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Quality production of *kharif* onion (*Allium cepa*) in response to biofertilizers inoculated organic manures

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ABSTRACT

Onion (*Allium cepa* L.) is a highly nutrient responsive vegetable crop. In the light of fragmental information available on the response of *kharif* onion to biofertilizers enriched organic manures, a field experiment was conducted during rainy (*kharif*) season of 2006–08 on acidic kaolinitic Rhodustalf soil representing foothill conditions of Nagaland. Amongst different organic manures, poultry manure produced the highest response on bulb yield (21.18 tonnes/ha), followed by FYM (16.74 tonnes/ha), vermicompost (14.37 tonnes/ha) = pig manure (12.74 tonnes/ha). Incorporation of *Azotobacter chroococcum* into different organic manures failed to improvise any significant changes in bulb yield due to high initial microbial abundance in organic manures. Different growth-attributing characters followed the similar response. Poultry manure similarly registered highest nutrient uptake as kg/ha (26.39 N – 10.91 P – 55.96 K), followed by FYM (22.80 N – 9.10 P – 47.90 K) with Pig manure and vermicompost (15.08/16.72 N – 7.30/10.91 P – 51.02/55.96 K) displaying no significant difference. Economic analysis in terms of cost : benefit ratio supported these observations. These studies proposed that if organic manures possess enough initial microbial load, the biofortification of organic manures need not be exercised.

Key words: Biofertilizers, *kharif* onion, Organic manures, Quality production, Rhodustalf

India is the second largest producer of onion in the world next to China, with 70% of the total production comes as winter crop, and remaining 30% as *kharif* onion as off-season crop. *Kharif* season varieties fetch invariably high market returns. Onion (*Allium cepa* L.) is not cultivated commercially in north-eastern region including Nagaland due to unfavourable climatic conditions. Earlier preliminary trials envisaged the scope of growing off-season onion through bulblets during *kharif* under foothills of Nagaland (Singh 2006). Onion requires substantial quantity of plant nutrients but the fertilizer application in Nagaland is negligible. Organic manures alone or enriched with biofertilizers serve as the effective source of manuring in an eco-friendly manner.

Application of organic manures to acidic soils reduces the soluble and exchangeable aluminum temporarily by forming complexes and or chelates with organic substances and providing favourable environment for plant growth and also improved physical, chemical and biological properties (Ngullie *et al*. 2008). Devi and Ado (2005) reported that biofertilizer inoculations of onion on the other hand, increased the yield and saved the fertilizer requirement by 25%, thereby, reduced the cost of cultivation. No information is available about the nutrients requirements of the *kharif* onion in north-eastern region including Nagaland in particular. In this background information, the field experiment was conducted to study the response of organic manures alone and in combination with *Azotobacter chroococcum* on growth, bulb yield, quality and nutrient uptake by *kharif* onion under foothills of Nagaland.

MATERIALS AND METHODS

Field experiment was carried out during *kharif* season of 2006-07 and 2007-08 at the experimental farm (25º 45'43" N latitude; 9º53'04" E longitude), Medziphema Campus of Nagaland University located at an altitude of 304.8 m above mean sea level in the foothills of Nagaland. The experimental site is characterized by subtropical climate with high humidity (52–86%), moderate temperature (7.2–28.8ºC) and high rainfall (200–250 cm). The soil was sandy loam, well drained having *p*H 4.5, organic carbon 2.0%, 212.3 kg/ha available N, 10.5 kg/ha P_2O_5 and 173.2 kg/ha available K_2O. A total of 9 treatments replicated thrice were tested in a ramdomised

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complete block design. The details of the treatments comprised of T_1: control (untreated), T_2: FYM (40 tonnes/ha), T_3: pig manure (30 tonnes/ha), T_4: vermicompost (10 tonnes/ha), T_5: poultry manure (20 tonnes/ha), T_6: FYM (40 tonnes/ha + *Azotobacter chroococcum)*, T_7 : pig manure (30 tonnes/ha + *Azotobacter chroococcum*), T_8: vermicompost (10 tonnes/ha + *Azotobacter chroococcum*) , T_9: poultry manure (20 tonnes/ha + *Azotobacter chroococcum*). The recommended doses of fertilizers for onion was considered as 100 N – 60 P_2O_5 – 60 K_2O kg/ha. While different organic manures, viz FYM (0.26% N – 0.080% P – 0.38% K), pig manure (0.34% N – 0.10% P – 0.42% K), vermicompost (1.10% N – 0.12% P – 0.78% K) and poultry manure (0.71% N – 0.14% P – 0.52% K) applied at the rate of 40, 30, 20 and 10 tonnes/ha, respectively supplying total nutrients as 104 N–32 P_2O_5–152 K_2O kg/ha through FYM, 102 N–30 P_2O_5 – 126 K_2O through pig manure, 110 N–12 P_2O_5–78 K_2O through vermicompost and 142 N–28 P–104 K through poultry manure. Organic manures, viz pig manure, poultry manure and vermicompost were incorporated at the final stage of field preparation as per the treatment details. The bulblets of cv. Agrifound Dark Red, each weighing about 15–20 g was dipped thoroughly in *Azotobacter chroococcum* slurry, followed by drying shade. Planting was done in plot size of 1.5 m × 1.5 m on 30 August at the spacing of 20 cm × 15 cm in both the years and harvested on 30 November (when more than 50% leaves dropped down).

Observations on the plant height, number of leaves/plant, neck thickness and yield were recorded in addition to bolting and doubling. In this region, bolting (referred to as hard stem producing seed stalks) and doubling (referred to as splitting of onion bulb). Diameter of bulb was measured with the help of Vernier caliper at the mid point of the bulb. The total soluble solid was determined by using hand refractometer calibrated at 20°C. The bulbs were squeezed mechanically to extract the juice, and two drops of the juice was taken in the specimen chamber of the hand refractometer with the help of glass rod. The reading of the transaction point between the light and shaded portion was recorded and expressed in °Brix.

The bulb samples were initially dried at $65^0C \pm 3^0C$ later ground through Wiley Grinding Machine to prepare homogenous mixture. The onion bulb samples were then digested in diacid mixture of $HClO_4$:H_2SO_4 in 1:3 ratio. The diacid digests were finally subjected to analysis of N through alkaline permanganate steam distillation microkjeldahl method, P colorimetrically using vanadomolybdophosphoric acid yellow colour method and K flame photmetrically (Jackson 1973).

The soil samples collected after harvest were dried, grounded and sieved through 2 mm sieve size. The ready soil samples hence, subjected to analysis of *p*H and organic carbon. The available nitrogen (alkaline permanganate steam distillation microkjeldahl method), phosphorus (Brays-P) and potassium (neutral NH_4OAc extraction) were also analyzed as per standard procedures (Jackson 1973). The economical analysis was carried out as per prevailing market value. The data generated for both growing seasons were pooled together and then analyzed statistically (Panse and Sukhatme 1978).

RESULTS AND DISCUSSION

Growth attributes

Different treatments significantly influenced the height of plants as well as number of leaves/plant (Table 1). The highest plant height (54.76 cm) and number of leaves/plant (12.65) were recorded with treatment T_9 involving combination of poultry manure + *Azotobacter chroococcum* which not superior over T_5 (12.30) having poultry manure

Table 1 Effect of organic manures and biofertilizers on growth, yield and quality attributes of *kharif* onion (pooled data)

Treatment	Growth attribute							Quality	
	Plant height (cm)	No. of leaves/plant	Neck thick-ness (cm)	Doubling (%)	Bolting (%)	Bulb diameter (cm)	Yield (tonnes/ha)	TSS °Brix	Protein (%)
T_1	37.98	9.37	1.20	16.36	8.90	3.51	8.44	10.83	4.62
T_2	47.10	11.37	1.79	22.14	11.59	4.83	16.74	12.0	5.87
T_3	42.93	10.70	1.46	19.24	11.96	4.34	12.74	11.83	5.37
T_4	43.80	10.61	1.45	19.99	10.54	4.48	14.37	11.75	4.87
T_5	52.70	12.30	2.00	24.04	12.15	5.82	21.18	11.83	6.12
T_6	48.30	11.69	1.74	20.38	13.27	4.91	17.03	12.61	6.12
T_7	44.50	11.18	1.63	20.53	10.42	4.34	12.58	11.08	5.75
T_8	44.28	11.30	1.70	20.38	9.98	4.41	15.25	11.45	5.25
T_9	54.76	12.65	2.37	25.73	11.82	5.90	21.48	12.16	6.30
CD (*P*=0.05)	3.47	0.46	0.14	1.91	2.06	0.23	2.85	0.55	0.27

T_1, Control; T_2, FYM @ 40 tonnes/ha; T_3, pig manure @ 30 tonnes/ha; T_4, vermicompost @ 10 tonnes/ha; T_5, poultry manure @ 20 tonnes/ha; T_6, FYM + *Azotobacter;* T_7, pig manure + *Azotobacter;* T_8, vermicompost + *Azotobacter;* T_9, poultry manure + *Azotobacter* alone. The treatment T_9 recorded the maximum neck thickness (2.37 cm), followed by treatment T_5 (2.00 cm). Among the various organic manures used, Poultry manure (T_5) exerted better growth of the onion crop at all the stages. These observations suggested that application of poultry manure alone produced the best response on all the growth parameters of the plant due to high initial microbial load supported by sufficient quantity of organic carbon to be later used for microbial proliferation, and consequently releasing the nutrients readily in assimilable forms supporting the biotic principle of carbon sequestration through improved biomass production (Sanyal 2001). In present studies, microbial load of Poultry manure was considerably higher (42×10^4 cfu/g bacterial count and 22×10^4 cfu/g fungal county) compared to FYM (11×10^3 cfu/g bacterial count and 10×10^3 cfu/g fungal count), pig manure (22×10^3 cfu/g bacterial count and 16 x 10^3 cfu/g fungal count) or vermicompost (26×10^3 cfu/g bacterial count and 21×10^3 cfu/g fungal count). Earlier studies by Khalif *et al.* (2002) reported similar observations, stressing the effectiveness of different organic manures in maintaining the regulated release of nutrients throughout the growth period ensuring optimum supply level of all the nutrients. However, the efficacy of organic manures was further enhanced by enrichment with biofertilizers according to Ngullie *et al*. 2008.

Onion crop harvested for bulbs, bolting does not generally occur. But, bolting and doubling in onion in north-east India is a common feature when raising during *kharif* season. These problems are often as ascribed to sub-optimum fertilization, besides unfavourable meteorological conditions (Ngullie *et al*. 2010). Maximum bolting of 13.27% observed with treatment T_2 adding FYM followed by treatment T_5 using poultry manure. But, treatment T_4 using vermicompost exerted most favourable response in curbing the intensity of bolting (10.54%). On the other hand, maximum doubling 0f 25.73% was observed with treatment T_9 using combination of poultry manure + *Azotobacter chroococcum*, but was statistically at par with treatment T_5 (poultry manure), demonstrating the role of possible soil fertility improvements.

Yield attributes and yield

Organic manure alone or in combination with biofertilizer was found to have a significant effect over control in increasing different growth parameters leading to improved bulb yield. The treatment T_9 (poultry manure + *Azotobacter chroococcum*) registered maximum bulb size (5.90 cm), but statistically at par (Table 1) with T_5 (poultry manure alone) In earlier studies, Jayathilake *et al.* (2002) observed significantly higher bulb weight and diameter by inoculation of *Azospirillium* along with 50% recommended dose of NPK fertilizers. Treatment T_9 (poultry manure + *Azotobacter chroococcum*) produced the response was on par with poultry manure treatment followed by treatment T_6 (FYM + *Azotobacter chroococcum*). The treatment T_9 produced 64% higher increase in bulb yield over the treatment T_1 (control) and 19.58% over the treatment T_6 (FYM + *Azotobacter chroococcum*). The highest yield (21.48 t/ha) was recorded with treatment T_9 (poultry manure + *Azotobacter chroococcum*). Such response of poultry manure due to relatively high nutrient concentration and initial microbial population helped in mobilizing the unavailable pool of nutrients in soil, thereby triggering the acquisition of optimum nutrient supply across critical crop phenophases. Better growth of leaves/plant as effective nutrient sink served the required photosynthates in increasing the size of bulb, which eventually translated into higher yield. Similarly conclusions were drawn by Amanullan and Somusundran (2007).

Bulb quality

Bulb quality evaluated in terms of TSS and protein content expressed differential response of treatments. The highest TSS (12.61°Brix) was recorded with treatment T_6 involving a combination of FYM + *Azotobacter chroococcum,* followed by treatment T_9 (12.16° Brix) using poultry manure + *Azotobacter chroococcum*, both exceeding over treatment T_1 (control). Studies in past using organic manures along with biofertilizers inoculation have demonstrated an improvement in TSS (Rather *et al*. 2003, Pachori *et al.* 2005). The treatment T_9 (poultry manure + *Azotobacter chroococcum*) showed maximum protein content (6.30%) statistically at par with treatment T_6 (FYM + *Azotobacter chroococcum*).

Nutrient uptake

Application of various organic manures with or without biofertilizer *Azotobacter chroococcum* showed significant response on the uptake of nutrients compared to (Table 2). The treatment T_9 registered the maximum uptake of N, P and K (27.67 N–11.14 P–57.35 kg/ha K) which was statistically on par with treatment T_5, but superior over treatment T7 (16.31 N–6.38 ^{P} , 44.55 kg/ha K) or treatment T_8 (17.58 N–8.62 P–42.44 kg/ha K) involving *Azotobacter* inoculation along with pig manure or vermicompost, respectively. The maximum uptake of K was observed with the treatment T_9 (57.35 kg/ha) T_5 (55.95 kg/ha) T_6 (51.02 kg/ha) all three treatments without significant difference. Increase in uptake of N, P and K with increasing level of FYM was earlier observed by Patil *et al.* (2005) and Singh *et al*. (2001).

Soil fertility changes

Application of organic manure either alone or in combination with biofertilizer showed no effect on changes in soil *p*H after the crop harvesting (Table 2). However, the response on organic carbon content was observed significant. The maximum organic carbon (2.25%) was observed with the treatments like T_2,T_4,T_6,T_8,T_9 confirming that most of the organic manures are effective building up the organic carbon status of soil since microbial abundance helped in

Table 2 Effect of organic manures and biofertilizers on nutrient uptake by the crop and fertility status of soil after harvest (Pooled data)

Treatments	Nutrient uptake by bulb (kg/ha)			*p*H	Organic carbon (%)	Available nutrients (kg/ha)		
	N	P	K			N	P	K
T_1	8.04 (0.95)	2.96 (0.35)	16.62 (1.96)	4.46	1.87	183.66	9.20	160.10
T_2	22.80 (1.36)	9.10 (0.54)	47.90 (2.86)	4.60	2.28	283.66	12.24	210.50
T_3	15.08 (1.18)	6.85 (0.53)	37.60 (2.95)	4.46	2.05	268.00	12.06	216.11
T_4	16.72 (1.16)	7.30 (0.50)	39.17 (2.72)	4.60	2.25	259.66	12.17	215.19
T_5	26.39 (1.25)	10.91 (0.52)	55.96 (2.64)	4.60	2.26	278.66	13.58	191.18
T_6	22.01 (1.29)	7.00 (0.41)	51.02 (2.99)	4.70	2.30	292.00	13.63	199.87
T_7	16.31 (1.30)	6.38 (0.51)	44.55 (3.54)	4.50	2.15	283.00	12.15	225.63
T_8	17.58 (1.15)	8.62 (0.56)	42.44 (2.78)	4.56	2.25	270.00	12.52	193.88
T_9	27.67 (1.29)	11.14 (0.52)	57.35 (2.66)	4.56	2.28	282.00	13.49	210.29
CD (*P*=0.05)	3.56	1.59	12.31	N.S	0.17	24.52	2.16	23.91

T_1, Control; T_2, FYM @ 40 tonnes/ha; T_3, pig manure @ 30 tonnes/ha; T_4, vermicompost @ 10 t/ha; T_5, poultry manure @ 20 t/ha; T_6, FYM + *Azotobacter*; T_7, pig manure + *Azotobacter*; T_8, vermicompost + *Azotobacter*; T_9, poultry manure + *Azotobacter*
Initial soil fertility (212.3 kg/ha available N, 10.5 kg/ha available P_2O_5 and 173.2 kg/ha K_2O)

Table 3 Effect of organic manures and biofertilizer on economics of cultivation of onion (mean of two years)

Treatment	Cost of cultivation (₹)			Gross returns (₹/ha)	Net returns (₹/ha)	Cost : benefit ratio
	Fixed cost	Treatment cost	Total			
T_1	29 200		29 200	73 180	43 980	1:2.51
T_2	29 200	16 000	45 200	154 440	109 240	1:3.42
T_3	29 200	18 000	47 200	118 420	71 220	1:2.51
T_4	29 200	30 000	59 200	125 920	66 720	1:2.13
T_5	29 200	20 000	49 200	197 760	148 560	1:4.02
T_6	29 200	16 075	45 275	158 280	113 005	1:3.50
T_7	29 200	18 075	47 275	122 180	74 905	1:2.58
T_8	29 200	30 075	59 275	134 810	75 535	1:2.27
T_9	29 200	20 075	49 275	203 330	154 055	1:4.13

T_1, Control; T_2, FYM @ 40 tonnes/ha; T_3, pig manure @ 30 tonnes/ha; T_4, vermicompost @ 10 tonnes/ha; T_5, poultry manure @ 20 tonnes/ha; T_6, FYM + *Azotobacter*; T_7, pig manure + *Azotobacter*; T_8, vermicompost + *Azotobacter*; T_9, poultry manure + *Azotobacter*

sequestering the mineralized carbon from organic manures and loading in to the soil carbon pool. These observations are in close conformity with observations made by Sanyal (2001) who observed build-up in soil organic matter following the application of organic manures.

All the treatments recorded significantly higher available N content in soil after harvest of crop over control. Maximum available N (292.0 kg/ha) was observed with treatment T_6 why due to much lower C:N ratio 10:1 mineralizing the N from tagged an sources. These were followed by T_9 and T_2. The treatment T_6 involving FYM + *Azotobacter* was at par with all other treatments except application of T_4 and T_1. The maximum available P_2O_5 (13.49 kg/ha) was recorded with treatment T_5, T_6 and T_9 at par with rest of other treatments but all being superior to T_1 (control). These results could be viewed in the context of comparatively constant C:P ratio in these organic manures, irrespective of whether or not chroococcum is incorporated in treatment. Earlier Pachauri *et al*. (2005) observed increase in available P status in the plot treated with FYM. The results from present studies showed that control treatment recorded minimum available K_2O (160.10 kg/ha) as compared to rest of the other treatments. Maximum available K_2O (225.63 kg/ha) was observed with treatment Pig manure + *Azotobacter* which was significantly higher than treatments like T_4 and T_7 including T_1 due to varying carbon content of manures. Rest of the treatments displayed no response to each other.

Economics

An economic analysis on response of different treatments showed invariably better cost : benefit ratio over control (Table 3).The treatment T_9 registered highest net returns (₹ 1,54,055) and cost benefit ratio (1:4.13) compared to rest of treatments (₹ 66,720–1,48,560 and 1:2.13–1:4.02). The difference in cost : benefit ratio with best treatment T_9 verses T_1 was still wider over control (1:4.13 versus 1:2.51) signified the importance of organic manures over control in harnessing quality production of onion, provided microbial abundance is sufficient to induce the desired mineralization of organic carbon, and thereby release of nutrients.

REFERENCES

Amanullah M M and Somasundaram E. 2007. Recycling of poultry manure. *Agricultural Update* **2**(1): 25–6.

Devi A K B and Ado L. 2005. Effect of fertilizers and biofer~lizerso n physiological growth parameters of multiplier onion *(AlIium cepa* var. *aggregatum). Indian Journal of Agricultural Sciences* **75** (6): 352–4.

Jackson M L. 1973. *Soil Chemical Analysis*, pp 76–95. Prentice Hall, New Delhi.

Jayathilake P K S, Reddy, I P, Srihari D, Neeraja G and Reddy R 2002. Effect of nutrient management on growth, yield and yield attributes of *rab*i onion (*Allium cepa* L.). *Vegetable Science* **29**(2): 184–5.

Khalif F A, El-Hamid A S A, Mohammed E I and Hassan M A N. 2002. Response of onion crop var. Shandewed to some source of organic fertilizers. *Assiut Journal of Agricultural Sciences* **33**(5): 73–8.

Ngullie E, Singh A K and Singh V B. 2008. Improving rainfed onion through enriched organic manures in Rhodustaff. *(in) Ambedkar Jayanti National Seminar on Sustainable Horticultural Research in India. Perspective, Priorities and Preparedness*, April 14–15, 2008, Dr. Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh.

Ngullie E, Singh V B, Singh A K, Singh Harmandeep 2010. Fertilizing for sustainable onion production systems. *Better Crops–South Asia* **2**: 8–12

Pachauri S P, Singh V and Pachauri C P. 2005. Effect of FYM, nitrogen, and potassium on growth, yield and quality of onion. *Annals of Plant &. Soil Research* **7**(1): 54–6.

Panse V G and Sukhatme P V 1978. *Statistical Methods for Agricultural Workers,* 328 pp. ICAR, New Delhi.

Patil P V, Chalwade P B, Solanke A S and Kulkarni VK. 2005. Effect of fly ash and FYM on nutrient uptake and yield of onion. *Journal of Soils and Crops* **15**(1): 187–92.

Rather S A, Ahmed N and Chatto M A. 2003. Response of onion to microbial inoculation and chemical nitrogen. *Haryana Journal of Horticultural Science* **32**(3&4): 270–1.

Sanyal S K. 2001. Colloidal chemical properties of humic substances: A Relook. *Journal of Indian Society of Soil Science* **49**(4): 567–69.

Singh R P, N K Jain and Poonia B L. 2001. Integrated nutrient management in rainy season onion (*Allium cepa*). *Indian Journal of Agricultural Sciences* **71**(5): 310–2.

Singh V B. 2006. Prospectus of onion cultivation in Nagaland. *Horticultural Newsletter* **1**(1): 14–15.