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Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality Attributes of Hybrid bitter gourd (*Momordica charantia* L.)

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A B S T R A C T

Bitter gourd (*Momordica charantia* L.) is popular vegetable because of its rich nutritive value, high productivity and easy package of practices which respond favourably to application of different soil organic amendments like vermicompost. In this experiment it was designed to evaluate the effect of different combinations of organic (vermicompost) and inorganic (NPK) source of nutrients on growth, yield and quality of bitter gourd. The application of vermicompost @ 4.68 t ha^{-1} recorded 3.99 kg/ fruits per vine with an average fruit weight of 62.18 g/fruit. Application of NPK @ 100:60:50 kg ha^{-1} recorded maximum fruit yield/vine (3.64 kg) and with average fruit weight 56.75 g/fruit. Interaction effect of vermicompost @4.68 t ha^{-1} and inorganic fertilizer, NPK @ 50:30:25 kg ha^{-1} was found to be best treatment combination for yield and yield attributing traits and as well as for benefit cost ratios. The maximum yield *i.e.* 36.81 t ha^{-1} was found under the combined use of vermicompost@ 4.68 t ha^{-1} and inorganic fertilizer@ 50:30:25 kg ha^{-1}. It was also observed that some of the quality attributes like TSS (^{o} Brix), Zn and Fe content of the fruit were significantly influenced with the application of different levels of vermicompost while vitamin C and Fe were significantly affected with the application of both organic and inorganic fertilizers in different combinations.

Introduction

Bitter gourd (*Momordica charantia* L.) is a tropical and subtropical vegetable crop of the family cucurbitaceae. Bitter gourd is a leading vegetable crop of India, the higher yield and maximum returns make it the most preferred vegetable crop of Indian farmers (Naveen *et al.,* 2012). Fruits are considered as a rich source of vitamins and minerals and are rich in vitamin C (88 mg/100 g).It possesses antioxidant, antimicrobial, antiviral, anti-hepatotoxic, anti ulcerogenic properties and also have the ability to lower blood sugar (Behera, 2011).

It has great demand in domestic and international market among fresh vegetables due to its hypoglycaemic property. Leading states growing the crop are Andhra Pradesh followed by Odisha, Bihar, Chhattisgarh and Madhya Pradesh. It is grown both in rainy season and as well in spring summer season. Fruits vary in shapes, size, colour and bitterness. A numbers of varieties and hybrids have been recommended by the government

institute as well as by private companies. Hybrids have an edge over the varieties owing to its higher yield potential and robust nature. Bitter gourd hybrids respond well to manure and fertilizer applications. However, continuous use of the heavy doses of fertilizers damage the natural ecology and adversely affects the nutrient recycling and the biological communities in soil which otherwise support the crop production (Prasad *et al.,* 2009). Therefore, it is being increasingly realized that organic manure is the cheapest eco-friendly resource for providing nutrients to crop plant and helps in curtailing the use of chemical fertilizers. Manures not only supply plant nutrients but also add organic matter, which improve physical condition of soil (Lundwick and Johnston, 2002). Among various sources of organic manures, vermicompost have been recognized as having considerable potential as soil amendments. Therefore, it is necessary to explore the potential of vermicompost and possibility of supplementing chemical fertilizer. The vermicompost has been found to be an ideal organic source of nutrient as, it is rich in macro and micro nutrient and helps to increase yield (Hidalgo and Pashanasi *et al.,* 1999). Therefore the present study was designed to evaluate the effect of different combinations of organic (vermicompost) and inorganic (NPK) source of nutrients on growth, yield and quality of bitter gourd and also on the economics of bitter gourd production.

Materials and Methods

The experiment was carried out at vegetable research farm of Bihar Agricultural University, Sabour, Bhagalpur to study the effect of inorganic and organic fertilizers on growth, yield and quality attributes of bitter gourd (*Momordica charantia* L). The climate of this place is tropical to subtropical and slightly semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter. December and January are usually the coldest months, where May and June are the hottest months. The major rainfall precipitates generally between June and October. The details of meteorological observations recorded as monthly maximum and minimum temperature and rainfall from January to June 2012 collected form agro-meteorological observatory, Bihar Agricultural College, Sabour, Bhagalpur have been depicted graphically in Figure 1 and 2. The weather conditions prevailing during the period of investigation was close to the normal for the place and could be termed congenial for the growth and development of bitter gourd hybrid, Varun. The soil of the experimental plot was Indo-Gangetic alluvial in origin. The land was fairly levelled and well drained. The soil of the experimental plot was sandy loam in texture and medium in fertility. The soil reaction was in the neutral range exhibiting suitability for cultivation of bitter gourd. The design of experiment was RBD (factorial).A bitter gourd hybrid, Varun was used as experimental material. Varun is a F_1 hybrid developed by Bharti Seeds Pvt. Ltd. and is recommended for sub-tropical a zone which is grown in local Bhagalpur area. Its fruit is medium size, green, attractive and high yielding. There were nine treatments replicated thrice. Treatment wise different organic manures were applied before sowing of seeds and mixed in the soil. One third dose of nitrogen as urea with full dose of phosphorus (P_2O_5) as DAP, potash (K_2O) as murate of potash and vermicompost were applied before sowing of seeds as per pit, in commensuration with treatments specifications (Table 1).

The desired amount of fertilizers and vermicompost as per treatments was mixed thoroughly and the mixture was placed in the top 6-20 cm layer of soil pit. After

incorporation of the fertilizers mixture, seeds were sown next day after irrigation. The remaining two third dose of nitrogen was applied in two split doses at an interval of twenty five and forty five days after sowing of seeds.

Tagged plants were used for recording various observations. The observations recorded for the aforesaid five plants were worked out to give means in respect of growth, yield and quality parameters, which were utilized in statistical analysis by the method of analysis of the variance prescribed by Panse and Sukhatme (1978). Comparison of the treatments was made with the help of critical differences (CD).

Results and Discussion

The morphological characters of bitter gourd crop namely, length of main vine (m), number of branches per vine, days to first female flower emergence, node number to first female flower emergence, days taken to first fruit picking, number of fruit per vine, fruit length (cm), fruit girth (cm), fruit weight per vine (kg), average fruit weight (g), yield t ha^{-1} were influenced by the combined application of NPK and vermicompost. Application of only 100% chemical fertilizers or 100% vemicompost alone could not influence the growth or the yield characters significantly as compared to combined application. The data pertaining to the various observations on growth and quality parameters in bitter gourd have been show in Table 2 and that regarding yield and economics in Table 3. Application of vermicompost 100 per cent brought significantly increased length of main vine (4.03 m) and number of branches (8.72) per plant, number of fruits (62.86), fruit length (13.97 cm), fruit girth (8.44 cm), average fruit weight (62.18 g), fruit yield (3.99 kg $vine^{-1}$) and also the yield (31.91t). These findings are in consonance with the earlier studies of Arancon *et al.,* (2006), Prabha *et al.,* (2007), Narkhede *et al.,* (2011). All the yield parameters and yield improved due to the application of higher dose of vermicompost because, vermicompost provided better nutrition status by improving the physical, biological and chemical properties of soil.

Vermicompost might have reduced the soil compactness and improved soil aeration which helped in better root development resulting deep penetration of root system which facilitated better absorption of water as well as nutrient. Present finding is in agreement with the findings of Renukaand Ravi Shankar (2001) in tomato, Sreenivas *et al.,* (2000) in brinjal and Reddy and Rao (2004) in bitter gourd, Azarmi *et al.,* (2008) in Tomato.

Application of vermicompost 100 per cent significantly decreased the number of nodes (13.23) to first female flower appearance, days (49.48) to first female flower emergence and days (59.30) to first fruit picking and was followed by vermicompost 75 percent and vermicompost 50 per cent in all the cases. The earliness might be also due to the enhanced production of growth promoting substances like gibbrelic acid, IAA by application of vermicompost which induce the earliness of female flower production, more flower stalks resulting early fruit harvesting. The similar findings have also been made observed by Sreenivas *et al.,* (2000) and Kameswari *et al.,* (2010).Total soluble solids (TSS) and Vitamin 'C' increased progressively with the vermicompost @ 100 per cent because bitter gourd responded favourably to application of organic amendment like vermicompost and this enhanced the antioxidant (vitamin C) content of the leaves and fruits (Marilou *et al.,* 2012). Vermicompost released nutrient in soil and provided favorable condition in the plant root zone resulting higher absorption or uptake of major as well as minor nutrient which might have directly related to concentration of T.S.S. in fruits.

Fig.1 Temperature (^{0}C) during experimental period in the year 2012

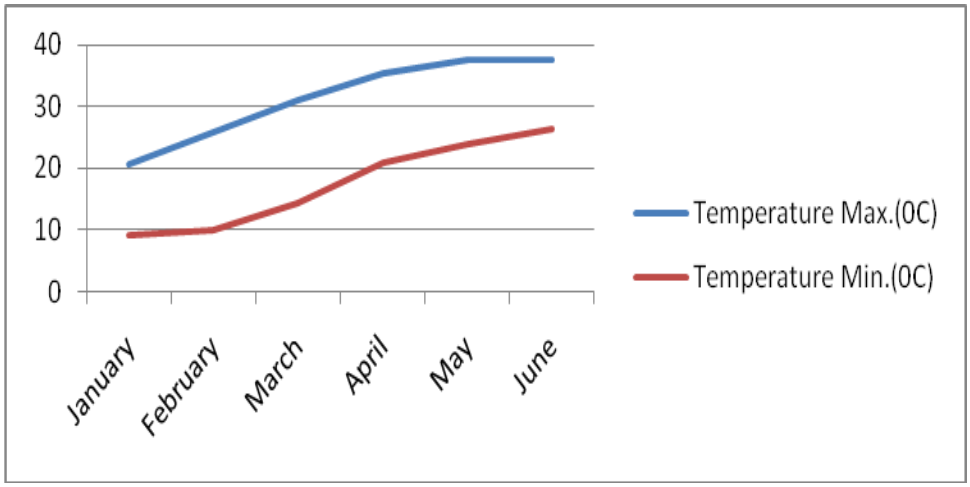

Fig.2 Relative humidity (%) and rainfall (mm) during experimental period

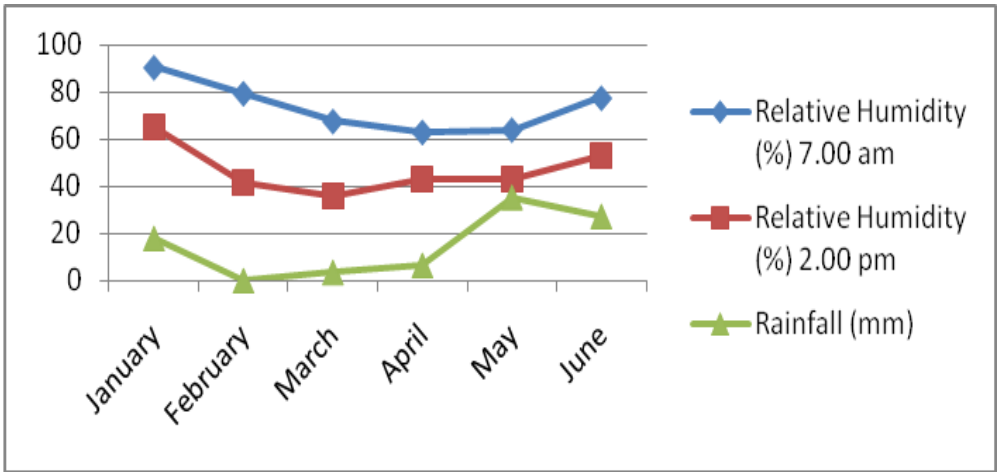

Table.1 Treatment combinations

Name of Treatment		Treatment Combination							
		N		P		K		Vermicompost (t ha^{-1})	
T_1	F_1 x V_1	100	:	60	:	50	x	4.68	t ha^{-1})
T_2	F_1 x V_2	100	:	60	:	50	x	3.50	t ha^{-1}
T_3	F_1 x V_3	100	:	60	:	50	x	2.43	t ha^{-1}
T_4	F_2 x V_1	75	:	45	:	37.5	x	4.68	t ha^{-1}
T_5	F_2 x V_2	75	:	45	:	37.5	x	3.50	t ha^{-1}
T_6	F_2 x V_3	75	:	45	:	37.5	x	2.43	t ha^{-1}
T_7	F_3 x V_1	50	:	30	:	25	x	4.68	t ha^{-1}
T_8	F_3 x V_2	50	:	30	:	25	x	3.50	t ha^{-1}
T_9	F_3 x V_3	50	:	30	:	25	x	2.43	t ha^{-1}

Table.2 Effect of vermicompost, inorganic fertilizer and its interactions on growth and quality of bitter gourd

	length of main vine (m).		No. of branches per plant		days to first female flower emergence		node no. to first female flower emergence		days to first fruit picking		TSS (^{0}Brix.)		Vit C (mg/100g)		Iron (%)		Zinc (ppm)	
V1	4.03		8.72		49.48		13.23		59.30		5.68		78.46		0.1539		41.60	
V2	3.82		8.17		52.31		14.05		62.78		5.29		72.03		0.1278		37.24	
V3	3.62		7.81		53.07		13.98		63.69		4.83		66.59		0.1349		47.69	
F1	4.01		8.57		54.02		14.22		64.35		5.50		65.06		0.1537		39.14	
F2	3.84		8.13		50.58		13.78		61.33		5.26		74.13		0.1289		42.24	
F3	3.61		8.01		50.25		13.27		60.09		5.04		77.89		0.1341		45.16	
F1XV1	4.17		9.05		54.85		14.72		65.80		5.70		65.28		0.1551		36.73	
F2XV1	3.93		8.60		47.51		13.20		57.27		5.65		81.15		0.1531		47.80	
F3XV1	3.90		8.52		46.08		11.77		54.82		5.68		88.94		0.1536		40.27	
F1XV2	4.00		8.61		54.43		14.30		64.69		5.62		66.11		0.1541		37.87	
F2XV2	3.97		8.04		51.84		13.43		62.84		5.43		74.29		0.1193		36.73	
F3XV2	3.48		7.87		50.67		14.33		60.80		4.82		75.70		0. 1101		37.13	
F1XV3	3.88		8.06		54.02		13.63		62.56		5.18		63.79		0.1519		42.83	
F2XV3	3.55		7.73		50.58		13.70		63.87		4.70		66.94		0.1142		42.18	
F3XV3	3.43		7.64		50.25		13.70		64.66		4.61		69.03		0.1387		58.07	
	SE m±	CD(P= 0.05)	SE m±	CD(P= 0.05)	SEm ±	CD(P= 0.05)	SE m±	CD(P= 0.05)	SE m±	CD(P =0.05)	SEm ±	CD(P=0. 05)	SEm ±	CD(P=0. 05)	SE m±	CD(P =005)	SEm ±	CD(P=005)
F	0.03	0.10	0.05	0.15	0.31	0.92	0.08	0.24	0.39	1.17	0.039	0.117	0.002	0.006	0.002	0.006	0.68	NS
V	0.03	0.10	0.05	0.15	0.31	0.92	0.08	0.24	0.39	1.17	0.039	0.117	0.002	0.006	0.002	0.006	0.68	2.03
FXV:	0.01	NS	0.15	NS	0.92	NS	0.24	0.73	1.16	NS	0.117	NS	0.006	NS	0.006	NS	2.03	6.08

Table.3 Effect of vermicompost, inorganic fertilizer and its interactions on yield and economics of bitter gourd

	number of fruits per vine.		fruit length (cm).		fruit girth (cm).		average fruit weight (g).		fruit weight per vine (kg).		fruit yield (t/ha) of bitter gourd.		Gross income.(Rs. ha^{-1})		Net income. (Rs. ha^{-1})		B:C ratios	
V1	62.86		13.82		8.41		62.18		3.99		31.91		223340.44		153172.34		2.19	
V2	62.70		12.85		8.01		58.70		3.76		30.11		210777.78		147647.68		2.34	
V3	55.32		11.95		7.88		58.57		3.25		25.98		181832.00		125187.90		2.20	
F1	61.81		12.46		8.35		56.75		3.64		29.14		203964.44		139395.61		2.20	
F2	56.78		13.53		8.10		60.71		3.52		28.18		197244.44		133930.35		2.11	
F3	62.29		12.62		7.85		61.98		3.83		30.68		214741.33		152681.95		2.43	
F1XV1	56.18		13.20		8.53		55.75		3.20		25.63		181832.00		107963.84		1.51	
F2XV1	63.93		13.83		8.35		64.88		4.16		33.28		181832.00		162773.24		2.32	
F3XV1	68.47		14.43		8.33		65.91		4.60		36.81		181832.00		188779.95		2.74	
F1XV2	65.36		12.84		8.33		57.73		4.02		32.16		225101.33		160716.50		2.50	
F2XV2	55.35		13.78		8.02		57.02		3.22		25.72		180058.67		116928.58		1.85	
F3XV2	67.40		11.92		7.69		61.34		4.06		32.45		227173.33		165297.95		2.67	
F1XV3	63.89		11.34		8.18		56.77		3.70		29.63		207405.33		149506.50		2.58	
F2XV3	51.06		12.99		7.93		60.24		319		25.53		178733.33		122089.24		2.16	
F3XV3	51.00		11.51		7.53		58.70		2.85		22.77		159357.33		103967.95		1.88	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=005)	SEm±	CD (P=005)	SEm±	CD (P=005)	SEm±	CD (P=005)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=005)
F	0.48	1.45	0.11	NS	0.045	NS	0.39	1.18	0.03	0.08	0.22	0.65	1514.86	4540.88	1514.86	4540.88	0.024	0.073
V	0.48	1.45	0.11	0.34	0.045	0.14	0.39	1.18	0.03	0.08	0.22	0.65	1514.86	4540.88	1514.86	4540.88	0.024	NS
FXV:	1.45	4.36	0.34	NS	0.136	NS	1.18	3.54	0.08	0.24	0.65	1.95	4544.59	4540.88	4544.59	13622.63	0.073	0.219

These findings are closely related to those Sreenivas *et al.,* (2000) in ridge gourd, Kodzeij & Kosteckaj (1994) in cucumber. Application of vermicompost 100 per cent significantly improved the iron (0.1539%) content in the fruit. Increase in various parameters in fruits with higher doses of vermicompost might be due to increase in the available micro and macro nutrients (Kale *et al.*, 1992) and (Giraddi, 1993). Application of vermicompost showed significant influence on zinc (Zn) content in fruit. Each increasing doses of vermicompost significantly decreased the zinc (Zn) content in fruit and recorded maximum zinc (Zn) concentration (42.83 ppm) under applied 50 per cent vermicompost. Minimum zinc (Zn) content (36.73 ppm) in fruit was recorded under vermicompost @ 100 per cent. In the present investigation application of vermicompost 50 % significantly increased Zn content because of low content of phosphorus, higher P_2O_5 causes antagonistic effect on Zinc (Zn) ion absorption. Similar finding was observed by (Aroiee and Omidbagi, 2004) in medicinal pumpkin. Application of vermicompost 100 per cent significantly increased the gross income (Rs. 223340.44 ha^{-1}) and net income (Rs. 153172.34). Significant increase the gross income and net profit with application of higher vermicompost in the present investigation may be because of the increase in the yield and reduced production cost.

The growth attributes like main vine length (4.01 m) and number of branches (8.57) increased significantly due to the application of 100 percent inorganic fertilizer. Minimum node number to first female flower emergence (13.27), days taken to first female flower emergence (50.25), days to first fruit picking (60.09) were recorded under lowest dose i.e. 50 per cent of inorganic fertilizer. This might be because higher dose of inorganic fertilizer (NPK) promotes vegetative growth & improves vegetation and delays flower initiation and application of lower dose of inorganic fertilizer i.e. @ 50 per cent might have provided balanced nutrition and brought better growth, development and promoted timely flower initiation in plants. Similar findings have also been reported by the Reddy *et al.,* (2004) in bitter gourd, Kameshwari *et al.,* (2011) in ridge gourd, Singh *et al.,* (2012) in bottle gourd, Srinivass *et al.,* (2000) in cucumber, Obyese *et al.,* (2013) in pumpkin. Number of fruit per plant, average single fruit yield (61.98 g), fruit weight per vine (3.83 kg per plant), yield (30 t ha^{-1}) significantly increased with application of 50 per cent inorganic fertilizer. The progressive increase in number of fruits per plant, fruit weight and fruit yield (t ha^{-1}) might be due to the optimum dose of NPK, which accelerated mobility of photosynthesis from the source to the sink as influenced by the growth hormone, and NPK uptake. These finding are in agreement with the findings of Umamhaswrappah (2004) in Bottle gourd, Cheema *et al.,* (2001) and Hocking *et al.,* (2003) in canola, Jillani *et al.,* (2009) and Prabhu *et al.,* (2003) in cucumber. Total Soluble Solids (5.50^{o}Brix), in fruit was significantly improved by the application of inorganic fertilizer @ 100 per cent. Ascorbic acid (77.89 mg 100 g^{-1} fresh fruit weight) content was higher in treatment 50 per cent inorganic fertilizer followed by 75 per cent inorganic fertilizer (74.13 mg $100g^{-1}$). Increasing level of inorganic fertilize reduced vitamin "C" content because when a plant is exposed with nitrogen it increases protein production and reduced carbohydrate synthesis since vitamin C is synthesized from carbohydrates. Similar results have also obtained by Meenakshi *et al.,* (2007) in bitter gourd, Shweta *et al.,* (2007) in tomato. Application of inorganic fertilizer @ 50 per cent recorded maximum net profit *i.e.*, 152681.95 (Rs./ha) with higher benefit: cost ratio (2.43) which was found most outstanding treatment. These higher B: C ratio

was mainly due to lower cost of cultivation with the use of lower level of inorganic fertilizer and producing higher yield in comparison to remaining level. These results are also in conformity with the findings of Kameshwari *et al.,* (2009) in cucumber and Vijay Kumar *et al.,* (2012) in bottle gourd and Dewangen (2012) in bottle gourd.

Combine use of vermicompost and NPK fertilizer showed significant influence in case of number of nodes to first female flower, no. of fruits per vine, fruit weight (kg) per vine, yield (t ha^{-1}),gross income, net income, and B:C ratio, Among the quality characters, significant effect due vermicompost and NPK fertilizer interaction was observed in case of zinc content in fruit (ppm).The minimum node number to first female flower emergence (11.77) was noticed under the combined use of inorganic fertilizer @ 50 per cent and vermicompost @ 100 per cent. Maximum node number (14.72) was recorded under F_1 x V_1vermicompost. It might be due to the fact that the plants in the presence of inorganic nutrients (NPK) along with vermicompost probably regulated the plant physiological and morphological functions which resulted in completion of the vegetative growth at faster rate and as a result, plant entered into the reproductive phase earlier which caused the first female flower to appear at lesser node number. The results of the present investigation have similarity with the findings reported earlier by Rai *et al.,* (2012), Kameswari *et al.,* (2011) in cucumber, Vijay Kumar *et al.,* (2012) in bottle gourd, Dewagan (2012) in bottle gourd. The plants developed under NPK fertilizer 50 per cent and vermicompost 100 per cent significantly produced higher number of fruits per vine (68.47) and average fruit weight. The maximum fruit yield per vine (4.60 kg per vine and) yield (36.81t ha^{-1}) was attained under the combined use of vermicompost @ 100 per cent and inorganic fertilizer (NPK) @ 50 per cent, which was superior to vermicompost 100 per cent x inorganic fertilizer 75 per cent, vermicompost 75 per cent x inorganic fertilizer 50 per cent and vermicompost 75 per cent x inorganic fertilizer 100 per cent. The results summarized above in respect of number of fruits per vine and average fruit weight and average yield of fruits (t per ha) are in consonance with the findings reported earlier by Anuja and Poovizhi (2009) in cucumber and Kameswari *et al.,* (2010) in sponge gourd, Vijay *et al.,* (2012) and Dewagan (2012) in bottle gourd. Wang *et al.,* (2010) in Chinese cabbage, and Atiyeh *et al.,* (2001) in marigold. Maximum zinc content *i.e.*, 58.07 ppm was noticed under the combine use of vermicompost @ 50 per cent x inorganic fertilizer @ 50 per cent which was significantly superior to all other combinations.

The gross income, net profit and B: C ratio was markedly affected due to different sources of nutrients and recorded maximum values under the application of vermicompost@ 4.68 t ha^{-1} and 50:30:25kg NPK (50% fertility level). The higher gross income under 100 per cent vermicompost x 50 per cent fertilizer level was mainly due to higher yield, while enhanced net income and benefit: cost ratios was because the cost of cultivation involved in the production was minimum under this treatment combination. These results are also in conformity with findings of Vijay Kumar *et al.,* (2012) in bottle gourd, Kameswari *et al.,* (2010), and Dewangen, (2012) in bottle gourd.

On the basis of above discussions it may be concluded that, the application of 100 per cent vermicompost (4.68 t ha^{-1}) and combination with 50 per cent of inorganic fertilizer was found to be most effective treatment combination for getting higher yield and maximum net return.

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