Effect of Integrated Use of Nitrogen on Yield and Nutrient Uptake of Summer Onion

Saima Sultana[1], Alok Kumar Paul[1*], Deeder Sultana[2] and A. S. M. Fazle Bari[1]

[1]Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[2]Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

Article History

Manuscript No. 288b
Received in 24th February, 2012
Received in revised form 5th September, 2012
Accepted in final form 6th September, 2012

Correspondence to

*E-mail: alokpaulsau@yahoo.com

Keywords

Nitrogen, urea, vermicompost, cowdung, uptake, summer onion, yield

Abstract

Effect of integrated use of nitrogen on yield and nutrient uptake of summer onion (*Allium cepa* var. BARI Piaz-2) was assessed in a field experiment carried out in Sher-e-Bangla Agricultural University Farm, Dhaka during the *kharif* season of 2007. Urea, cowdung (CD) and vermicompost (VC) were combined in a way to supply N at 120 kg ha^{-1} from the sources and set in twelve treatments such no fertilizer (T_1), 120 kg N ha^{-1} supplied from urea (T_2), 100 kg N ha^{-1} supplied from urea with 20 kg from CD (T_3), 100 kg N ha^{-1} supplied from urea with 20 kg from VC (T_4), 80 kg N ha^{-1} supplied from urea with 40 kg from CD (T_5), 80 kg N ha^{-1} supplied from urea with 40 kg from VC (T_6), 60 kg N ha^{-1} supplied from urea with 60 kg from CD (T_7), 60 kg N ha^{-1} supplied from urea with 60 kg from VC (T_8), 40 kg N ha^{-1} supplied from urea with 80 kg from CD (T_9), 40 kg N ha^{-1} supplied from urea with 80 kg from VC (T_{10}), 120 kg N ha^{-1} supplied from CD (T_{11}), 120 kg N ha^{-1} supplied from VC (T_{12}), arranged in a RCBD design with three replications. The results indicated that maximum bulb yield (12.16 t ha^{-1}) and stover yield (5.46 t ha^{-1}) of summer onion were obtained in treatment receiving 80 kg N ha^{-1} from urea with 40 kg N ha^{-1} substituted by CD (T_5), followed by the treatment receiving 80 kg N ha^{-1} from urea with 40 kg N ha^{-1} substituted by VC (T_6). Comparing with other fertilizer treatments, the yields were significantly lower in treatments where N from urea source was below 50%. Similarly, the N, P, K and S uptake (72.78, 5.53, 55.88 and 28.93 kg ha^{-1}, respectively) by onion plants at harvest stage was also significantly ($p<0.01$) greater in treatments receiving 80 kg N ha^{-1} from urea with 40 kg from CD (T_5) followed by treatment T_6. Thus the data suggest that integrated use of N 80 kg from urea with 40 kg from CD or 80 kg from urea with 40 kg from VC has produced maximum yields and is therefore recommended for advantageous onion production.

1. Introduction

Onion is one of the major important bulb and spice crop in Bangladesh as well as in the world (Jones and Mann, 1963). There is a significant response of onion to organic and inorganic fertilizers (Nasreen and Hossain, 2000; Ullah, 2003). The importance of N, P, K, S, Zn and B for the growth and yield of vegetable crops is well established. Among the nutrients, N plays a pivotal role in synthesizing amino acid and metabolic activities to increase vegetative growth of onion which ultimately helps in increasing bulb size and total yield (Singh and Kumar, 1969; Rai, 1981). Before the advent of chemical fertilizers, farmers mostly elide on organic materials as the sole source to promote health and productivity of the soil. Then the era of chemical fertilizers were an effective substitute as a ready source of nutrients. But a large variety of organic wastes are available in the country that can be used as potential manure to improve soil organic matter as well as crop productivity (BARI, 2007). It includes the excreta (cowdung and urine) of the domestic animals, crop residues, household and farmyard wastes, vermicompost (VC), municipal sewage sludge and other organic wastes. Cowdung (CD) is basically the digested residue of herbivorous matter which is acted upon by symbiotic bacteria residing within the animal's rumen that improves soil organic matter. Vermicompost is the outcome of earthworm activities which is important in maintaining and enhancing the quality of environment and conserving resources for sustainable agriculture (Simanaviciene et al., 2001). Integrated use of organic and inorganic fertilizers can improve crop productivity and sustain soil health and fertility. Incorporation of both organic and inorganic plant nutrients to attain higher productivity improves enzymatic activity and

CO_2 production, prevent soil degradation, and thereby help meet future food supply needs. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter (Marinari et al., 2000). Application of compost along with chemical fertilizers has been reported to give highest yield and maximum return. So, integrated applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and increased yield of onion. With a view to generate information on this aspect, the present trial was carried out to study the effect of integrated use of nitrogen on yield and nutrient uptake of summer onion and find out the appropriate combination of nitrogen from different organic and inorganic sources for higher yield..

2. Materials and Methods

The research work was conducted on the farm division of Sher-e-Bangla Agricultural University, Dhaka during the *kharif* season of 2007. The soil of the experimental field belongs to the Tejgaon series of AEZ (agro-ecological zone) No. 28, Madhupur Tract, classified as Shallow Red Brown Terrace Soils in Bangladesh soil classification system. Composite soil sample at 0-15 cm was collected from the field and analyzed for soil characteristics before the initiation of the experiment. The soil is Silty Clay Loam in texture having pH 6 and contains organic matter 0.83%, total N 0.078%, available P 19.72 ppm, exchangeable K 0.17 meq 100 g^{-1} soil, available S 20.51 ppm. The climate is characterized by sub-tropical accompanied by heavy rainfall, high humidity, high temperature, relatively long day during the *kharif* season. BARI Piaz-2, a high yielding variety of summer onion was selected for this experiment. Light textured and well drained soil was selected for raising seedlings. The seedbeds were 3×1 m^2 in size with height of about 20 cm of the soil. Seedbeds were mixed with well-decomposed cowdung @ 10 t ha^{-1}; applying Furadan 3G @ 20 kg ha^{-1} and covered by polyethylene for two days. Onion seeds were soaked over night (12 h) in water and allowed to burgeon in a piece of moist cloth keeping in the sunshade for one day. Then seeds were sown directly in the seedbed for raising seedlings. The experiment consisted of 12 treatment combinations and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. An area of 380 m^2 was divided into three equal blocks representing the replications, each containing 12 plots. Thus, the total numbers of micro plots were 36, each measuring 2×2 m^2. The distance between two plots was 1 m and between blocks was 1.5 m. The experimental plot was opened by a tractor, then the land was ploughed and cross-ploughed several times with the help of a power tiller followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soil for transplanting of seedlings. Finally, the land was leveled and the experimental plot was partitioned into the unit plots.

The treatment combinations of the experiment are T_1: No fertilizer; T_2:120 kg N ha^{-1} supplied from urea; T_3:100 kg N ha^{-1} supplied from urea + 20 kg N ha^{-1} substituted by CD; T_4:100 kg N ha^{-1} supplied from urea + 20 kg N ha^{-1} substituted by VC; T_5:80 kg N ha^{-1} supplied from urea + 40 kg N ha^{-1} substituted by CD; T_6:80 kg N ha^{-1} supplied from urea + 40 kg N ha^{-1} substituted by VC; T_7:60 kg N ha^{-1} supplied from urea + 60 kg N ha^{-1} substituted by CD; T_8:60 kg N ha^{-1} supplied from urea + 60 kg N ha^{-1} substituted by VC; T_9:40 kg N ha^{-1} supplied from urea + 80 kg N ha^{-1} substituted by CD; T_{10}:40 kg N ha^{-1} supplied from urea + 80 kg N ha^{-1} substituted by VC; T_{11}:120 kg N ha^{-1} supplied from CD; T_{12}:120 kg N ha^{-1} supplied from VC.

Urea, TSP, MOP and gypsum were used @ 260, 220, 200 and 180 kg ha^{-1}, respectively. The entire amount of TSP, MOP, gypsum and well decomposed cowdung were added to the soil at the time of final land preparation. Urea was applied in four equal splits and vermicompost was applied in three splits where 50% in first split and remaining 50% in two equal splits. Healthy and disease free uniform sized 45 days old seedlings of BARI Piaz-2 were transplanted in the main field with the spacing of 25×10 cm^2 on 13th May 2007. Intercultural operations were done whenever required for getting better growth and development of the plants. The crop was harvested on 7 August 2007 according to their attainment of maturity showing the sign of drying out of most of the leaves and collapsing at the neck of the bulbs. Five plants were randomly selected from each plot and necessary information was recorded. Bulb and stover yield were also determined. Both plants and soil samples were collected, processed and were analyzed for N, P, K and S. P was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer (LKB Novaspec, 4049), K was determined by flame photometer, S was analysed by turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspec, 4049). N was determined by Micro-Kjeldahl method as described by Bremner and Mulvaney (1982). Vermicompost was analyzed for organic matter, total N, available P, K and S contents following the methods used for plant and soil analysis. Vermicompost contained 11.06% organic matter, 0.64% total N, 0.0225% available P, 0.0783% available K and 0.0313% available S. The statistical analysis was done as per method of Gomez and Gomez (1984). The significance of the differences among the pairs of treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 1% and 5% level of probability.

3. Results and Discussion

3.1. Yield and yield contributing characters

Nitrogen has positive role in respect of yield and yield contributing characters of summer onion. There was a significant variation of bulb diameter among the 12 different treatments (Table 1). Result showed that treatment T_5 gave the highest bulb diameter (3.79 cm) followed by T_6 (80 kg N supplied from urea + 40 kg N substituted from VC) and T_3 (100 kg N supplied from urea + 20 kg N substituted from CD). Treatment T_6 and T_3 are statistically alike. Lowest bulb diameter (2.44 cm) was obtained from T_1 (control) treatment. It is observed that integrated application of nitrogen increased bulb diameter. Treatment receiving 120 kg N ha^{-1} from cowdung and vermicompost without any urea was better only than the control. Similar result was obtained by Jayathilake et al. (2003).

Bulb weight and bulb yield of onion increased significantly over the control. Result revealed that treatment T_5 (80 kg N supplied from urea and 40 kg N substituted by CD) gave the highest (30.40 g) bulb weight followed (29.10 g) closely by treatment T_6 (80 kg N supplied from urea and 40 kg N substituted by VC). Treatment T_3 and T_4 also showed statistically similar performance with treatment T_5. In contrast, the lowest bulb weight (14.90 g) was obtained from T_1 (control) treatment. However, treatment T_9 (40 kg ha^{-1} N supplied from urea and 80 kg substituted by CD) and T_{10} (40 kg ha^{-1} N supplied from urea and 80 kg substituted by VC) gave inferior results compared to treatment T_2 where 120 kg ha^{-1} N supplied only from urea. Similarly, the highest bulb yield of 12.16 t ha^{-1} was recorded in treatment T_5 (80 kg N from urea and 40 kg N substituted by CD) followed by the treatments T_6, T_3, T_4 and T_7 which were statistically identical. Treatments receiving 120 kg N from urea (T_2), 40 kg N from urea and rest of the 80 kg N substituted by CD or VC (T_9 and T_{10}) produced comparable yields but were significantly lower than the treatments T_5 and T_6. Treatments receiving N solely from CD and VC (T_{11} and T_{12}) produced lower bulb yield compared with the other fertilizer treatments. The lowest bulb yield (5.96 t ha^{-1}) was obtained from T_1 (control) treatment. Like bulb yield, the stover yield of summer onion was also significantly influenced by the integrated use of nitrogen. Highest stover yield (5.46 t ha^{-1}) was found in the treatment T_5 followed by the treatment T_6 (5.38 t ha^{-1}) which are statistically similar. Treatment receiving 100% N from cowdung (T_{11}) and vermicompost (T_{12}) was only better than the control (T_1) with respect to stover yield. These results indicated that in the given experimental conditions, combined application of cowdung with urea and vermicompost with urea significantly improved stover yield of summer onion only when the N contribution from urea was 50% or more. Cowdung and vermicompost alone did not prove as effective as urea alone. Urea is a quick and more potent source of nitrogen for increasing the vegetative growth as compared to manure but the combination of the two sources was found more effective up to a certain limit.

Table 1: Effect of integrated use of nitrogen supplied from urea, cowdung and vermicompost on the yield and yield attributing characters of summer onion

Treatments	Bulb diameter (cm)	Bulb weight (g)	Bulb yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	2.44^{h}	14.90^{i}	5.96^{h}	2.61^{g}
T_2	2.87^{ef}	24.10^{def}	9.64^{cde}	3.67^{d}
T_3	3.44^{b}	28.25^{abc}	11.30^{ab}	5.11^{ab}
T_4	3.19^{c}	27.10^{a-d}	10.84^{abc}	4.82^{b}
T_5	3.79^{a}	30.40^{a}	12.16^{a}	5.46^{a}
T_6	3.56^{b}	29.10^{ab}	11.64^{a}	5.38^{a}
T_7	3.14^{cd}	26.80^{b-e}	10.72^{a-d}	4.41^{c}
T_8	2.98^{de}	25.25^{c-f}	10.10^{b-e}	4.11^{c}
T_9	2.79e^{fg}	23.45^{efg}	9.38^{def}	3.57^{de}
T_{10}	2.71^{fg}	21.90^{fgh}	8.76^{efg}	3.29^{ef}
T_{11}	2.65^{g}	20.38^{gh}	8.15^{fg}	3.06^{f}
T_{12}	2.63^{gh}	18.55^{h}	7.42^{g}	2.96^{f}
Level of significance	0.01	0.01	0.01	0.01

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

Singh et al. (2001) also observed partially related results in *kharif* onion (*Allium cepa*) cv. N53. They found that the average bulb weight increased significantly up to 120 kg N ha^{-1} and FYM at 10 t ha^{-1}. They also stated that integrated application of 150 kg N with 9 t FYM (farm yard manure) ha^{-1} gave the highest bulb yield. Das et al. (2002) found that the highest results in terms of straw and crop yields were obtained from 50% vermicompost with 50% chemical fertilizers. Reddy and Reddy (2005) noticed that yield of onion increased significantly with increasing levels of vermicompost and nitrogen fertilizer and the highest yield was recorded with vermicompost at 30 t ha^{-1} with 150 kg N ha^{-1}. Dixit (1997) reported that increasing N application rates increased bulb yields of summer onion up to 120 kg N ha^{-1}. Higher yields were also obtained with the higher rate of farmyard manure used. Application of 120 kg N ha^{-1} with 20 t ha^{-1} farmyard manure increased yields by 42.79% compared to the control.

3.2. Nutrient uptake

Table 2 represents the effect of integrated use of nitrogen from urea, cowdung and vermicompost regarding N uptake by the summer onion plants at harvest stage. N uptake by onion bulb and leaf followed similar pattern in response to various combinations of fertilizer treatments. The results showed that N uptake by onion plant were significantly greater in N fertilized than in the control treatment. The maximum N uptake of 72.78 kg ha^{-1} by onion plant was obtained in treatment T_5 receiving 80 kg N from urea with 40 kg N from cowdung followed by the treatment T_6 where 80 kg N supplied from urea with 40 kg N substituted by vermicompost with a value of 66.71 kg ha^{-1}. Significantly lowest N uptake was obtained in treatment T_{11} and T_{12} receiving full amount of N from cowdung and vermicompost, respectively, comparing with the other fertilizer treatments. The minimum N uptake by onion plant (16.64 kg ha^{-1}) was recorded with control treatment (T_1) receiving no fertilizer or manure. These observations are in accordance with those of Zahir and Mian (2006) in case of wheat who reported that combination of organic and inorganic N resulted in superior values of net N release than their single application. Their observation that the best mixture ratio between inorganic and organic N sources was 3:1, partially agreed with the present study. Hedge (1988) observed that uptake of N, P, K, Ca and Mg in leaves and bulbs generally increased due to higher dry matter production. Kumar et al. (2006) also found that the N, P, K and S uptakes were increased significantly over the control with the application of 150 kg N ha^{-1}. Halvorson et al. (2002) stated that nitrogen fertilization influenced N uptake of onion. Total leaf-plus-bulb N uptake at final harvest was 80 and 60.5 kg ha^{-1} with nitrogen fertilization and without nitrogen fertilization, respectively. These results suggested that integrated use of urea with cowdung and urea with vermicompost performed better than the use of urea, cowdung or vermicompost alone in terms of improving N uptake by the summer onion plants even with the fact that the level of applied N was same that is 120 kg N ha^{-1} either alone from urea, cowdung and vermicompost or combinations. The combined application of N 80 kg from urea with 40 kg N from cowdung closely followed by N 80 kg from urea with 40 kg N from vermicompost based on net N contribution produced excellent results.

Table 2: Effect of integrated use of nitrogen supplied from urea, cowdung and vermicompost on the N and P uptake by summer onion plant

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Bulb	Leaf	Total	Bulb	Leaf	Total
T_1	12.55^{l}	4.09^{k}	16.64^{l}	0.49^{j}	0.10^{g}	0.59^{j}
T_2	30.15^{g}	8.79^{g}	38.94^{g}	1.68^{fg}	0.30^{ef}	1.98^{g}
T_3	45.11^{c}	15.13^{c}	60.24^{c}	3.42^{bc}	0.84^{bc}	4.26^{c}
T_4	41.58^{d}	14.53^{d}	56.11^{d}	2.91^{cd}	0.72^{c}	3.63^{d}
T_5	54.74^{a}	18.04^{a}	72.78^{a}	4.40^{a}	1.13^{a}	5.53^{a}
T_6	49.73^{b}	16.98^{b}	66.71^{b}	3.84^{b}	1.00^{ab}	4.84^{b}
T_7	38.99^{e}	12.01^{e}	51.00^{e}	2.44^{de}	0.49^{d}	2.93^{e}
T_8	33.78^{f}	10.20^{f}	43.98^{f}	1.96^{ef}	0.37^{de}	2.33^{f}
T_9	27.59^{h}	8.12^{h}	35.71^{h}	1.44^{fgh}	0.26^{efg}	1.70^{g}
T_{10}	23.32^{i}	6.51^{i}	29.83^{i}	1.17^{ghi}	0.20^{efg}	1.37^{h}
T_{11}	21.25^{g}	6.00^{ij}	27.25^{j}	1.03^{hij}	0.17^{fg}	1.20^{hi}
T_{12}	17.98^{k}	5.74^{j}	23.72^{k}	0.80^{ij}	0.14^{fg}	0.95^{i}
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

Phosphorus uptake by summer onion plants was significantly influenced due to the addition of different combinations of nitrogen from urea, cowdung and vermicompost (Table 2). Application of 80 kg ha^{-1} N from urea with 40 kg from cowdung (T_5) showed the highest phosphorus uptake by onion plant (5.53 kg ha^{-1}) followed by the treatment T_6 (80 kg N supplied from urea + 40 kg N substituted by VC) with a value of 4.84 kg ha^{-1}. On the contrary, the lowest phosphorus uptake (0.59 kg ha^{-1}) was recorded in treatment T_1 (control). Jat and Ahlawat (2004) reported that application of vermicompost to chickpea improved N and P uptake by the cropping system over no vermicompost treatment.

Effect of integrated use of nitrogen from urea, cowdung and vermicompost showed significant difference with respect to potassium uptake by summer onion plant is presented in Table 3. K uptake by the bulb and leaf of summer onion showed similar performance in different treatment combinations. The result revealed that potassium uptake by summer onion plant was maximum (55.88 kg ha^{-1}) in the treatment T_5 where 80 kg N supplied from urea with 40 kg N substituted by cowdung. The next higher (50.42 kg ha^{-1}) potassium uptake was obtained in treatment T_6 (80 kg N supplied from urea and 40 kg N substituted by VC). In contrast, control treated plot (T_1) showed lowest (11.17 kg ha^{-1}) potassium uptake by summer onion plant. It might be, due to the fact that integrated application of nitrogen showed positive effect compared to their sole effect on potassium uptake by onion plant. Singh et al. (2005) also point out that the maximum potassium uptake was recorded with the application of 60 kg N ha^{-1} plus Azolla treatment.

The amount of S taken up by onion bulb and leaf with different combinations of nitrogen from urea, cowdung and vermicompost resulted (Table 3) significantly higher value over the control. Like other nutrient uptake by summer onion plant the highest (28.93 kg ha^{-1}) S uptake was recorded in the treatment T_5 receiving 80 kg N from urea and 40 kg N from cowdung and the next higher (25.84 kg ha^{-1}) quantity of S uptake was

Table 3: Effect of integrated use of nitrogen supplied from urea, cowdung and vermicompost on K and S uptake by summer onion plant

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Bulb	Leaf	Total	Bulb	Leaf	Total
T_1	7.92^l	3.25^l	11.17^l	5.87^l	1.20^h	7.07^l
T_2	22.17^g	7.77^g	29.94^g	12.55^g	2.66^f	15.21^g
T_3	32.14^c	13.09^c	45.23^c	18.13^c	4.90^c	23.03^c
T_4	29.70^d	12.64^d	42.34^d	16.83^d	4.70^c	21.53^d
T_5	40.69^a	15.19^a	55.88^a	22.85^a	6.08^a	28.93^a
T_6	35.96^b	14.46^b	50.42^b	20.20^b	5.64^b	25.84^b
T_7	28.71^e	10.63^e	39.34^e	15.71^e	3.86^d	19.57^e
T_8	24.85^f	9.08^f	33.93^f	13.83^f	3.16^e	16.99^f
T_9	19.84^h	7.23^h	27.07^h	11.63^h	2.44^f	14.07^h
T_{10}	16.70^i	5.81^i	22.51^i	10.07^i	1.92^g	11.99^i
T_{11}	15.18^j	5.28^j	20.46^j	9.37^j	1.73^g	11.10^j
T_{12}	12.76^k	4.92^k	17.68^k	8.12^k	1.63^g	9.75^k
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

achieved by treatment T_6 (80 kg N supplied from urea + 40 kg N substituted by VC). The lowest S uptake (7.07 kg ha^{-1}) was obtained in treatment T_1 receiving no organic or organic fertilizer. Neeraja et al. (2000) stated that increased level of N fertilizer significantly increased the leaf, bulb and whole plant uptake of Ca, Mg and S at different stages of crop growth. The uptake of these nutrients continued until bulb maturity. They also revealed that the total uptake of Ca, Mg and S was 16.66, 9.2 and 25.48 kg ha^{-1} with 200 kg N ha^{-1}, respectively.

4. Conclusion

Integrated use of urea, cowdung and vermicompost performed better than the use of urea, cowdung or vermicompost alone in terms of improving crop yield and nutrient uptake by summer onion despite the level of applied N was same that is 120 kg N ha^{-1}. Effect of sole application of urea was better compared to the sole application of cowdung or vermicompost. The combination of N 80 kg ha^{-1} from urea with 40 kg ha^{-1} from cowdung and 80 kg ha^{-1} from urea with 40 kg ha^{-1} from vermicompost based on net N contribution produced excellent results and therefore, may be recommended for optimum summer onion production.

5. References

BARI, 2007. Annual Report 2006-07. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, 8.

Bremner, J.M., Mulvaney, C.S., 1982. Total nitrogen. In: Miller, R.H., Keeny, D.R., (Eds.), Methods of Soil Analysis.. American Society of Agronomy Inc., Madison, Wisconsin, USA, 595-622.

Das, P.K., Jen, M.K., Sahoo, K.C., 2002. Effect of integrated application of vermicompost and chemical fertilizer on growth and yield of paddy in red soil of South Eastern Ghat Zone of Orissa. Environment and Ecology 20(1), 13-15.

Dixit, S.P., 1997. Response of onion (*Allium cepa* L.) to nitrogen and farmyard manure in dry temperate high hills of Himachal Pradesh. Indian Journal of Agricultural Science 67(5), 222-223.

Gomez, A.K., Gomez, A.A., 1984. Staristical Procedures for Agricultural Research (2nd Edn.). John Wiley and Sons, New York, USA.

Halvorson, A.D., Follett, R.F., Bartolo, M.E., Schweissing, F.C., 2002. Nitrogen fertilizer use efficiency of furrow-irrigated onion and corn. Agronomy Journal 94, 442-449.

Hedge, D.M., 1988. Effect of irrigation and nitrogen fertilization on yield, quality, nutrient uptake and water use of onion (*Allium cepa* L.). Singapore Journal of Primary Industries 16(2), 111-123.

Hunt, J., 1980. Determination of total sulphur in small amount of plant material. Analyst 105, 83-85.

Jat, R.S., Ahlawat, I.P.S., 2004. Direct and residual effect of vermicompost, biofertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence. Indian Journal of Soil Science 12(2), 41-54.

Jayathilake, P.K.S., Reddy, I.P., Srihari, D., Reddy, K.R., Neeraja, G., 2003. Integrated nutrient management in onion (*Allium cepa* L.). Tropical Agricultural Research 15, 1-9.

Jones, H.A., Mann, L.K., 1963. Onion and their Allies. Leonard Hill [Books] Ltd., New York, 169.

Kumar, S., Tiwari, C.P., Singh, V., 2006. Bulb yield and quality of onion (*Allium cepa* L.) as affected by application rates of nitrogen and potassium fertilizer. Agricultural Science Digest 26(1), 11-14.

Marinari, S., Masciandaro, G., Cenccanti, B., Grego, S., 2000. Influence of organic and inorganic fertilizers on soil biological and physical properties. Bioresource Technology 72(1), 9-17.

Murphy, J., Riley, J.P., 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27, 31-36.

Nasreen, S., Hossain, A.K.M., 2000. Influence of chemical fertilizers and organic manure on the growth and yield of onion. Bangladesh Journal of Agricultural Research 25(2), 221-231.

Neeraja, G., Reddy, K.M., Reddy, M.S., Reddy, I.P., 2000. Studies on uptake of secondary nutrients at different stages of growth of onion (*Allium cepa* L.) in relation

to different levels of irrigation and nitrogen. Journal of Research ANGRAU 28(1/2), 13-18.
Rai, M.M., 1981. Principles of Soil Science. MacMillan India Ltd., Calcutta, 179-182.
Reddy, K.C., Reddy, K.M., 2005. Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa* L.)-radish (*Raphanus sativus* L.) cropping system. Journal of Research ANGRAU 33(1), 11-17.
Simanaviciene, O., Mazvila, J., Vaisvila, Z., Ryliskiene, E., Arbacauskas, J., Eitminavicius, L., 2001. Comparison of the efficacy of NPK fertilizer rates, calculated by different methods and the effect of farmyard manure and straw in the crop rotation. Zemdirbyste, Mokslo Darbai 75, 14-28.
Singh, K., Kumar, S., 1969. Effect of nitrogen and phosphorus fertilization on the growth and yield of onion (*Allium cepa* L.). Journal of Research Ludhiana 6, 764-768.
Singh, R.K.K., Athokpam, H.S., Changte, Z., Singh, N.G., 2005. Integrated management of Azolla, vermicompost and urea on yield and nutrient uptake by rice and soil fertility. Journal of the Indian Society of Soil Science 53(1), 107-110.
Singh, R.P., Jain, N.K., Poonia, B.L., 2001. Integrated nutrient management in rainy-season onion (*Allium cepa*). Indian Journal of Agricultural Science 71(5), 310-312.
Ullah, M.M., 2003. Nutrient management in summer onion. PhD Thesis, Department of Soil Science, BSMRAU, Gazipur.
Zahir, S., Mian, I.A., 2006. Effect of integrated use of farm yard manure and urea on yield and nitrogen uptake of wheat. Journal of Agricultural and Biological Science 1, 1.