



Effect of conjoint use of farmyard manure and fertilizers on yield and nutrient uptake by onion (*Allium cepa*) and soil fertility

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ABSTRACT

Field experiment was conducted for two consecutive *rabi* seasons (2010-11 and 2011-12) at the Research farm, R B S College, Bichpuri, Agra (Uttar Pradesh) to study the effect of conjoint use of FYM and chemical fertilizers on yield and nutrients uptake by onion (*Allium cepa* L.) and soil fertility. The experiment was laid out in randomized block design with twelve treatments and three replications. The results revealed that the scale leaves/bulb and fresh weight of onion bulb and bulb yields increased significantly up to 150% NPK level over control. The yields of onion bulbs were significantly lower with the sub-optimal dose of NPK fertilizers. All the parameters further increased when 10 tonnes FYM/ha was added along with 100% NPK. An additional bulb yield of 3.35 tonnes/ha was realized with 100 % NPK + 10 tonnes/ha over 100% NPK alone. Application of 100% NPK + 5 kg Zn + 1 kg B/ ha produced 32.13 tonnes/ha bulbs and dry matter yield (5.03 tonnes/ha) of onion which was superior to 100 % NPK alone (30.36 and 4.75 tonnes/ha). The maximum protein content (5.75 %) and yield (29.75 q/ha) were obtained with 150% NPK and 100% NPK + 10 tonnes FYM/ha, respectively. The uptake of N, P, K, S, Zn and B by the onion bulbs was found to be associated with production of dry matter resulted by the addition of 100% NPK + 10 t FYM/ha. However, the maximum uptake of Zn (281.0 g/ha) and B (392.1 g/ha) by onion bulbs was noted under 100% NPK+5 kg Zn/ha and 100% NPK + 1 kg B/ha, respectively. The conjoint use of 10 t FYM/ha with 100 % NPK significantly improved the status of available N, P, K, S, Zn and B in post harvest soil over the NPK fertilizers alone. Available B and Zn contents were found to be higher in treatment combination of 100% NPK + 1 kg B /ha and 100 % NPK + 5 kg Zn/ha, respectively. The minimum amounts of available nutrients in post harvest soil were recorded under control treatment.

Key words: Boron, Fertilizers, FYM, Nutrient uptake, Onion, Soil fertility, Yield, Zinc

Onion (*Allium Cepa* L.) is one of the most important commercial vegetable crops grown in India. Onion has culinary, dietary and medicinal importance in daily life of Indian people and due to its export trade, it 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. Use of optimum fertilization is the key factor in increasing the productivity which can be realized with the judicious application of plant nutrients to onion crop (Pal *et al.* 2016 a). The continuous use of NPK fertilizers has remarkably increased production but simultaneously brought about problems related to micronutrient deficiencies, particularly those of boron and zinc in soil. Boron is essential micronutrient required for normal growth and development of crop plants. Boron in plants is reported to function at membrane level and is

credited with maintaining membrane integrity and enhanced ability of membranes to transport vital nutrients. Boron acts as new cell developer in meristematic tissue, fruit and seed setting. It is involved in the regulation of the carbohydrate metabolism and its transport within the plants, DNA synthesis in meristems, syntheses of amino acids and proteins. Zinc is also an important micronutrient reported deficient in Indian soils and plays a significant role in various enzymatic and physiological activities of plant bodies. These are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, maintenance of the integrity of biological membranes and resistance to infection by certain pathogens. Response to applied zinc for better growth and yield of vegetable crops has been reported from almost all corners of the country (Solanki *et al.* 2010, Singh *et al.* 2015). Application of boron has been found to improve the production of vegetable crops (Singh 2003, Varghese and Duraisami 2005). Judicious use of farmyard manure with chemical fertilizers improves soil physical, chemical and biological properties and improves crop productivity. It also helped in arresting the emerging deficiencies of macro, secondary

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and micronutrients favourably and achieving economy and efficiency in fertilizers use. In view of shrinkage of land resources for cultivation, short supply and escalating cost of chemical fertilizers, environmental pollution and ill effects on soils, animals and human health, there is need to use farmyard manure 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 proportion of organic manure and mineral fertilizers for vegetable crops. The present investigation was, therefore, carried out to study the effect of farmyard manure and chemical fertilizers on yield, nutrient uptake and quality of onion.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons of 2010-11 and 2011-12 at Research farm, RBS College, Bichpuri, Agra, Uttar Pradesh. The farm is situated at 27° 2' N latitude and 77° 9' E longitude at an altitude of 163.4 m amsl. The experimental site is characterized by semi-arid climate with extreme temperature during summer (45 to 48° C) and very low temperature during winter (as low as 2°C). The average rainfall is about 650mm, most of which is received from June to September. The experimental soil was sandy loam in texture having pH 7.9, organic carbon 3.1 g/kg, available N 152 kg/ha, available P 9.5 kg/ha, available K 106 kg/ha and available S 15 kg/ha, DTPA-zinc 0.55 mg/kg and boron 0.18 mg/kg. The experiment was laid out in randomized block design with three replications. The experiment included twelve treatments, viz. T₁ control, T₂ 50% RD of NPK, T₃ 50% NPK+10 tonnes FYM/ha, T₄ 50% NPK+1 kg B/ha, T₅ 50% NPK + 5 kg Zn /ha, T₆ 50% NPK + 1 kg B + 5 kg Zn /ha, T₇ 100% RD of NPK (150 kg N+100 kg P₂O₅ +50 kg K₂O/ha), T₈ 100% NPK+ 10 tonnes FYM / ha, T₉ 100% NPK+ 1 kg B/ha, T₁₀ 100% NPK+ 5 kg Zn /ha, T₁₁ 100% NPK + 1 kg B+ 5 kg Zn /ha and T₁₂ 150% NPK. Potassium in the form of muriate of potash was applied at planting but the crop received N in two splits, half as basal and half at 60 days after planting. Phosphorus was applied as triple superphosphate at planting. Zinc and boron were applied as zinc chloride and boric acid, respectively at the time of 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. The yield attributes of onion crop were recorded at harvest. 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 contents by digesting the samples using di-acid mixture of HNO₃: HClO₄ (10:4) followed by estimation of Zn using an AAS. Phosphorus, K and S were determined by vanadomolybdo phosphoric yellow colour method, flame photometer (Jackson 1973), turbidimetric method (Chesnin and Yien 1951), respectively. Boron in aliquot was estimated using carmine method (Hatcher and Wilcox, 1950). Nitrogen

content in bulbs was estimated by modified Kjeldahl method and protein content was calculated by multiplying with a factor of 6.25. The uptake of nutrients was obtained as product of their concentrations and yield. After harvest of crop, soil samples were collected and analyzed for available N (0.32 % alkaline KMnO₄ oxidizable), P (0.5 M NaHCO₃ extractable), K (1 N neutral ammonium acetate extractable), S (0.15% CaCl₂ extractable), B (hot water extractable) and Zn (DTPA extractable) as described by Page *et al.* (1982). The trend of results was similar during both the years hence; data were subjected to pooled analysis for results and discussion.

RESULTS AND DISCUSSION

Yield attributes and yield

The yield attributes of onion, viz. fresh weight/bulb and scale leaves/bulb were significantly influenced due to application of inorganic fertilizers (50 to 150% NPK) in comparison to control (Table 1). Among these NPK levels, the maximum values of these yield attributes were recorded under 150% NPK which may be attributed to release of adequate nutrients in balanced amounts by NPK fertilizers (Pal *et al.* 2016 b). These two characters of onion bulbs also increased significantly by integrating FYM or supplementary nutrients like boron and zinc with NPK fertilizers. However, the maximum values of yield attributes (fresh bulb weight and number of scale leaves/bulb) were recorded under combined application of 100% NPK + FYM, indicating that supplementing the inorganic fertilizers with FYM improved the general soil environment, which helped to improve the yield attributes of onion (Table 1). Similar results were reported by Singh and Pandey (2006). Application of 100% NPK+1 kg B/ha also improved the yield attributes significantly over control. The combined application of 100% NPK + Zn + B proved superior to 100% NPK + Zn and 100% NPK + B in respect of yield attributes of onion (Singh 2003). The bulb yield and dry matter yield of onion increased significantly with increasing NPK levels over control. The yield of bulb and dry matter of bulb increased by 51.7 and 53.3 per cent with the application of 150% NPK over control, respectively. The response of onion to NPK may be attributed to their low status in soil and exhaustive nature of onion crop removing more nutrients and thus resulting response to NPK fertilizers. Further, the use of sub-optimal dose (50% NPK) caused 23.0 and 23.5% increase in yields over control, respectively followed by 40.1 and 41.4% increase due to application of optimal dose (100% NPK). Similar findings were also reported by Pal *et al.* (2016 b). Application of 10 tonnes FYM/ha along with 100 % NPK recorded significantly higher yield followed by 150 % NPK alone (Table 1). The highest pooled bulb and dry matter yields (33.71 and 5.26 tonnes/ha) were obtained in the treatment receiving optimal dose of NPK with FYM (100% NPK + 10 tonnes FYM/ha) and the lowest yields (21.67 and 3.36 tonnes/ha) were recorded in control plots (Fig 1). Improvement in yield

Table 1 Effect of various treatments on yield attributes yields and quality of onion (mean of two years)

Treatment	Fresh weight/ bulb (q)	Scale leaves/ bulb	Bulb yield (t/ ha)	Dry matter yield (t/ha)	Protein content (%)	Protein yield (q/ha)
T ₁ Control	39.76	25.6	21.67	3.36	4.37	14.55
T ₂ 50% RD of NPK	45.17	26.8	26.73	4.15	4.75	19.61
T ₃ 50% NPK+10 t FYM/ ha	49.02	27.5	30.28	4.73	5.25	24.73
T ₄ 50% NPK+1 kg B/ha	45.96	27.0	27.22	4.24	4.94	20.79
T ₅ 50% NPK+5 kg Zn/ha	46.42	27.2	28.30	4.43	5.00	22.47
T ₆ 50% NPK+1 kg B+5 kg Zn/ ha	47.23	27.5	29.00	4.53	5.12	23.04
T ₇ 100% RD of NPK	49.95	27.9	30.36	4.75	5.25	24.83
T ₈ 100% NPK+10 t FYM/ ha	55.95	28.7	33.71	5.26	5.69	29.75
T ₉ 100% NPK+1 kg Boron/ha	51.25z	28.0	31.25	4.89	5.37	26.15
T ₁₀ 100% NPK+5 kg Zn/ ha	52.85	28.1	31.80	4.96	5.50	27.11
T ₁₁ 100% NPK+1 kg B + 5kg Zn/ha	53.13	28.4	32.13	5.03	5.56	27.85
T ₁₂ 150% NPK	54.85	28.5	32.87	5.15	5.75	29.49
SEM±	1.18	0.83	1.41	0.41	0.15	1.10
CD (P=0.05)	2.46	1.75	2.89	0.48	0.31	2.25

due to combined application of inorganic fertilizers and FYM might be attributed to controlled release of nutrients in the soil through mineralization of FYM which might have facilitated better crop growth. The results thus, indicate that about 50 % of the NPK fertilizers can be saved by addition of 10 tonnes FYM/ha without any adverse effect on yield. Similar results were reported by Verma *et al.* (2014) and Singh *et al.* (2015). Application of 1 kg B/ha along with 50 and 100 % NPK increased the yield over respective NPK levels alone (Singh 2003). Similarly, application of 5 kg Zn/ha with 50 and 100 % NPK produced significantly higher bulb yield and dry matter yield. The magnitude of Zn response progressively increased with increasing levels of

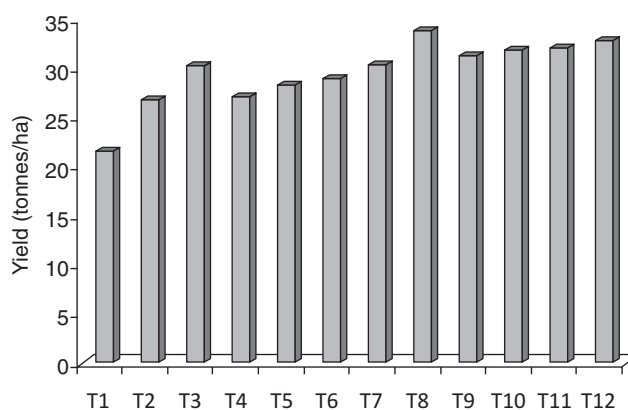


Fig 1 Effect of various treatments on yield of onion bulbs

NPK (Singh *et al.* 2015). This increase in yields was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism. Treatment having 100 % NPK + 10 tonnes FYM/ha out-yielded both the treatments namely 100 % NPK + 5 kg Zn/ha and 100 % NPK + 1 kg B/ha indicating the greater beneficial role of FYM than those of zinc and boron.

Quality

The lowest values of content and yield of protein were recorded in control (Table 1) which may be attributed to low nitrogen status of the soil. The protein content of onion bulbs increased from 4.37% at control to 5.75% with 150% NPK (T₁₂) application. The protein synthesis is closely associated with the supply of nitrogen. Nitrogen is a constituent of amino acids and proteins. Increased supply of nitrogen, therefore, resulted in greater protein content in bulbs. Our results confirm the findings of Pal *et al.* (2016 b). The content and yield of protein also improved over control when 100% NPK was added with 5 kg Zn/ha and 100% NPK+1 kg B/ha. the percentage and yield of protein in onion bulbs increased significantly with 100% NPK +B + Zn over 100 % NPK + B and 100 % NPK + Zn treatments. Varghese and Duraisami (2005) and Pal *et al.* (2016 a) also reported an increase in protein content with B and Zn application in cauliflower and onion, respectively. The magnitude of increase was higher with 100% NPK + 10 tonnes FYM/ha as compared to 100% NPK alone or combined with Zn and B. FYM itself contains N and upon its decomposition produces many organic acids which in turn make the insoluble N soluble and thus increases N availability. Similar were the results of Pachauri *et al.* (2005) and Singh *et al.* (2015) who also reported an improvement in content and yield of protein with fertilizer and FYM application. However, both the treatments (100% NPK+10 tonnes FYM/ha and 150 % NPK alone) were statistically on par with respect to content and yield of protein in onion bulbs.

Nutrient uptake

The values of nutrients uptake followed the pattern of yield obtained at various treatments. The nitrogen uptake by onion bulbs increased significantly with increasing levels of NPK up to 150% level. The increases in N uptake by

onion bulbs with 150% NPK were 25.3 and 103.4% over 100% NPK and control, respectively. This increase may be attributed to higher availability of N with the addition of fertilizers (Pal *et al.* 2016 b). A further increase in N uptake by onion bulbs was recorded with 100% NPK + 10 tonnes FYM/ha 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 B or Zn along with 100% NPK over control due to higher production of dry matter of bulbs. Increasing levels of NPK fertilizers (50% to 150%) 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 100% NPK + 10 tonnes FYM/ha which differed significantly from most of the treatments. Higher phosphorus uptake could be attributed to conversion of fixed phosphorus in to readily available form by organic acids released during the decomposition of FYM and consequent improvement in the available P in soil and better biochemical activity in the crop plants (Singh and Pandey 2006). Application of 100% NPK+ B+ Zn also resulted in higher uptake of P by bulbs over NPK alone 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 100% NPK+ 10 tonnes FYM/ ha recorded higher K uptake by 26.5 and 123.1% over 100% NPK alone and control, respectively. This increase in K uptake may be attributed to higher dry matter yield with this treatment. Pal *et al.* (2016 b) also reported similar results in onion crop. Inclusion of B and Zn alone with 50 or 100% NPK also improved K uptake over respective NPK levels. The sulphur uptake by onion bulbs ranged from 6.9 kg/ha in control to 15.5 kg / ha with 100% NPK+ 10 tonnes FYM/ha. 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 100% NPK + B + Zn also improved the uptake of S by onion bulbs over control. The uptake of Zn and B by onion bulb with different treatments ranged between 135.2 and 281.0 g/ha and 199.4 and 392.8 g/ha, respectively (Table 2). The uptake of Zn and B increased significantly with the conjoint application of FYM and 100% NPK in comparison to control. The uptake of B and Zn by onion bulbs increased with addition of B and Zn with 100% NPK, respectively. The maximum uptake of B and Zn by onion was recorded with 100% NPK + 1 kg B/ha and 100% NPK+ 5 kg Zn/ha, respectively. Increase in B and Zn uptake could be due to increase in dry matter production and B and Zn concentrations in bulbs. Solanki *et al.* (2010) and Singh (2003) reported similar results for Zn and B uptake, respectively. The lowest Zn and B uptake by bulbs was recorded in control due to lower dry matter yield.

Soil fertility

Data (Table 3) indicate that the available nitrogen

Table 2 Effect of various treatments on uptake of N, P, K, S (kg/ha), B and Zn (g/ha) by onion bulbs (mean of two years)

Treatment	Nitrogen	Phosphorus	Potassium	Sulphur	Zinc	Boron
Control	23.4	4.9	19.9	6.9	135.2	199.4
50% RD of NPK	31.2	6.9	27.7	8.9	168.9	250.1
50% NPK + 10 t FYM/ ha	39.3	9.9	34.3	11.4	224.2	305.0
50% NPK + 1 kg B/ ha	33.1	7.8	28.2	9.9	176.4	324.9
50% NPK + 5 kg Zn/ ha	35.2	7.3	29.9	9.9	218.6	265.1
50% NPK + 1 kg B+5 kg Zn/ha	36.9	9.8	30.9	10.7	216.3	343.1
100% NPK	38.0	7.8	35.1	11.6	193.8	288.7
100% NPK+10 t FYM/ ha	47.6	13.9	44.4	15.5	256.5	364.5
100% NPK+1 kg Boron/ ha	41.8	12.7	35.9	12.9	203.2	392.8
100% NPK+5 kg Zn/ha	43.5	12.6	37.2	12.9	281.0	306.6
100% NPK+1 kg B + 5kg Zn/ ha	44.5	13.9	37.5	13.3	274.1	391.9
150% NPK	46.3	14.1	43.8	15.2	213.7	320.6
SEm+ ₋	1.40	1.03	2.21	1.21	11.5	19.5
CD (P=0.05)	2.94	2.16	4.53	2.48	24.0	39.9

content in post harvest soil ranged from 149.3 to 237.3 kg/ha and highest value was associated with 100% NPK+10 tonnes FYM/ha (Singh *et al.* 2015). This showed an increase of 56.1% over initial value (152 kg/ha). Such increase in available N is ascribed to the mineralization of FYM. These results are in line with the findings of Pal *et al.* (2016 b). Further, by increasing doses of nutrients, the amount of available N also increased significantly (T₇, T₈ and T₁₂). With the same level of nutrients application, the magnitude of soil available N was always higher with balanced nutrients application (T₈ and T₁₂). Application of B and Zn alone with NPK levels (50 and 100%) improved the available N status of the soil in comparison to the application of NPK

Table 3 Effect of various treatments on available N, P, K (kg/ha), S, B and Zn (mg/kg) in post harvest soil (mean of two years)

Treatment	Nitrogen	Phosphorus	Potassium	Sulphur	Boron	Zinc
Control	149.3	8.2	102.5	7.1	0.47	0.55
50% RD of NPK	171.4	10.3	126.3	7.4	0.48	0.57
50% NPK + 10 t FYM/ ha	198.7	13.1	137.0	8.3	0.51	0.61
50% NPK + 1 kg B/ ha	175.2	10.7	125.2	7.5	0.68	0.55
50% NPK + 5 kg Zn/ ha	176.0	9.8	126.5	7.4	0.48	0.74
50% NPK + 1 kg B+5 kg Zn/ha	178.0	10.0	128.0	7.5	0.67	0.64
100% NPK	202.3	13.3	150.6	8.0	0.49	0.60
100% NPK+10 t FYM/ ha	237.3	16.5	163.0	9.1	0.54	0.64
100% NPK + 1 kg Boron/ha	201.8	12.6	151.5	8.2	0.71	0.61
100% NPK + 5 kg Zn/ ha	200.4	12.8	153.0	8.1	0.54	0.83
100% NPK + 1 kg B + 5kg Zn/ ha	199.4	13.8	153.8	8.4	0.69	0.77
150% NPK	233.1	16.7	174.0	8.5	0.55	0.61
SEM+ ₋	5.0	0.39	3.46	0.16	0.04	0.06
CD (P=0.05)	10.5	0.82	7.28	0.34	0.08	0.12

alone. Control plots showed reduction in the available N status due to removal of nitrogen with cropping without fertilization. The minimum available P content in soil was in control plots 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 150% NPK over 100 and 50% NPK levels significantly increased the available P status (Pal *et al.* 2016 b). Use of B and Zn along with 100% NPK had no significant effect on available P status. Incorporation of FYM along with 100% NPK recorded significantly higher available P content as compared to other treatments except 150% NPK. Similar findings have also been reported by Singh and Pandey (2016) and Verma *et al.* (2014). The increased P availability with FYM could be ascribed to

its 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 as compared to its initial status of 106 kg/ha (Table 3). Increasing levels of NPK fertilizers from 50 to 150% significantly increased the available K status in soil and maximum value (174.0 kg/ha) was recorded at 150% NPK level. Application of B and Zn along with 50 and 100% NPK had no significant effect on available K status in soil over respective NPK levels. The relatively higher amount of available K (163 kg/ha) in post harvest soil was recorded with 100% NPK+ 10 tonnes FYM/ha. The increase in available K under 100% NPK + 10 tonnes FYM/ha might be due to decomposition of FYM 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). 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 over control. But an appreciable increase in available S content was found in the treatment receiving FYM along with NPK fertilizers. Application of 100% NPK+10 tonnes FYM/ha significantly raised the available S status of soil (9.1 mg/kg) followed by 150 % NPK (8.5 mg/kg). Similar findings have also been reported by Singh *et al.* (2015). Available boron status of the soil also improved significantly with all the levels of NPK fertilizers. Addition of 10 tonnes FYM/ha, or 1 kg B/ha also improved the boron status in soil. Among these treatments, application of 1 kg B/ha was more effective in improving the status of boron. The maximum value of available B (0.71 mg/kg) was recorded with 100 % NPK + 1 kg B/ha treatment indicating the beneficial effect of combined use of nutrients. This increase may be attributed to supply of boron through boron fertilizer to the soil. The available B content in post harvest soil was found to be decreased in control. Significant increase in available B was noticed due to addition of FYM+ 100% NPK (0.54 mg/kg). Addition of zinc along with 100% NPK significantly raised the level of available Zn content (0.83 mg/kg) in the soil over control (Table 3). A significant build up of available Zn due to zinc sulphate application has been reported by Pal *et al.* (2016 a). Further, the inclusion of FYM also contributed significantly to the buildup of Zn content (0.64 mg/kg). This could be attributed to the direct contribution of FYM to nutrient pool and its beneficial effect either through complexation or mobilization of native Zn. Similar findings have also been reported by (Singh *et al.* 2015).

It may be concluded from the results that the conjoint use of 100% NPK along with 10 tonnes FYM/ha not only sustained the higher yield of onion, but also improved the quality of bulb and soil fertility. The findings indicated that balanced use of fertilizers alone or in combination with FYM resulted in significant build up of available nutrients in post harvest soil. Incorporation of B and Zn along with NPK levels also improved the yield and status of available

B and Zn in post harvest soil.

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