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Evaluation of integrated nutrient management on the performance of bottle gourd [*Lagenaria siceraria* (Molina) Standl.]

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Abstract: The present investigation was conducted during 2011-2012 and 2012-2013 at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Vishwavidyalaya, Monhanpur, Nadia, West Bengal, India, to find out the effect of organic manure, chemical fertilizers and bio fertilizers in an integrated manner for yield maximization and quality improvement in bottle gourd cv. Pusa Naveen. The experiment consisted of eleven nutrient based treatment combinations, including different level of applications of inorganic fertilizers (Urea, single super phosphate and muriate of potash), organic manure (vermicompost) and bio fertilizers (*Azotobacter* and PSB). Present investigation clearly indicated the beneficial effect of integrated nutrient management on yield and quality characters of bottle gourd. The maximum length of main vine (226.00 cm), branches per plant (5.67), fruit number (10.00), fruit weight (873.33 g), fruit length (21.07 cm) and fruit diameter (8.18 cm) were recorded in the treatment which received equal proportions of N from inorganic and organic sources along with bio fertilizers (*Azotobacter* and PSB). Quality characters namely, total soluble solids (TSS) and ascorbic acid in bottle gourd fruit were enhanced in the most favourable way due to application of 75% N from inorganic source and 25% N from organic source along with bio fertilizer (PSB). Keeping view on yield sustainability, balance in ecosystem, soil health improvement and good health of human beings, it may be suggested that vegetable growers particularly in new alluvial zone of West Bengal may supplement 25-50% recommended dose of nitrogen through vermicompost in bottle gourd cultivation along with bio fertilizers *viz. Azotobacter* and PSB.

Keywords: *Azotobacter*, Biofertilizers, Bottle gourd, Nutrient management, PSB, Vermicompost

INTRODUCTION

Our demand of vegetable will be 250 million ton by 2020 AD (Singh, 2000), where as the expected production at present are about 160 million ton and annually 0.8% of agricultural land being usurped for urbanization (Kar, 2002). Among the several factors related to vegetable production, nutrient management is one of the key factor for achieving higher yield and better quality of the crop. The use of high yielding crop varieties and chemical fertilizers has resulted in rapid increase in agricultural production system, at the same time indiscriminate use of chemical fertilizers will lead to widespread nutrient deficiency in soils, disturbed soil reaction, development of nutrient imbalance in plant, increased susceptibility to plant diseases, reduced soil organic matter, lesser occurrence of beneficial soil micro organism and increased environmental pollution as well as human health hazards. Organic manures supply important plant elements, both macro and micro. Apart from supplying plant nutrients, they favour aggregation of fine soil particles, thereby promoting good soil structure and it is also essential for healthy development of soil micro-organisms which further carry out biochemical transformations, play active role in decomposing organic matter and help in releasing the essential plant nutrients (Sureshkumar and Karuppaiah, 2008). Bio fertilizers are microbial in origin and are useful in increasing yield, quality and production of crops when they are used in combination with organic manures and inorganic fertilizers in a balanced proportion (Kumar *et al.*, 2012). Thus, in this respect integrated nutrient management (INM) plays a vital role to maintain soil fertility, to bring stability, sustainability in agricultural production and also avoid over dependence on chemical fertilizers. Efficient use of integrated plant nutrient supply system is a pre-requisite for achieving continuous advances in biological productivity of vegetable crops in ecologically sustainable manner (Sreenivas *et al.*, 2000). Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is one of the most important cucurbitaceous vegetable crops, grown intensively in West Bengal and also in other parts of the country for its widespread consumption. Keeping in view the above discussed facts and due to lack of sufficient information on INM in bottle gourd particularly in West Bengal state, the present experiment was undertaken to find out the combined effect of organic manure, chemical fertilizers

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and bio fertilizers in an integrated manner for yield maximization in bottle gourd and study the effect of integrated nutrient management on the quality characters of bottle gourd fruit.

MATERIALS AND METHODS

This present experiment was conducted at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal for two winter seasons during 2011-2012 and 2012-2013. The soil of experimental site is sandy loam in nature with around 0.57% organic carbon, 0.06% total nitrogen, available phosphorous 30.10 kg/ha, available potassium 115.7 kg/ha and pH 6.5. The experimental site is under subtropical humid region with range of average temperature of 36^0C (max.) to 24^0C (min.) and average relative humidity (R.H.) of 60% (max.) to 95% (min.) during the experimental period (May to September) of both the years.

The experiment was consisted of eleven treatments with various combinations of nutrient management, applied to bottle gourd variety Pusa Naveen, included different level of applications of inorganic fertilizers (Urea, single super phosphate and muriate of potash), organic manure (vermicompost) and bio fertilizers (*Azotobacter* and Phosphate Solubilising Bacteria [PSB] – *Pseudomonas sp.*) as mentioned in Tables 1-5. The experiment was laid out in randomized block design (R.B.D.) with 3 replications of each treatment, Bottle gourd seeds were sown in the field at a spacing of 2.5 m ×1.5 m in plots of 5.0 m × 3.0 m size. Normal cultural practices and plant protection measures were followed during the cultivation process. Two plants were selected at random from each plot of each treatment as representative sample for recording the data. The pooled mean values of each treatment in each replication for individual observation were calculated. After collection of data, it was tabulate in proper form and subjected to statistical analysis with the help of computer package MSTAT-C and also tested with DMRT.

RESULTS AND DISCUSSION

Effect of different nutrient management on vegetative growth characters of bottle gourd: Integrated nutrient management treatments rendered their significant effect on all the vegetative characters except number of

Table 1. Effect of integrated nutrients on vegetative characters of bottle gourd.

Treatments	Length of main vine (cm)	Length of internode (cm)	Number of branches/ plant	Number of nodes on main vine
T_1: Without application of any chemical fertilizer, organic manure as well as biofertilizer	133.33	10.47	4.00	19.17
T_2: Full recommended dose of NPK (N : P_2O_5 : K_2O : : 80:60:50 kg/ha)	183.07	13.32	5.00	19.83
T_3: Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha	196.67	14.39	5.00	20.25
T_4: Full recommended dose of NPK + Phosphate solubilizing bacteria (PSB)	137.00	15.22	4.67	20.08
T_5: Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha	166.67	15.56	5.00	21.83
T_6: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	175.67	12.39	4.67	21.08
T_7: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K +PSB @10 kg/ha	179.00	14.78	5.00	20.75
T_8: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 5kg/ha + PSB @ 5kg/ha	222.06	17.57	5.33	22.08
T_9: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	220.67	17.28	4.33	22.00
T_{10}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + PSB @ 10 kg/ ha	183.33	17.17	5.00	21.25
T_{11}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 5 kg/ha + PSB @ 5 kg/ha	226.00	18.11	5.67	22.17
S.Em. (±)	39.82	1.30	0.67	2.39
CD at 5%	96.76	3.16	1.62	5.81

Table 2. Effect of integrated nutrients on flowering characters of bottle gourd.

Treatments	Days to first male flower initiation	Days to first female flower initiation	Node number of 1st female flower appearance	Total number of male flowers per plant	Total number of female flowers per plant	Sex ratio (female: male)
T_1: Without application of any chemical fertilizer, organic manure as well as biofertilizer	33.22	40.95	15.18	48.72	12.26	0.25
T_2: Full recommended dose of NPK (N : P_2O_5 : K_2O : : 80:60:50 kg/ha)	37.56	48.02	14.93	56.56	12.34	0.22
T_3: Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha	34.80	44.00	13.07	52.13	14.22	0.27
T_4: Full recommended dose of NPK + Phosphate solubilizing bacteria (PSB)	34.49	42.56	13.48	44.06	14.35	0.32
T_5: Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha	36.08	47.48	12.89	48.16	15.60	0.32
T_6: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	36.86	42.45	12.99	54.60	16.66	0.30
T_7: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K +PSB @10 kg/ha	36.77	42.97	13.00	48.40	16.80	0.35
T_8: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 5kg/ha + PSB @ 5kg/ha	34.61	44.50	11.67	53.06	15.42	0.29
T_9: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	35.41	42.11	11.94	50.12	16.22	0.32
T_{10}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + PSB @ 10 kg/ha	36.59	43.48	12.44	41.93	15.93	0.38
T_{11}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* & @ 5 kg/ha + PSB @ 5 kg/ ha	36.59	46.58	10.33	42.80	19.80	0.46
S.Em. (±)	0.95	1.86	0.85	3.24	2.12	0.04
CD at 5%	2.30	4.52	2.06	7.87	5.15	0.10

Table 3. Effect of integrated nutrients on yield attributing characters of bottle gourd.

Treatments	Number of fruits per plant	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
T_1: Without application of any chemical fertilizer, organic manure as well as biofertilizer	7.51	695.00	17.24	5.49
T_2: Full recommended dose of NPK (N : P_2O_5 : K_2O : : 80:60:50 kg/ha)	7.96	711.67	18.18	5.99
T_3: Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha	8.67	715.00	18.67	6.14
T_4: Full recommended dose of NPK + Phosphate solubilizing bacteria (PSB)	8.06	741.67	19.79	6.26
T_5: Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha	8.87	781.67	19.37	7.22
T_6: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	8.15	751.67	19.67	6.55
T_7: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K +PSB @10 kg/ha	8.60	773.33	18.53	6.09
T_8: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 5kg/ha + PSB @ 5kg/ha	9.98	830.00	20.32	7.82
T_9: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	9.72	803.33	20.30	7.78
T_{10}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + PSB @ 10 kg/ha	9.05	773.33	20.00	7.72
T_{11}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 5 kg/ha + PSB @ 5 kg/ha	10.00	873.33	21.07	8.18
S.Em. (±)	0.72	42.68	0.40	0.36
CD at 5%	1.15	103.71	0.97	0.87

nodes on main vine (Table 1). Treatment consisted of 50% recommended dose (RD) of N from inorganic source + 50% RD of N supplemented through vermicompost + recommended doses of P and K + PSB @ 5 kg/ha + *Azotobacter* @ 5kg/ha *viz.,* T_{11} recorded best performances for length of main vine (226.00 cm), length of internodes (18.11 cm) and branches per plant (5.67). T_0 where no nutrient was applied from outside was the lowest performer for the results of the said characters. Sareedhar *et al.,* (2006) reported that higher vine length, number of leaves, and intermodal length of gherkin were registered in the treatment which received recommended dose of inorganic fertilizer along with organic manures, namely, farmyard manure (25 t/ha), press mud (25 t/ha) and vermicompost (25 t/ha). According to Sureshkumar and Karuppaiah (2008) comparatively higher vine length was obtained by application of integrated nutrients in bitter gourd with various sources of nutrients. They obtained best result from the treatment combination of 75% NPK (60:30:20 Kg/ha) + vermicompost at 5 t/ha + *Azospirillum* at 2 kg/ha. So, both these results are in conformity with the findings of the present experiment.

Effect of different nutrient management on flowering characters of bottle gourd: Bottle gourd plant required maximum days for first male and female flower initiation (37.56 days and 48.02 days, respectively) when the soil was fertilized with full RD of NPK i.e. in case of T_2 (Table 2). On the other hand plants of the plots with addition of manure and bio fertilizers along with inorganic fertilizers from outside took comparatively lesser days for initiation of both the flowers. Similar kind of result has been revealed in a study on integrated nutrient management in cucumber by Bindyia *et al.*, (2006) where they observed that combined application of vermicompost (2 t/ha) + ½ RD of NPK (50:30:30 Kg/ ha) + *Azotobacter* and PSB each at 5 kg/ha showed earliness and took lesser number of days for 50% flowering. First female flower appeared on 10.33 number of nodes, when the plants received 50% N from inorganic source + 50% N from organic source along with biofertilizers (*Azotobacter* and PSB each @ 5 kg/ha) *viz.* T_{11} (Table 2). The said combination also found to be best for production of maximum number of female flowers (19.80) per plant and sex ratio (female : male – 0.46). Mulani *et al.,* (2007) observed that in bitter gourd minimum days for 50% flowering and significantly lowest node number on which first female flower appeared were recorded with the application of neem cake (25% N) + poultry manure (75% N) + vermicompost + sulphate of potash + package (combination of neem cake) + *Trichoderma viridae* + *Azotobacter* + *Azospirillum* + PSB + neem seed kernal extract whereas, the highest sex ratio in pumpkin was found with the application of 9 kg N and 12 kg P/ha with *Azospirillum* and phosphobacteria (Karuthamani *et al.,* 1995). So, the results of the present experiment are in a good agreement with the above mentioned findings.

Effect of different nutrient management on yield attributing characters of bottle gourd: Significant influences on yield attributing characters were exerted by the nutrient management treatments (Table 3). Fruit number (10.00), fruit weight (873.33 g), fruit length (21.07 cm) and fruit diameter (8.18 cm) were recorded as the maximum in the treatment which received equal proportions of N from inorganic and organic sources along with biofertilizers *viz.* T_{11}. Minimum results of yield attributing characters were obtained in the plots those received no nutrients from outside (T_1). According to Anitha *et al,* 2003, the highest yield of pickling melon was obtained with the application of 10 t vermicompost + NPK @ 70: 25: 25 kg/ha. Experimental results of Anjanappa *et al.* (2012) revealed that enhanced yield parameters of cucumber (cv. Hassan Local) like, number of fruits per vine and maximum fruit weight were recorded with the application of FYM + *Azotobacter* + Phosphobacteria + *Trichoderma*. Mulani *et al.* (2007) reported that in bitter gourd a synergistic interaction between organic manure and bio fertilizers resulted in enhanced fruit length and fruit girth which ultimately increased average fruit weight. The results of the present experiment have corroborated well with the findings of earlier research works.

Effect of different nutrient management on quality characters of bottle gourd: Quality characters namely, total soluble solids (TSS) and ascorbic acid in bottle gourd fruit were enhanced in a favourable way due to application of inorganic fertilizer, organic manure and biofertilizers in an integrated manner (Table 4). The maximum (2.31^0brix) and minimum (1.57^0Brix) values of TSS content were recorded respectively in T_7 and T_1. Positive influences of substitution of inorganic fertilizer with different organic manures on TSS content have been reported by Mahenddran and Kumar (1997) and Chitrakar *et al.* (2007) in cabbage. Like TSS, ascorbic acid content in bottle gourd fruit was maximum (7.60mg/100g) and minimum (6.04mg/100g) is T_7 and T_1, respectively. Kameswari and Narayanamma (2011) stated that application of poultry manure along with recommended dose of nitrogenous fertilizers and vermicompost improved the quality characters like TSS and ascorbic acid content in ridge gourd. According to Azarmi *et al.* (2009), vermicompost had positive influences on growth, yield and quality of 2 fruit cucumber (*Cucumis sativus* L.) varieties (cv. 'Sultan F1' and cv. 'Storm F1'). From these reports, it is evident that the results of the present investigation are well supported by the findings of the earlier workers.

Effect of different nutrient management on yield of bottle gourd along with economic projections: Highest fruit yield in the present experiment was 19.11 t/ha and found when the soil of the experimental plot received 50% RD of N from inorganic fertilizer (urea), 50% RD of N from organic manure (vermicompost) along with bio fertilizers *viz. Azotobacte*r and PSB each @ 5 kg/ha (T_{11}) (Table 5). The recorded fruit yield in this

Table 4. Effect of integrated nutrients on quality characters of bottle gourd.

Treatments	TSS (^{0}Brix)	Ascorbic acid content (mg/100 g of dried flesh of fruit)
T_1: Without application of any chemical fertilizer, organic manure as well as biofertilizer	1.57	6.04
T_2: Full recommended dose of NPK (N : P_2O_5 : K_2O : : 80:60:50 kg/ha)	1.90	6.26
T_3: Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha	1.90	6.63
T_4: Full recommended dose of NPK + Phosphate solubilizing bacteria (PSB)	2.07	7.13
T_5: Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha	1.93	7.06
T_6: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	1.93	6.80
T_7: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K +PSB @10 kg/ha	2.31	7.07
T_8: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 5kg/ha + PSB @ 5kg/ha	2.17	7.53
T_9: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	2.30	7.43
T_{10}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + PSB @ 10 kg/ha	2.27	7.23
T_{11}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 5 kg/ha + PSB @ 5 kg/ha	2.30	7.60
S.Em. (±)	0.24	0.192
CD at 5%	0.58	0.552

Table 5: Effect of integrated nutrients on yield of bottle gourd along with economic projections.

Treatment	Fruit yield / plant (kg)	Fruit yield/ plot (kg)	Total yield (t/ ha)	Percentage increase in yield over T_1	Total cost of cultivation (Rs/ ha)	Gross income (Rs/ha)	Net income (Rs/ha)	Benefit : cost ratio
T_1: Without application of any chemical fertilizer, organic manure as well as biofertilizer	4.18	23.38	15.59	--	49400.00	150000.00	100600.00	2.04
T_2: Full recommended dose of NPK (N : P_2O_5 : K_2O : : 80:60:50 kg/ha)	5.82	23.74	15.83	1.54	64775.66	237450.00	172674.34	2.66
T_3: Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha	6.12	25.26	16.84	8.02	65025.66	252600.00	187574.34	2.88
T_4: Full recommended dose of NPK + Phosphate solubilizing bacteria (PSB)	6.11	24.88	16.59	6.41	65025.66	248850.00	183824.34	2.83
T_5: Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha	6.25	25.33	16.89	10.84	65025.66	253350.00	188324.34	2.90
T_6: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	6.52	26.77	17.85	14.50	78743.045	267750.00	189006.95	2.40
T_7: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K +PSB @10 kg/ha	6.33	25.92	17.28	8.34	78743.045	259200.00	180456.95	2.29.
T_8: 75% of N through inorganic fertilizer + 25% of N through vermicompost + full P and K + *Azotobacter* @ 5kg/ha + PSB @ 5kg/ha	6.60	28.12	18.75	20.27	78743.045	281250.00	202506.95	2.57
T_9: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 10 kg /ha	7.24	27.54	18.36	17.77	82460.425	275400.00	192939.57	2.34
T_{10}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + PSB @ 10 kg/ha	6.69	27.46	18.31	17.45	82367.422	274650.00	192282.58	2.33
T_{11}: 50% of N through inorganic fertilizer + 50% of N through vermicompost + full P and K + *Azotobacter* @ 5 kg/ha + PSB @ 5 kg/ha	7.77	28.66	19.11	22.58	83478.426	286650.00	203171.57	2.43
S.Em. (±)	0.48	0.84	0.44	--	--	--	--	--
CD at 5%	1.17	2.04	1.07	--	--	--	--	--

treatment was 22.58% higher over the control treatment. It was observed that combination of equal proportions of N from inorganic and organic sources and bio fertilizers either alone each @ 10kg/ha or both jointly each @ 5kg/ha did better performances towards fruit yield of bottle gourd. Higher yield due to integrated nutrient management was reported earlier in pumpkin by Karuthamani *et al.* (1995), in cucumber by Bindiya *et al.* (2006), in sponge gourd and ridge gourd by Nair and Nair (2006), in bitter gourd by Mulani *et al.* (2007) and in snake gourd by Karuppaiah and Balasankari (2008). The highest benefit:cost ratio during the course of investigation of 2.90 has been obtained from T_5 (Full recommended dose of NPK + *Azotobacter* @ 5kg/ha + PSB @ 5 kg/ha) @10 kg/ha) followed by T_3 (Full recommended dose of NPK + *Azotobacter* @ 10 kg/ha) where as the lowest ratio of 2.03 has been recorded from T_1.

Conclusion

Integrated nutrient management treatments rendered their significant effect on almost all the vegetative growth characters and yield attributing characters as well as fruit quality parameters of bottle gourd cv. Pusa Naveen. Treatment consisted of 50% RD of N from inorganic source + 50% RD of N supplemented through vermicompost + recommended doses of P and K + PSB @ 5 kg/ha + *Azotobacter* @ 5kg/ha recorded maximum performances with respect to almost all the vegetative growth as well as yield characters. Whereas, best result for the TSS and ascorbic acid content of the fruits were recorded when the plants were applied with 75% RD of N from inorganic source + 25% RD of N supplemented through vermicompost + recommended doses of P and K + PSB @ 5 kg/ha. Control treatment where no nutrient was applied from outside was the lowest performer for the results of the said characters. So, keeping view on yield sustainability, balance in ecosystem, soil health improvement and good health of human beings it may be suggested that vegetable growers particularly new alluvial zone of West Bengal may supplement 25-50% recommended dose of nitrogen through vermicompost instead of applying full recommended dose of nitrogen from inorganic source in bottle gourd along with biofertilizers *viz. Azotobacter* and PSB.

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