International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 1240-1244

Received: 21-09-2020
Accepted: 24-10-2020

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Influence of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality attributes of bitter gourd (*Momordica charantia* L.) var. green long

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6r.10931

Abstract
The present investigation entitled "Influence of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality attributes of bitter gourd (*Momordica charantia* L) var. Green Long" was carried out during the year 2019-2020 in the Department of Horticulture, Sam Higginbottom University of Agriculture Technology & Sciences Prayagraj in the months of Feb 2019 to May 2019. The experiment was laid out in Randomized Block Design (RBD) with 11th treatments combinations with control. The results revealed that T10 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha was found suitable for application in winter season bitter gourd cultivation for better flowering, growth, fruit yield and quality viz., The maximum average vine length (cm) at 30, 60, 90 DAS were recorded 124.65cm, 243.77cm, 368.61cm respectively, number of branches per plant at 30, 60, 90 DAS were recorded 4.34, 8.56, 14.56 respectively, number of leaves per plant at 30, 60, 90 DAS were recorded 80.86, 128.58, 288.76 respectively, Days to first female flower emergence were recorded at 33.17days respectively, Days to first male flower emergence were recorded at 30.41days respectively, Node. No. to which 1st male flower appearance were recorded at 13.46 respectively, Node. No. to which 1st female flower appearance were recorded at 24.87 respectively, Days to first fruit picking were recorded at 45.88 days respectively, No. fruit per plant were recorded at 42.20 respectively, length of fruit were observed 25.47cm and width of fruit were observed 17.24cm, Average fruit weight were observed 69.52gm, total yield per plant were recorded 2.934kg, fruit yield were recorded 52.81(t ha^{-1}), total soluble solids were observed 4.81(^{0}Brix), ascorbic acid were observed 84.52 (mg$100g^{-1}$) and Shelf life were recorded 8.74 days respectively. The highest yield benefit cost ratio (4.38) were obtained in treatment T_7 50% RDF + Azotobacter under Prayagraj agro climatic condition.

Keywords: Bittergourd**,** nitrogen, phosphorus, potassium, azotobacter

Introduction
Vegetables supply most of the nutritional requirement of our body like carbohydrate, fat, protein, salts and other macro and micro nutrients including vitamins. Among these bittergourd (*Momordica charantia* L.) is an important vegetable crop used all over the world. Bitter gourd (*Momordica charantia* L.) is one of the important vegetables grown in India, China and South East Asia. It is a commercial vegetable which belongs to family Cucurbitaceae. The crop is highly cross pollinated due to monoecy. The crop is an annual climber. According to Chakravarty (1959) [6], its native home is tropical Asia particularly East India and South China. It is commonly known as bitter melon, karela, currila, maidan apple and balsam pear (Morton, 1967) [11]. The diploid chromosome number is 2n=2x=22. It belongs to genus, '*Momordica*' which comprises of 23 species in Africa alone. There are 60 species in this genus, out of them *Momordica charantia* L. is widely cultivated. This is a plant of the tropics. Bitter melon originated in India. Among the cucurbits, bitter gourd is cultivated over an area of 78.74 (000'HA) in India with a production of 870.15 (000'MT) and productivity of 11.05 tons/ha (N.H.B., 2017-18). The bitter gourd is cultivated over an area of 99 (000'HA) in India with a production of 1204 (000'MT) (N.H.B., 2018-19).
Bitter gourd has several uses. The immature fruits are boiled, curried, stuffed or sliced and fried before consumption. The fruits are also pickled, canned and dehydrated. The green fruits have high nutritive value and can very well be compared with any other vegetables.

The fruit contains 2.1g of protein, 4.2g of carbohydrates, 1.8mg iron, 20mg of calcium, 55mg of phosphorus, 210 IU of vitamin A and 88mg of vitamin C per 100gm of edible portion (Aykryod, 1963). The fruits, young shoots and flowers are used for flavouring, the leaves as green and the pulpy aril as a sweet. The fruit of bitter gourd is having a lot of medicinal properties and said to have cooling effect, prevents constipation and checks jaundice and indigestion. The bitter principle in bitter gourd is due to 'momordicine', an alkaloid which is different from 'cucurbitacins' present in other genera of cucurbits. Momordicine is the momordicosides-glycosides of tetracyclic triterpinoids with cucurbitane skeleton (Chandravadana & Subhash Chandra, 1990) [7]. It is considered for having medicinal properties and with a compound named 'Charantin' present in the bitter gourd, is useful to reduce blood sugar of diabetic patients. The fruit of bitter gourd fruit is similar in nutritional value compared to other cucurbits, with the notable exceptions that it is much higher in folate and vitamin C. parts used: fruit, seeds, seed oil, leaves; uses: antidiabetic, anti-infective, antipyretic, anthelmintic, laxative, possible antifungal, androgenic, antiviral, antimalarial actions; possibly useful for infertility; precautions: pregnancy, lactation, children, patients taking hypoglycemic medications; may cause uterine bleeding or contractions, hepatotoxicity; seeds are toxic to children.

Plant nutrition is one of the most important factors that increase plant production. Nitrogen (N) is one of the most important nutrients affecting the growth, development, and yield and fruit quality of plants. Integrated nutrient sources are increased the nutrient use efficiently and soil fertility thus enhance the productivity of tomato. Organic manures not only balance the nutrient supply but improve the physical and chemicals properties of soil. Vermicomposting known to increase protein synthesis in plant, have definite influence on plant growth and yield. Bio fertilizers, which are eco-friendly and more economics, can play an important role in reducing the dependence on chemical fertilizers.

Farm yard Manure is prepared basically using cow dung, cow urine, waste straw and other dairy wastes. FYM is rich in nutrients a small portion of N is directly available to the plants while a larger portion is made available as and when the FYM decomposes. When cow dung and urine are mixed, a balanced nutrition is made available to the plants. Availability of Potassium and Phosphorus from FYM is similar to that from inorganic sources Application of FYM improves soil fertility.

Vermicompost has been shown to be richer in many nutrients than compost produced by other composting methods. It has also outperformed a commercial plant medium with nutrients added, but levels of magnesium required adjustment, as did pH. Increases in the total nitrogen content in vermicompost, an increase in available nitrogen and phosphorus in the soil. Enhances germination, plant growth and crop yield, Improves root growth and structure, Enriches soil with micro-organisms.

Azotobacter is the important and well-known nitrogen fixing aerobic bacterium. It is used as a biofertilizer for all non-leguminous plants especially Rice, Cotton, and Vegetables etc. Azotobacter cells are not present on the rhizosplane but are abundant in the rhizosphere region. The lack of organic matter in the soil is a limiting factor for the proliferation of Azotobacter in the soil.

Materials and Methods

The present investigation entitled "Influence of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality attributes of bitter gourd (*Momordica charantia* L.) var. Green Long" was carried out during the year 2019-2020 in the Department of Horticulture, Sam Higginbottom University of Agriculture Technology & Sciences Prayagraj in the months of Feb 2019 to May 2019. The experiment was conducted on Bitter gourd (*Momordica charantia* L) var. Green Long. The experiment was laid out in randomized block design with 12 treatments replicated three. The treatments involved were T_{0}- Control, T_{1}- 100% RDF (90:60:60), T_{2}- 75% RDF + FYM@20 tonnes/ha, T_{3}-75% RDF + Vermicompost@10 tonnes/ha, T_{4}- 75% RDF + Azotobacter, T_{5}- 50%RDF + Vermicompost@10 tonnes/ha, T_{6}- 50%RDF + FYM@20 tonnes/ha, T_{7}- 50%RDF + Azotobacter, T_{8}- 25% RDF + FYM@20 tonnes/ha + Azotobacter, T_{9}- 25%RDF + Vermicompost@10 tonnes/ha + Azotobacter, T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha, T_{11}- 50 % RDF + FYM@20 tonnes/ha + Azotobacter.

Results and Discussion

Growth parameters

The data revealed that the combination of different Organic and inorganic fertilizers and bio fertilizers affected growth parameter like Vine length, Number of branches per plant and number of leaves per plant of bittergourd as shown in (Table 1). Significant difference in the Vine length, Number of branches per plant and Number of leaves per plant was recorded due to application of different combinations of organic, inorganic fertilizers and bio-fertilizers. The treatment T_{10} -50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha recorded the maximum Vine length (368.61 cm), followed by T_{9} (363.68cm) and the maximum number of leaves per plant T_{10} -50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (288.76), followed by T_{11}- 50 % RDF + FYM@20 tonnes/ha + Azotobacter (284.39) and the maximum number of branches per plant was T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (14.56), followed by T_{11}- 50 % RDF + FYM@20 tonnes/ha + Azotobacter (13.62) which differed significantly from each other as well from other treatments. Where in RDF: Recommended Dose of fertilizers, Bio-fertilizer: Azotobacter. The plot size was 2 m x 1 m and spacing followed was 50cm x 1 m. the land was brought to a fine tilth by through ploughing and tillage. The organic manures were applied one week before sowing, for proper decomposition, full dose of nitrogen, phosphorus and potassium Bio-fertilizers Azotobacter, as per treatment were applied just before the sowing. All cultural practices were followed regularly during crop growth and observations were recorded on growth characters i.e., Vine length, number of leaves per plant, number of branches per plant were recorded from time to time. It was noticed that number of branches per plant, number of leaves per plant increased with increasing Vine length successively with the increasing levels of organic inorganic fertilizer and bio-fertilizer. Combination of organic inorganic fertilizer and bio-fertilizer also recorded maximum Vine length, number of branches and number of leaves also which helped the plants in better photosynthesis to attain vigor. The findings of the present investigation are in conformity with the reports of as reported Arancon *et al.*, (2006) [2], Prabha *et al.*, (2007) [17], Prasad *et al.*, (2009) [18], Narkhede *et al.*, (2011) [16], Thriveni *et al.*, (2015) [21] in bittergourd.

Table 1: Influence of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality attributes of bitter gourd (*Momordica charantia* L.) var. green long

Treatments	Vine length (cm)			No. of branches per plant			No. of leaves per plant			Days to first female flower emergence	Days to first male flower emergence	Node no. to which first male flower appear	Node no. to which first female flower appear
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS				
T_0 control	102.29	204.94	288.14	1.25	4.23	7.29	54.64	82.67	144.44	53.17	45.52	8.60	16.13
T_1- 100% RDF (90:60:60)	116.05	218.70	310.54	2.31	5.48	10.49	62.18	109.04	210.98	48.12	41.24	9.64	18.53
T_2 75% RDF + FYM@20 tonnes/ha	110.24	236.70	326.57	2.30	5.36	11.59	65.92	110.90	222.69	45.92	39.52	9.28	20.07
T_3 75% RDF + VC@10 tonnes/ha	112.22	228.57	330.52	2.43	6.50	10.65	65.44	111.18	268.40	42.08	36.47	9.63	21.43
T_4 75% RDF + Azotobacter	117.97	231.47	341.54	3.19	6.41	10.03	75.01	103.64	251.46	51.15	35.75	10.56	18.40
T_5 50%RDF + VC@10 tonnes /ha	121.08	232.52	338.57	3.25	7.31	10.92	68.57	118.06	209.28	49.75	31.87	10.52	22.76
T_6 50%RDF + FYM@20 tonnes/ha	119.44	229.52	340.20	3.21	7.42	11.52	65.61	119.56	248.64	47.39	32.52	10.22	19.44
T_7 50%RDF + Azotobacter	115.66	231.58	342.61	2.72	5.66	10.70	62.52	118.64	253.01	44.75	45.16	10.69	20.62
T_8 25% RDF + FYM@20 tonnes + Azotobacter	117.75	238.50	355.62	2.89	5.76	9.75	72.48	120.68	250.65	46.30	43.19	10.51	18.50
T_9 25%RDF + VC@10 tonnes + Azotobacter	121.45	241.53	363.68	2.92	6.64	9.83	71.72	121.89	275.38	43.21	35.82	10.97	20.55
T_{10} 50% RDF + FYM@20 tonnes/ha + VC@10 tonnes/ha	124.65	243.77	368.61	4.34	8.56	14.56	80.86	128.58	288.76	33.17	30.41	13.46	24.87
T_{11} 50 % RDF + FYM @20 tonnes/ha + Azotobacter	123.69	240.42	361.80	3.72	7.81	13.62	78.50	126.79	284.39	36.28	31.87	11.77	22.50
F- test	S	S	S	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.599	0.737	0.495	0.242	0.260	0.342	1.380	1.295	3.232	1.81	0.76	0.447	1.265
C. D. at 0.5 %	1.243	1.528	1.026	0.502	0.539	0.709	2.862	2.686	6.702	3.76	1.58	0.927	2.624

Flowering parameters

The data revealed that the combination of different organic, inorganic and bio fertilizer affected various flowering parameters as shown in (Table 1.) The minimum days to first female flower emergence was observed in T_{10} -50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (33.17 days) Followed by T_{11} - 50 % RDF +FYM@20 tonnes/ha + Azotobacter (36.28 days) and the minimum days to first male flower emergence was observed in T_{10} - 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (30.41 days) Followed by T_{11} - 50 % RDF +FYM@20 tonnes/ha + Azotobacter (31.87 days) and Node number to which first male flower appearance was observed in T_{10} - 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (13.46 days) Followed by T_{11} - 50 % RDF +FYM@20 tonnes/ha + Azotobacter (11.77 days) and Node number to which first female flower appearance was observed in T_{10} - 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (24.87 days) Followed by T_{11}- 50 % RDF +FYM@20 tonnes/ha + Azotobacter (22.50 days) treatment T_{10} Might be due to luxuriant vegetative growth and better translocation of nutrients to the aerial parts. Maximum days to first male and female flower emergence and Node number to which first male and female flower appearance in T_0 (Control) might be due to non-availability of nutrients. Similar findings were reported by Sree nivas *et al.*, (2000) [20], Mulani *et al.*, (2007) [13], Priyanka *et al.*, (2009) [19], Kameswari *et al.*, (2010) [8], Baset *et al.*, (2011) [3], Mukesh *et al.*, (2012) [12] in bittergourd.

Yield parameters

The data revealed that the combination of different Organic and inorganic fertilizers and bio fertilizers affected Yield parameter like Days to first fruit picking, Number of fruits per plant, average fruit length, average fruit width, average fruit weight, fruit yield per plant, fruit yield t/ha of bittergourd as shown in (Table 2). Significant difference in the Days to first fruit picking, Number of fruits per plant, average fruit length, average fruit width, average fruit weight, fruit yield per plant, fruit yield t/ha was recorded due to application of different combinations of organic, inorganic fertilizers and bio-fertilizers. The treatment T_{10} (50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha) recorded the Minimum days to first fruit picking (45.88 days), followed by T_{11} (51.18 days) and the maximum number of fruits per plant T_{10} -50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (42.20), followed by T_4- 75% RDF + Azotobacter (38.14) and the maximum average fruit length was T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (25.47cm), followed by T_{11}- 50 % RDF +FYM@20 tonnes/ha

+ Azotobacter (22.67cm), the Average fruit width was observed in T_{10} (17.24cm), followed by T_{9}- 25%RDF +vermicompost@10 tonnes + Azotobacter (16.05 cm) respectively, the Average fruit weight was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (69.52gm), followed by T_{11}- 50 % RDF +FYM@20 tonnes/ha + Azotobacter (63.48gm), fruit yield per plant was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (2.934kg), followed by T_{4}- 75% RDF + Azotobacter (2302kg), and fruit yield (t ha-1) was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (52.81 t ha-1) followed by T_{9}- 25%RDF +vermicompost@10 tonnes +Azotobacter (42.69 t ha-1).which differed significantly from each other as well from other treatments. Where in RDF: Recommended Dose of fertilizers, Bio-fertilizer: Azotobacter. It was noticed that Days to first fruit picking, Number of fruits per plant, average fruit length, average fruit width, average fruit weight, fruit yield per plant, fruit yield t/ha increased with increasing plant gwoth successively with the increasing levels of organic inorganic fertilizer and bio-fertilizer. Combination of organic inorganic fertilizer and bio-fertilizer also recorded maximum Days to first fruit picking, Number of fruits per plant, average fruit length, average fruit width, average fruit weight, fruit yield per plant, fruit yield t/ha also which helped the plants in better photosynthesis to attain vigor. The findings of the present investigation are in conformity with the reports of as reported by Sreenivas *et al.,* (2000) [20], Bindiya *et al.,* (2006) [4], Mulani *et al.,* (2007) [13], Karuppaiah and Balasankari (2008) [9], Kameswari *et al.,* (2010) [8] in bitter gourd.

Table 2: Influence of organic, inorganic and bio-fertilizers on growth, flowering, yield and quality attributes of bitter gourd (*Momordica charantia* L.) var. green long

Treatments	Days to first fruit picking	Number of fruit per plant	Average fruit length	Average fruit width	Average fruit weight	Fruit yield per plant	Fruit yield t/ha	Total soluble solid	Ascorbic acid (mg $100g^{-1}$)	Shelf life (days)
T_0 control	67.99	22.76	11.54	6.45	43.25	0.983	17.70	3.16	75.62	5.57
T_1- 100% RDF (90:60:60)	53.55	30.51	16.07	9.07	52.45	1.601	28.81	4.16	78.52	7.52
T_2 75% RDF + FYM@20 tonnes/ha	53.73	33.37	18.51	10.07	53.75	1.792	32.26	4.31	81.52	7.19
T_3 75% RDF + VC@10 tonnes/ha	60.12	35.87	15.51	12.75	59.14	2.122	38.19	4.15	80.15	7.16
T_4 75% RDF + Azotobacter	57.55	38.14	15.77	14.54	60.41	2.302	41.44	4.67	77.45	7.96
T_5 50%RDF + VC@10 tonnes /ha	61.54	34.17	17.81	13.40	60.18	2.059	37.07	4.72	76.52	7.32
T_6 50%RDF + FYM@20 tonnes/ha	61.22	34.21	17.07	13.42	60.89	2.085	37.54	4.20	81.52	7.73
T_7 50%RDF + Azotobacter	58.96	36.51	18.27	13.23	62.98	2.300	41.40	4.33	81.52	7.66
T_8 25% RDF + FYM@20 tonnes + Azotobacter	60.33	30.51	18.37	13.92	60.75	1.854	33.38	4.19	80.45	7.20
T_9 25%RDF + VC@10 tonnes + Azotobacter	55.85	37.51	18.38	16.05	63.18	2.371	42.69	4.26	79.54	7.56
T_{10} 50% RDF + FYM@20 tonnes/ha + VC@10 tonnes/ha	45.88	42.20	25.47	17.24	69.52	2.934	52.81	4.81	84.52	8.74
T_{11} 50 % RDF + FYM @20 tonnes/ha + Azotobacter	51.18	32.44	22.67	14.92	63.48	2.056	37.00	4.26	81.45	8.10
F- test	S	S	S	S	S	S	S	S	S	S
C. D. at 0.5 %	5.59	3.26	2.15	1.60	4.460	0.250	5.00	0.73	2.45	0.660
S. Ed. (±)	2.69	1.57	1.03	0.77	2.15	0.121	2.41	0.35	1.38	0.318

Quality parameters

The data revealed that the combination of different organic, inorganic and bio fertilizer affected various Quality parameters as shown in (Table 2.) Quality parameter like Total soluble solid was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (4.81) followed by T_{5}- 50%RDF+vermicompost@10 tonnes /ha (4.72) respectively the maximum ascorbic acid was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (84.52 mg100g-1), followed by T_{6}- 50%RDF + FYM@20 tonnes/ha (81.52 mg100g-1) and maximum shelf life was observed in T_{10}- 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha (8.74 days), followed by T_{11}- 50 % RDF +FYM@20 tonnes/ha + Azotobacter (8.10 days). Treatment T_{10} Might be due to luxuriant vegetative growth and better translocation of nutrients to the aerial parts. Maximum value of Total soluble solid, ascorbic acid and shelf life in days of fruit T_0 (Control) might be due to non-availability of nutrients. Similar findings were reported by Karuthamani *et al.,* (1995) [10], Nair and Nair (2006) [15], Bindiya *et al.,* (2006) [4], Karuppaiah and Balasankari (2008) [9] in bitter gourd.

Conclusion

It is concluded from the investigation that the treatment T10 50% RDF + FYM@20 tonnes/ha + Vermicompost@10 tonnes/ha was found suitable for application in winter season bitter gourd cultivation for better flowering, growth, fruit yield and quality viz., vine length (cm), number of branches per plant, number of leaves per plant, days to first female flower emergence, days to first male flower emergence, node. No. to which 1st male flower appear, node. No. to which 1st male flower appear, node. No. to which 1st female flower appear, days to first fruit picking, number fruit per plant, length of fruit (cm), width of fruit (cm), average fruit weight (g), total yield per plant (kg), fruit yield (t ha^{-1}), total soluble

solids, ascorbic acid and Shelf life days. The highest yield benefit cost ratio (4.38) were obtained in treatment T_7 50%RDF + Azotobacter under Prayagraj agro climatic condition.

As the study was undertaken only for one season, it needs further confirmation by conducting more trials.

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