alkaline KMnO₄ oxidizable), P (0.5 M NaHCO₃ extractable), K (1 N neutral ammonium acetate extractable) and S (0.15% CaCl₂ extractable), as described by Page *et al.* (1982). The trend of results was similar during both the years thus, data were subjected to pooled analysis (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Yield attributes and yield

The yield attributes of onion, viz. fresh weight/bulb were significantly influenced by application of inorganic fertilizers (75–100% NPK) (Table 1). High value of fresh weight of bulb (85.3 g) was recorded under 100% NPK which may be attributed to release of adequate nutrients in balanced amounts by NPK fertilizers (Singh *et al.* 2015). The fresh weight of onion bulbs also increased significantly by integrating organic manures or supplementary nutrients like sulphur with NPK fertilizers. High fresh bulb weight (92 g) was recorded on combined application of 75% NPK+6 t/ha vermicompost indicating that supplementing the inorganic fertilizers with vermicompost improved the general soil environment, which in turn improved the yield attributes of onion (Table 1). Application of 75% NPK + 15 t/ha FYM also resulted in higher fresh weight of onion as compared to application of 75% NPK alone. Similar results were reported by Singh and Pandey (2006). The maximum fresh weight of bulb (98 g) was recorded with 75% NPK+6t/ha vermicompost +20 kg/ha S.

The bulb yield and dry matter yield of onion bulbs increased significantly with increasing NPK levels. The yield of bulb increased by 66.7% with the application of 100% NPK over control. The response of onion to NPK fertilizers may be attributed to their low status in soil and exhaustive nature of onion crop removing more nutrients

Table 1 Effect of organic manures and fertilizers on yield and economics of onion

Treatment	Fresh weight of bulbs (g)	Bulb yield (t/ha)	Response (%)	Dry matter yield (t/ha)	Net returns (₹/ha)	B:C ratio
T ₁ Control	73.5	19.65		3.02	69105	1.47
T ₂ 75% RD of NPK	80.6	26.55	35.1	4.07	128155	2026
T ₃ 75% RDF+15 t/ha FYM	89.7	33.80	72.0	6.18	138830	2091
T ₄ 75% RDF+6 t/ha VC	92.0	34.35	74.8	6.35	143985	3.00
T ₅ 75% RDF+20 kg/ha S	84.8	29.92	52.2	5.43	128119	2.75
T ₆ 75% RDF+15 t/ha FYM+20 kg/ha S	95.0	36.78	87.1	6.66	139765	3.08
T ₇ 75% RDF+6 t/ha VC+20 kg/ha S	98.0	38.19	94.3	6.93	144375	3.20
T ₈ 100% RD of NPK	85.3	32.75	66.7	5.93	134271	2.48
CD (P=0.05)	4.9	2.78		0.43		

RDF, Recommended Dose of fertilizers; FYM, Farmyard Manure; VC, vermicompost.

and, thus, resulting response to NPK fertilizers. Similar findings were also reported by Verma *et al.* (2014) and Pal *et al.* (2016). The highest pooled bulb and dry matter yields (38.19 and 6.93 t/ha) were obtained with 75% NPK+6 t/ha vermicompost and the lowest yields (19.65 and 3.02 t/ha) were recorded in control plots. The treatment 75% RDF+15 t/ha FYM+20 kg/ha S had second highest bulb and dry matter yield. The results demonstrated the superiority of vermicompost over FYM in onion production which may be attributed to higher nutrient content in vermicompost (Sharma *et al.* 2009). Improvement in yield due to combined application of inorganic fertilizers and organic manures might be attributed to controlled release of nutrients in the soil through mineralization of organic manures which might have facilitated better crop growth. The results thus, indicate that about 25% NPK fertilizers can be saved by addition of 6t/ha vermicompost or 15 t/ha FYM without any adverse effect on yield. Similar results were reported by Verma *et al.* (2014) and Singh *et al.* (2015). Application of 20 kg/ha S along with 75% NPK increased the yield over application of 75% NPK alone. This increase in yield was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism. Similar results were reported by Verma and Singh (2012). Treatment having 75% NPK+6 t/ha vermicompost+20 kg/ha S out-yielded all the treatments, indicating the benefit of integrated use of organic manures and chemical fertilizers (Purohit and Nagaich 2015).

Economics

Data revealed that the higher net returns of onion crop were obtained with 75% NPK+6 t/ha vermicompost+20 kg/ha S (Table 1). This treatment produced higher bulb yield with net returns of ₹ 1,44,375/ha as compared to ₹ 143785/ha under 75% NPK+6 t/ha vermicompost. Higher net returns may be attributed to a higher bulb yield. Among the various treatments, maximum B:C ratio of 3.20 was recorded under 75%NPK+6 t/ha vermicompost+20 kg/ha S. Similar results were reported by Purohit and Nagaich (2015) and Singh *et al.* (2015). The minimum values of net returns (₹ 69105/ha) and B:C ratio (1.47) were recorded under control due to poor yield of onion bulbs.

Quality

The lowest values of content and yield of protein were recorded in control (Table 2) which may be attributed to low nitrogen status of the soil. The protein content of onion bulbs increased from 5.93% (control) to 6.87 % by 100% NPK application. Protein synthesis is closely associated with the supply of nitrogen, therefore, increased supply of nitrogen resulted in greater protein content in bulbs. Our results are in agreement with the findings of Verma *et al.* (2014) and Uikly *et al.* (2015). The content and yield of protein also improved over control when 75% NPK was added with 15 t/ha FYM and 6 t/ha vermicompost. The percentage and yield of protein in onion bulbs increased significantly with 75% NPK +20 kg/ha S over 75 % NPK alone. Verma and Singh (2012) also reported an increase in protein content with S application in onion. The magnitude of increase was higher with 75% NPK + 15 t/ha FYM as compared to 75% NPK alone or combined with S. FYM contains N and upon its decomposition produces many organic acids which make the insoluble nitrogen soluble and thus, increase N availability. Pachauri *et al.* (2005) and Singh *et al.* (2015) also reported an improvement in content and yield of protein with fertilizer and FYM application. Both the treatments (75% NPK+15 t/ha FYM and 75% NPK+6 t/ha vermicompost) proved statistically superior to most of the treatments with respect to content and yield of protein in onion bulbs. The maximum value of protein content (7%), and yield (481 kg/ha) were recorded in 75% NPK+15 t/ha FYM+20 kg/ha S and 75%NPK+6 t/ha vermicompost + 20 kg/ha S, respectively, which may be attributed to increased supply of nitrogen to plants from soil and increased dry matter yield of bulbs (Sharma *et al.* 2009).

Nutrient uptake

The values of nutrients uptake followed the pattern of yield obtained in various treatments. The nitrogen uptake by onion bulbs increased significantly with increasing levels of NPK fertilizers up to 100% level (Table 2). This increase may be attributed to higher availability of N in soil with the addition of fertilizers (Singh and Pandey 2006). A further increase in N uptake by onion bulbs was recorded with 75%

Table 2 Effect of treatments on quality and uptake of nutrients by onion bulbs

Treatment	Protein content (%)	Protein yield (kg/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulphur (kg/ha)
T ₁ Control	5.93	179.1	28.7	6.9	25.7	10.6
T ₂ 75% RD of NPK	6.56	267.0	42.7	10.2	37.0	15.0
T ₃ 75% RDF+15 t/ha FYM	6.87	424.6	68.0	17.3	59.3	24.7
T ₄ 75% RDF+6 t/ha VC	6.81	432.0	69.2	18.4	60.3	26.7
T ₅ 75% RDF+20 kg/ha S	6.69	363.3	58.1	13.6	47.8	22.8
T ₆ 75% RDF+15 t/ha FYM+20 kg/ha S	7.00	466.2	74.6	19.3	65.3	29.3
T ₇ 75% RDF+6 t/ha VC+20 kg/ha S	6.94	481.0	76.9	20.1	67.2	30.5
T ₈ 100% RD of NPK	6.87	407.4	65.2	16.0	55.7	23.1
CD (P=0.05)	0.39	52.2	3.10	2.05	4.65	1.31

NPK + 15 t/ha FYM and 75% NPK + 6 t/ha vermicompost which may be attributed to greater production of onion bulbs (Singh and Pandey 2006). There was a significant increase in N uptake by onion bulbs with addition of S along with 75% NPK over control due to higher production of dry matter (Uikey *et al.* 2015). The maximum amount of N (76.9 kg/ha) was utilized by the crop grown with 75% NPK+6 t/ha vermicompost+20 kg/ha S indicating the beneficial role of integrated use of nutrient sources to the crop. Increasing levels of NPK fertilizers (75–100%) increased P uptake significantly over control which may be due to better growth and dry matter production of bulbs and a deeper ramification of roots which causes higher uptake of P (Singh *et al.* 2015). The relatively higher P uptake was recorded with 75% NPK +6 t/ha vermicompost and 75% NPK + 15 t/ha FYM which differed significantly from most of the treatments (Table 2). Higher phosphorus uptake could be attributed to conversion of fixed phosphorus into readily available form by organic acids released during the decomposition of organic manures and consequent improvement in the available P in soil and better biochemical activity in the crop plants (Singh and Pandey 2006). Application of 75% NPK+6 t/ha vermicompost+20 kg/ha S also resulted in higher uptake of P by bulbs over only NPK and control, which may be attributed to beneficial effect of this treatment on the availability of P in soil. Application of NPK levels significantly improved the uptake of K by onion bulbs as compared to control. The 75% NPK+ 15 t/ha FYM and 75% NPK + 6 t/ha vermicompost recorded higher K uptake by onion bulbs over 75% NPK and control, respectively. This increase in K uptake may be attributed to higher dry matter yield with these treatments. Verma *et al.* (2014) also reported similar results in onion crop. Inclusion of S along with 75% NPK also improved K uptake over NPK levels. Sulphur uptake by onion bulbs increased from 10.6 kg/ha at control to 30.5 kg/ha with 75% NPK+ 6 t/ha vermicompost + 20 kg/ha S. The data indicate the need for integrated nutrient supply system for onion. These results are in consonance with the findings of Sharma *et al.* (2009). Increasing levels of NPK also improved the uptake of S by onion bulbs as a result of additional dose of nutrients which induced the

plant to absorb more amount of S. Application of 75% NPK + 20 kg/ha S also improved the uptake of S by onion bulbs (Uikey *et al.* 2015).

Soil fertility

There was a marked variation in soil pH due to various nutrient management practices. Soil pH was not affected markedly by NPK levels (75% and 100%). It reduced with application of organic manures (FYM and vermicompost) and minimum pH values were recorded under 75% NPK + 15 t/ha FYM+20 kg/ha S and 75 % NPK+6 t /ha vermicompost +20 kg/ha S (Table 3). This decrease in soil pH may be attributed to production of organic acids during their decomposition (Sharma *et al.* 2009). Organic carbon content increased significantly with all the treatments over control. Application of 100% NPK also improved the organic carbon content in post-harvest soil. Application of 75% NPK+organic manures significantly increased the organic carbon content in soil. The increase in organic carbon may be attributed to addition of organic carbon and better root growth (Verma *et al.* 2014). Application of 100 % NPK significantly increased available N content over control by 34.4% (Pal *et al.* 2016). Available N content in soil further improved with combined use of 75% NPK+15 t/ha FYM and 75% NPK+ 6 t/ha vermicompost. The available nitrogen content in post-harvest soil increased from 145 kg/ha to 210 kg/ha with 75% NPK+15 t/ha FYM+20 kg/ha S. Such increase in available N is ascribed to the mineralization of FYM. These results are in line with the findings of Singh and Pandey (2006). Control plots showed reduction in the available N status due to removal of nitrogen with cropping without fertilization. Control plots had minimum available P content in soil due to removal of P by crop in the absence of external source of P. The inclusion of P fertilizer raised the available soil P above its initial level of 9.5 kg/ha. Application of 100% NPK significantly increased the available P status (Pal *et al.* 2016). Use of S along with 75% NPK had no significant effect on available P status. Incorporation of FYM and vermicompost along with 75% NPK recorded significantly higher available P content as compared to other treatments. Similar findings have also

Table 3 Effect of various treatments on soil fertility

Treatment	pH	Organic C (g kg/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulphur (kg/ha)
T ₁ Control	8.0	3.1	145	8.4	95	13.5
T ₂ 75% RD of NPK	8.1	3.3	170	9.5	120	14.0
T ₃ 75% RDF+15 t/ha FYM	7.8	4.0	200	11.0	136	15.6
T ₄ 75% RDF+6 t/ha VC	7.7	3.9	195	11.2	142	15.8
T ₅ 75% RDF+20 kg/ha S	7.9	3.4	155	9.8	126	19.7
T ₆ 75% RDF+15 t/ha FYM+20kg/ha S	7.7	4.2	210	11.6	149	17.5
T ₇ 75% RDF+6 t/ha VC + 20 kg/ha S	7.7	4.2	206	11.4	148	20.0
T ₈ 100% RD of NPK	8.1	3.4	195	10.0	138	14.8
CD (P=0.05)	0.15	0.11	9.5	1.85	2.97	0.92

been reported by Singh and Pandey (2006) and Verma *et al.* (2014). The increased P availability with organic manures could be ascribed to their solubilizing effect on the native P through release of various organic acids (Singh *et al.* 2015). The status of available K declined in control treatment from initial status of 106 kg/ha (Table 3). Increasing levels of NPK fertilizers from 75 to 100% significantly increased the available K status in soil and relative higher value (138 kg/ha) was recorded at 100% NPK level. Application of S along with 75% NPK had no marked effect on available K status in soil over NPK level. Relatively higher amount of available K (138 kg/ha) in post-harvest soil was recorded with 75% NPK+15 t/ha FYM and 142 kg/ha with 75%NPK+6 t/ha vermicompost. The increase in available K under these treatments might be due to decomposition of FYM and vermicompost as accompanied by the release of more quantities of CO₂ which when dissolved in water, forms carbonic acid and which is capable of decomposing certain primary minerals and release of nutrients (Singh and Pandey 2006). The available K content in soil was maximum with the treatment having 75% NPK+15 t/ha FYM+20 kg/ha S. Growing of onion crop without S application caused decline in available S in the soil and maximum decline was noted in control. Application of NPK levels improved the status of available S in soil. But an appreciable increase in available S content was found in the treatment receiving FYM and vermicompost along with NPK fertilizers. Application of 75% NPK+15 t/ha FYM and 75 % NPK+6 t/ha vermicompost significantly raised the available S status of soil (15.6 and 15.8 kg/ha) followed by 100 % NPK (14.8 kg/ha). Similar findings have also been reported by Singh *et al.* (2015). The amount of available S in post-harvest soil was significantly increased with 75% NPK+20 kg S/ha over 75% NPK and control. The maximum amount of available S content was recorded in treatment having 75% NPK+6 t/ha vermicompost+20 kg/ha S.

It may be concluded that the combined use of 75% NPK along with organic manures, viz. 15 t/ha FYM and 6 t/ha vermicompost, not only sustained the higher yield of onion but also improved the quality of bulb and soil fertility over sole use of chemical fertilizers. The findings indicate that balanced use of fertilizers alone or in combination with organic manures resulted in significant build-up of organic carbon and available nutrients in post-harvest soil.

Vermicompost performed better than FYM with respect to productivity and profitability of onion crop. Incorporation of S along with NPK also improved the yield, and available S status in post-harvest soil.

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