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Integrated nutrient management for higher yield, quality and profitability of onion (*Allium cepa*)

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ABSTRACT

A field experiment was conducted during *rabi* seasons of 2008-09 and 2009-10 at Lakhaoti, Bulandshahr (UP) to study the effect of integrated use of inorganic fertilizer with FYM on yield, uptake of nutrients and economics of onion (*Allium cepa* L.). The experiment was laid out in randomized block design with ten treatments and three replications. The results revealed that the bulb diameter, scale leaves/bulb, fresh weight of bulb, specific gravity of bulb and bulb yield increased significantly with 150% RD of NPK over control. All the parameters further increased when 10 tonnes FYM/ha was added along with 100% NPK. An additional bulb yield of 2.2 tonnes/ha was realized with 100% NPK + 10 tonnes/ha over 100% NPK alone. Application of 100% NPK + 10 tonnes FYM + 6 kg Zn + 20 kg S/ha produced bulb (36.95 tonnes/ha) and dry matter yield (5.66 tonnes/ha) of onion which was superior to 150% NPK alone (34.08 and 5.22 tonnes/ha). The maximum gross return (₹ 234 902.5 tonnes/ha), net returns (₹ 171 085.1/ha) B: C ratio (2.67) and protein yield (368 kg/ha) were obtained with combined use of 100% NPK + FYM + Zn + S. However, the maximum protein content (6.6%) was recorded with 150% NPK application. The uptake of N, P, K, S and Zn by onion bulbs was found to be associated with production of dry matter resulted by the addition of 100% NPK + FYM + Zn + S. The results indicated that combined use of 100% NPK and FYM enriched with Zn and S was the most appropriate nutrient management for higher productivity and profitability of onion.

Key words: Economics, Integrated nutrient management, Nutrient uptake, Onion, Yield

Integration of chemical and organic sources and their efficient management has shown promise in not only sustaining the productivity and soil health but also in meeting a part of chemical fertilizer requirement of crops (Hedge and Dwivedi 1993, Aulakh 2011). The productivity of soil depends upon the adequate and balanced amount of all the essential nutrients including the secondary and micronutrients. The continuous use of NPK fertilizers has remarkably increased production but simultaneously brought about problems related to secondary and micronutrient deficiencies, particularly those of sulphur and zinc in soils. Sulphur performs many physiological functions like synthesis of sulphur containing amino acids which have a positive role in improving quality of bulbs. Zinc is also important micronutrient reported deficient in Indian soils and plays a significant role in various enzymatic and physiological activities of plant bodies. 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). Judicious use of farmyard manure with chemical fertilizers improves soil physical, chemical and biological properties and improves crop productively. Limited studies have been conducted to work out the optimal proportion of organic and mineral fertilizers. Continuous integrated use of organic manures and fertilizers would be quiet promising in assessing the sustainability of onion (*Allium cepa* L.) (Dwivedi and Kumar 2006). The present investigation was, therefore, carried out to study the effect of organic and inorganic fertilizers on yield, quality, nutrients uptake and economics of onion.

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MATERIALS AND METHODS

Field experiments were conducted at Amar Singh College Research Farm, Lakhaoti (Bulandshahr, Uttar Pradesh) during *rabi* season of 2008-09 and 2009-10. The climate of the study area is semi-arid with an average rainfall of about 750 mm per annum, about 80% of which is received during June to September. The soil of the experimental field was sandy loam belongs to order entisol and having pH 7.8, organic carbon 2.9 g/kg and available N, P, K, S and Zn 140, 9.5, 120, 15 kg/ha and 0.55 mg/kg, respectively. The experiment included 10 treatments, viz. T_1, control; T_2, 100% NPK (150 kg N + 100 kg P_2O_5 + 50 kg K_2O /ha); T_3, 100% NPK +6 kg Zn /ha; T_4, 100% NPK + 20 kg S /ha; T_5, 100% NPK + 10 tonnes FYM /ha; T_6, 100% NPK + 6 kg Zn + 20 kg S /ha; T_7, 100% NPK + 6 kg Zn + 10 tonnes FYM /ha;

T_8, 100% NPK + 20 kg S + 10 tonnes FYM /ha; T_9, 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM /ha and T_{10}, 150% NPK, each replicated three times in a randomized block design. 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 sulphur were applied as zinc chloride and elemental sulphur, respectively at the time of planting, respectively. 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. Processed bulb samples were analyzed for their nutrients by digesting the samples using diacid mixture (HNO_3: $HClO_4$: 10: 4) followed by estimation of Zn using an AAS. Phosphorus, K and S were determined by vanado molybdophosphoric yellow colour method, flame photometer (Jackson 1973) and turbidimetric method (Chesnin and Yien 1951), respectively. Nitrogen content was determined following micro Kjeldahl method. The protein content was computed from the nitrogen content multiplied by a factor 6.25. The uptake of nutrients was then computed from their concentration in bulb samples and bulb yield. The economics of onion production was worked out on the basis of prevailing market price of different inputs and final produce. 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

The various treatments had favourable influence on the fresh weight of a bulb, specific gravity, bulb diameter, number of scale leaves per bulb (Table 1). Application of 100 to 150% NPK fertilizer showed a significant positive effect on these parameters (Patel and Vachhani 1994). It might be attributed to the fact that balanced and judicious application of fertilizers and ensures synergistic reaction among nutrients and induced translocation of photo-synthates from source to sink. This finding also is conformity with the finding of Dexit and Kumar (2006). Application of 6 kg Zn and 20 kg S/ha in combination with 100% NPK further enhanced these yield attributes which may be attributed to low levels of Zn and S in experimental soil. The integrated use of 100% NPK + 10 tonnes FYM/ha resulted in an additive effect on these yield attributes probably due to beneficial effects of FYM on soil fertility. These yield attributes also increased significantly by integrating FYM or supplementary nutrients like Zn and S with NPK. However, maximum values of these yield attributes were recorded under combined use of 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM /ha (T_9) indicating that supplementing the inorganic fertilizers with FYM improved the general soil environment, which helped to improve the onion growth and yield attributing characters (Singh and Pandey 2006).

Yield

The bulb and dry matter yields of onion were affected significantly by various treatments over control (Table 1). Application of 100% NPK (T_2) alone increased the bulb yield and dry matter yield by 58.7% and 60.5 %, respectively over control. The difference in increase obtained in yield of onion at 100% NPK and 150% NPK (73.1%) indicates the superiority of super optimal dose apparently because the yield may be economically increased (Patel and Vachhani 1994). It is because of the appropriate dose of NPK could make better combination for completion of prominent processes like chlorophyll synthesis, enzymes activation for biochemical reaction with in plant tissue,

Table 1 Effect of various treatments on yield attributes and yield of onion (mean of 2008-09 and 2009-10 years)

Treatment	Bulb diameter (cm)	Scale leaves/ bulb	Fresh weight of bulb (g)	Specific gravity of bulb (g/cc)	Bulb yield (tonnes/ha)	Response (%)	Dry matter yield (tonnes/ha)
T_1, Control	4.75	12.2	74.0	1.10	19.40		2.96
T_2 100% NPK	5.20	13.3	85.1	1.15	30.80	58.7	4.75
T_3 100% NPK+ 6 kg Zn/ ha	5.27	14.0	87.5	1.16	32.50	67.5	5.00
T_4 100% NPK + 20 kg S/ha	5.30	14.3	88.0	1.17	32.15	65.7	4.94
T_5 100% NPK + 10 t FYM/ha	5.41	14.7	92.9	1.20	33.00	70.1	5.05
T_6 100% NPK + 6 kg Zn + 20 kg S/ha	5.37	14.6	94.5	1.22	32.86	69.4	5.02
T_7 100% NPK + 6 kg Zn + 10 t FYM	5.50	15.0	95.2	1.23	34.66	78.6	5.31
T_8 100% NPK + 20 kg S + 10 t FYM/ha	5.56	15.5	97.0	1.25	35.00	80.4	5.37
T_9 100% NPK+6kgZn+20 kg S + 10 t FYM/ha	5.66	15.9	100.8	1.30	36.95	90.5	5.66
T_{10} 150% NPK	5.60	15.3	97.1	1.26	34.08	75.7	5.22
CD (P=0.05)	0.29	0.41	5.3	0.13	1.80		0.40

wherein the plant get good opportunity for nutrient uptake which results in higher growth and development of plant as well as yield. Similar results were reported by Singh and Pandey (2006). Application of 100% NPK + 6 kg Zn/ha (T_3) and 100% NPK + 20 kg S/ha (T_4) also recorded significantly higher yield of bulb and dry matter over control. This increase in yields was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism (Verma and Singh 2012). Application of 100% NPK + 10 tonnes FYM/ ha (T_5) resulted in 69.2 and 70.6% increase in yield of bulb and dry matter over control, respectively. This higher productivity may be attributed to a sustained availability of major and trace elements. Similar results were reported by Verma *et al*. (2010). Combined use of FYM and supplementary nutrients (S and Zn) with chemical fertilizers gave the maximum bulb and dry matter yield and proved significantly superior to most of the treatments. The mean increase in bulb yield due to this treatment over control was 87.8 percent. The beneficial effect of S, Zn and farmyard manure may be due to their contribution in supplying additional plant nutrients, improvement of soil physical conditions and biological processes in soil. Further, the addition of FYM also maintains regular supply of macro and micronutrients in soil resulting in higher yields. These results are in conformity with the earlier work (Sharma *et al*. 2003). Bulb yield is the expression of physiological and metabolic activities of the plant. It is the product of all the factors such as fresh weight of the bulb. The fresh weight of the bulb is related to the size of bulb and dry matter content in bulbs. A critical examination of data (Table 1) reveals that these characters showed significant improvement with combined application of NPK + S + Zn + FYM (T_9). The results thus, indicate that for the same targeted yield as obtainable with full inorganic fertilizer (NPK), about 50% of the NPK requirement can be supplemented through 10 tonnes FYM + 6 kg Zn + 20 kg S/ha.

Economics

Data (Table 2) indicated that the maximum gross return of ₹ 234 902.5/ha was obtained from onion with 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha (T_9). On the other hand, minimum gross return of ₹ 125 150.0/ha was obtained with absolute control. The maximum net return of ₹ 171 085.1/ha was obtained from 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha (T_9). The treatments 100% NPK + 20 kg S + 10 tonnes FYM/ha (T_8) and 150% NPK (T_{10}) fetched the net return of ₹ 159 602.6/ha and ₹ 154 311.3/ha, respectively. In the light of this, it may be argued that more bulb production with these treatments may be the reason for the resultant profits. The minimum net return of ₹ 69 150.0/ha was obtained from onion with absolute control. The income per rupee spent (B/C ratio) was maximum (2.67) with 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha (T_9) from onion cultivation. The treatment 100 NPK + 20 kg S + 10 tonnes FYM/ha (T_8) and 150% NPK (T_{10}) gave more or less similar B/C ratio of 2.50 and 2.48 from the crop. It is due to more net return than cost of cultivation involved in these treatments. The minimum B/C ratio of 1.23 was obtained in control.

Table 2 Effect of various treatments on economics of onion (means of 2008-09 and 2009-10 years)

Treatment	Gross return (₹/ha)	Net return (₹/ha)	B : C ratio
T_1 Control	125 150.0	69 150.0	1.23
T_2 100% NPK	196 562.5	136 495.1	2.26
T_3 100% NPK+ 6 kg Zn/ ha	206 862.5	146 518.1	2.42
T_4 100% NPK + 20 kg S/ha	204 220.0	143 652.6	2.37
T_5 100% NPK + 10 t FYM/ha	211 645.0	148 577.6	2.35
T_6 100% NPK + 6 kg Zn + 20 kg S/ha	212 850.0	152 032.6	2.49
$T_7$100% NPK + 6 kg Zn + 10 t FYM	220 817.5	157 500.1	2.48
T_8 100% NPK + 20 kg S + 10 t FYM/ha	223 170.0	159 602.6	2.50
T_9 100% NPK+6 kgZn+20 kg S + 10 t FYM/ha	234 902.5	171 085.1	2.67
T_{10} 150% NPK	216 412.5	154 311.3	2.48

Quality

The lowest values of protein content and yield were recorded in control (Table 3) which may be attributed to low nitrogen status of the soil. The protein content of onion bulbs increased from 4.3% at control to 6.6% with150% NPK (T_{10}) 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. Protein content and yield of bulbs was improved over control when 100% NPK was added with 6 kg Zn/ha (T_3). The magnitude of increase was higher with 100% NPK + 20 kg S/ha (T_4) dose as compared to 100% NPK + 6 kg Zn/ha dose. The higher values of protein content and yield in onion bulbs were noted under 100% NPK + 10 tonnes FYM/ha (T_5) which proved significantly superior to 100% NPK alone. The protein percentage and yield in onion bulbs increased significantly with 100% NPK + Zn + S + FYM (T_9) over most of the treatments. 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) who also reported an improvement in nitrogen content in bulbs with fertilizer and FYM application. However, the maximum value of protein content (6.6%) in onion bulbs was recorded in 150% NPK (T_{10}) treatment in both crop seasons.

Nutrient Uptake

The value of nutrient uptake followed the pattern of yield obtained in different treatments. The N uptake by bulbs significantly increased with increasing levels of NPK

Table 3 Effect of various treatments on protein and uptake (kg/ha) of nutrients (mean of 2008-09 and 2009-10 years)

Treatment	Protein (%)	Protein yield (kg/ha)	N	P	K	S	Zn
T_1 Control	4.3	127.2	20.6	3.7	18.0	6.4	132.6
T_2 100% NPK	5.2	247.0	41.1	9.6	32.9	12.6	197.5
T_3 100% NPK+ 6 kg Zn/ ha	5.4	270.0	44.1	9.6	34.4	12.9	247.1
T_4 100% NPK + 20 kg S/ha	5.5	271.7	44.3	10.7	35.4	19.1	204.5
T_5 100% NPK + 10 t FYM/ha	5.9	298.0	49.2	12.4	38.9	16.1	242.8
T_6 100% NPK + 6 kg Zn + 20 kg S/ha	5.7	286.1	47.6	11.1	37.8	14.7	257.3
$T_7$100% NPK + 6 kg Zn + 10 t FYM	6.0	318.2	52.8	12.4	41.7	18.4	284.9
T_8 100% NPK + 20 kg S + 10t FYM/ha	6.2	333.0	54.9	13.1	40.7	20.5	251.0
T_9 100% NPK+6kgZn+20 kg S + 10 t FYM/ha	6.5	368.0	60.5	15.1	45.3	22.1	293.8
T_{10} 150% NPK	6.6	344.5	56.6	14.5	42.6	15.6	226.3
T_1 Control		49.5	3.10	2.65	4.62	1.27	22.95

up to 150% level. A further increase in N uptake by onion bulbs was recorded with 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha (T_9) which may be attributed to greater production of onion bulbs. The uptake of P by onion was significantly higher with all the treatments over control. Increasing levels of NPK fertilizers (100 and 150%) increased P uptake significantly over control which may be due to better growth and dry matter production of plants and a deeper ramification of roots which causes higher uptake of phosphorus. 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 (Sharma *et al*. 2003).The maximum P uptake was recorded with 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha which may be attributed to beneficial effect of this treatment on availability of P in soil (Singh *et al.* 1996).

The uptake of potassium increased with levels of NPK fertilizers which may be due to higher availability of the nutrient in question as compared to control. The higher K uptake by the crop was recorded with 100% NPK + 10 tonnes FYM/ha (T_5) indicating beneficial effect of integrated use of organic manures and inorganic fertilizers. The combined use of 100% NPK, farmyard manure, Zn and S proved beneficial as it increased the K uptake by onion crop significantly over control and most of the treatments. This increase in the utilization of K by onion bulbs with FYM, S and Zn is obvious as they increased the availability of K in soil. The higher N, P and K uptake by onion bulbs were recorded with treatments enriched with FYM with or without S and Zn than chemical fertilizer alone. This might be due to continuous release of nutrients from the soil enriched with FYM. These results are in conformity with those of Sharma *et al*. (2003) and Verma and Singh (2012), who reported that nutrient uptake, was higher with the application of NPK along with manures. The uptake of S by onion crop increased significantly with both the levels of NPK fertilizers and 100% NPK + 20 kg S/ha over control which may be attributed to greater bulb production and relatively higher S content in bulbs with sulphur application (Chandel *et al.* 2012). Application of 100% NPK + 10 tonnes FYM/ha also improved the uptake of S by onion crop. The combined application of 100% NPK + FYM + Zn + S (T_9) significantly increased S uptake by onion crop over most of the treatments (Verma and Singh 2012). All the treatments significantly improved the utilization of zinc by onion bulbs and lowest uptake was recorded in control. Zinc uptake increased significantly with 100% NPK + 6 kg Zn/ha (T_3) over other treatment which was mainly due to greater bulb production of onion (Singh and Singh 1995). The maximum zinc uptake by onion bulbs was noted with application of 100% NPK + 6 kg Zn + 20 kg S + 10 tonnes FYM/ha (T_9). Increase in zinc uptake could be due to increase in dry matter production and zinc concentration in bulbs. Solanki *et al*. (2010) also reported similar results.

Based on the study it is concluded that to get maximum productivity, profitability and quality from onion in alluvial soils, the crop should be managed with combined use of 100% RDF + 10 tonnes FYM + 6 kg Zn + 20 kg S/ha in Meerut region of western Uttar Pradesh..

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