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Effect of Organic Manures on Growth, Yield and Quality of *Solanum macrocarpon* L.

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ABSTRACT

The following investigation carried on effect of organic manures on growth, yield and quality of *Solanum macrocarpon* L. locally known as "Thulo Bihi" in the hills of Sikkim; conceded significant effect of FYM, Vermicompost and carrier based biofertilizer AMC on influencing the growth attributing characters and yield attributing characters, among the plants in different organic treatment layouts as compared to the control treatment application. Amidst 10 treatments (T1 to T10), T8 containing combined application of FYM @ 40t/ha, Vermicompost @ 2t/ha and Arka- Microbial consortium @ 10kg/ha out performed and recorded maximum values in all the aspects viz., Plant height (73.08 cm), number of branches per plant (4.75 nos.), stem girth (11.83 mm), number of leaves per plants (21.33 nos.), number of flowers per plant (21.25 nos.), number of fruits per plant (6.33 nos.), fruit weight (63.16 g), average fruit yield (9.33 t/ha) and TSS content (4.05 °B). Whereas, the number of days taken for 50% flowering and number of days taken for first fruit harvest 71.33 nos. and 104.92 nos. respectively, were significantly reduced. All the values of parameters in T8 were at par with T7 (FYM 40t/ha, vermicompost 1t/ha and AMC 10 kg/ha). However, minimum values were observed in control (T1) FYM 15 t/ha and other treatment combinations whose level of FYM was @ 20t/ha along with different level of Vermicompost and with or without AMC @ 10 kg/ha. The result concluded that the amount of organic manures applied in T8 or T7 can be recommended for commercial cultivation of Thulo Bihi in the hills of Sikkim.

Keywords Thulo bihi, Arka microbial consortium, FYM, Vermicompost, Organic manures.

INTRODUCTION

Solanum is a widespread genus of the family Solanaceae, has over 2300 species world- wide Shaboury *et al.* (2020) and there are some important species under this genus, which are cultivated in Sikkim i.e., brinjal, tomato, potato, chilli. The crop *Solanum macrocarpon* L. otherwise known as the African brinjal is herbaceous crop that grows up to 113 cm with smooth and erect branching, blackish-violet stem that is woody at the base, and are robust in high altitudes. Leaves are big (Approx 535 cm^2 leaf area) and borne alternately, sometimes opposite. Compared to brinjal, the flowers are bigger in size, violet in color with dark violet midribs, borne in clusters (there are 4-5 flowers / clusters

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but bears single fruit / cluster), hermaphrodite, with star-shaped corolla with 5 calyx often returned back. Fruits are light-green when immature and are brown with cracked skin at maturity Limbu *et al.* (2018).

Sikkim is the first and only fully organic state in India and its significant policies for nature friendly farming has been praised at highest level in the world. The state is bestowed with varied climate ranging from sub-tropical to alpine and hosts rich diversity of agriculture crops. The cultivation of high yielding and hybrids at commercial scale is limited in the state despite tremendous efforts different governmental and non-governmental organisations, however, cultivation of traditional crops and the landraces is embedded in lifestyle of the local community. *Solanum macrocarpon* L. is one among those crops in the Sikkim state, cultivated since the time immemorial with high consumer preferences and fetches good price in local market than the commercial *S. melongena. S. macrocarpon* is locally known as "Thulo Bihi" or "Mithey Bihi" and is found growing in every homestead garden; however, there are no available record on introduction of this crop Limbu *et al*. (2018).

The major economic part of the crop is fruits but the leaves are also eaten as vegetable Singh *et al.* (2013). Due to presence of high medicinal properties in the plants, the leaves and flowers are used to treat throat, teeth and stomach troubles while boiled roots juice is drunk to get rid of hookworms. The plants are, sometimes, used as ornamental plants too Taiwo *et al.* (2017). It contains percentage moisture (57.68%), ash (22.57%), protein (2.56%), fiber (2.05%), calcium (280.5), iron (41.49), magnesium (280.5), Zinc (3.98) and manganese (3.44) (in ppm) Henry *et al.* (2022).

In organic farming system, usually farmers apply only Farm Yard Manure (FYM) without specific dose. Other available inputs include vermicompost. Application of biofertilizer or the consortium of microbes to enhance growth and productivity is most desirable. Effect of such inputs (singly or in combination) needs to be evaluated for recommending the packages for nutrient management. Thus, the effect of different organic manures on *S. macrocarpon* L. was determined by taking observations of morphological characters like plant height, number of branches per plant, number of leaves per plant stem girth and yield attributing characters like days taken to first flowering, number of flowers per plant, days taken to first fruit harvest, number of fruits per plant, average weight of fruit and TSS content.

MATERIALS AND METHODS

The research was implemented at the farmer's field at Samdur, 6th Mile Tadong, Gangtok, In Randomized Block Design with 10 treatments in 03 replicates with 6 plants per plots. The total of 30 raised beds measuring 2 m × 1m was prepared. Soil in the beds was mixed with required FYM as per the treatment (Table 1).

Planting materials

One month old seedlings with three to four true leaves were procured from the progressive farmer located at Bering, East Sikkim and transplanted in the main field. The seedling roots were immersed in Arka – Microbial consortium before transplanting in the main field. Seedlings were transplanted on the beds giving the spacing of 75cm x 60 cm followed by immediate irrigation.

Arka Microbial Consortium was sourced from Indian Institute of Horticulture Research (IIHR, Bangalore) and applied as given in the user manual. 20g inoculum of AMC was used to treat 100-200 g

Table 1. Treatment details during the e.

Treatments	Organic manure	Application of manure's/ plot
T1 (C)	Farmers practice (FYM 15T/ha)	3.5 kg/ plot
T2	FYM 40T/ha (standard requirement)	8kg/plot
T3	FYM 20T/ha + Vermicompost 2T/ha	4kg +400g
T4	FYM 40T/ha + Vermicompost 1T/ha	8kg + 200g
T5	FYM 40T/ha + Vermicompost 2T/ha	8kg + 400g
T6	FYM 20T/ha + Vermicompost 1T/ha	4kg + 200g
T7	FYM 40T/ha + Vermicompost 1T/ha + AMC 10kg/ha	8kg + 200g + 2g
T8	FYM 40T/ha + Vermicompost 2T/ha + AMC 10kg/ha	8kg + 400g + 2g
T9	FYM 20T/ha + Vermicompost 2T/ha AMC 10kg/ha	4kg + 400g + 2g
T10	FYM 20T/ha + Vermicompost 1T/ha + AMC 10kg/ha	4kg + 200g + 2g

of seeds. The AMC solution (20 g/ L of water) was applied as soil drench near the rhizosphere of the specified treatment on 10th Day of transplanting.

The well decomposed FYM was enriched with AMC for field application near the rhizosphere (1 kg of AMC was mixed with 100 kg of FYM). All the attributes were measured and fully mature light green fruits were harvested from the end of July to mid-August in the year 2018. Harvesting was done in the evening time. The fruits were then washed with fresh water and weighed in digital balance, similarly parameters like plant height was measured by using a meter rule from the stem base up to the shoot apex, number of branches, number of leaves and number of flowers and fruits were counted from individual plant, stem girth of plant was measured using Vernier caliper, whereas, days to 50% flowering and days to first fruit harvest was recorded by keeping calendar date tracks from the day of transplanting to first full flower bloom stage and first fruit harvest stage. TSS of fruits was measured by using digital refractometer.

RESULTS

Data of growth attributing characters like plant height, number of branch/plant, number of leaves/ plant, stem girth and yield attributing characters like number of flowers and fruits/ plant, weight of fruit and days taken to 50% flowering and days taken to first fruit harvest, total yield/ha and TSS content were recorded.

Significant difference for the growth parameters has been shown in Table 2 amongst various treatments. The maximum plant height was observed in T8 followed by T7 i.e. (73.08 cm) and (72.33 cm) respectively, which was found to be statistically at par with each other. On the other hand, minimum plant height of 59.10 cm was observed in T1.

There was a significant difference in the number of branches per plant as compared to the control plants. The maximum number of branches per plant was recorded in T8 (4.75) followed by T7 (4.58) and with at par number of branches were recorded in T5 (4.55), T4 (4.37) and T2 (3.92). However, among all the treatments, the minimum number of branches was recorded in control T1 i.e. (3.00). T8 and T7 had the maximum stem girth values of 11.83 mm and 11.63 mm respectively, followed by T5 and T4 with the values pertaining 11.63 mm and 11.07 mm stem girth respectively. The treatment T1 recorded the lowest plant stem girth 7.40 mm. The number of fully developed leaves of *Solanum macrocarpon* L. varied from 15 to 21, the maximum number of leaves of African brinjal (21.33) was seen in the treatment T8, while, the minimum number of leaves (15) were seen in control treatment T1.

Likewise, there was a significant difference in the yield attributing parameters (shown in Table 3) among different treatments. The plants in T8 came to flowering at 71.33 days which was at par with T7 (71.88 days), T5 (71.88 days), T4 (72.00 days) and T2 (70.50 days). The maximum days taken for flowering was observed in plants treated with minimum amount of FYM at 15t/ha (T1 73.87 days). The maximum number of fully opened flowers of

Table 2. Effect of organic manures on growth attributing characters of *Solanum macrocarpon* L.

Treatments	Plant height (cm)	No. of branches /plant	Stem girth (mm)	No. of leaves
T1	59.10±1.01^{f}	3.00±0.00^{c}	7.40±0.69^{c}	15.00±0.50^{e}
T2	68.33±0.58^{c}	3.92±0.80a^{bc}	10.92±0.65^{a}	19.17±0.38^{bc}
T3	64.10±0.26^{d}	3.33±0.58^{bc}	8.40±0.70^{bc}	18.25±0.50^{d}
T4	69.90±0.17^{b}	4.37±0.23^{ab}	11.07±0.35^{a}	19.75±0.00^{b}
T5	70.11±0.58^{b}	4.55±0.58^{ab}	11.63±0.87^{a}	19.67±0.38^{b}
T6	62.53±1.10^{e}	3.33±0.58^{c}	7.60±0.53^{c}	18.58±0.52^{cd}
T7	72.33±0.58^{a}	4.58±0.52^{ab}	11.63±0.87^{a}	20.58±0.63^{a}
T8	73.08±1.59^{a}	4.75±0.66^{a}	11.83±0.0.64a	21.33±0.72^{a}
T9	64.43±0.51^{d}	3.67±0.52^{bc}	8.87±0.23^{b}	19.42±0.29^{b}
T10	63.97±1.23^{de}	3.67±0.58^{bc}	8.40±0.70^{bc}	19.17±0.29^{bc}
LSD	2.30	0.92	1.00	0.76

Table 3. Effect of organic manures on yield attributing characters of *S. macrocarpon* L.

Treatments	Days to 50% flowering	No. of flowers/plant	Days to first harvest	No. of fruits /plant
T1	73.87±0.55^{a}	18.67±1.04^{e}	107.47±0.38^{a}	3.58±1.01^{g}
T2	73.25±0.75^{ab}	19.83±0.76^{cd}	104.83±0.76^{d}	5.50±0.25^{bcd}
T3	73.67±1.18^{ab}	19.17±1.04^{de}	106.25±1.00^{abc}	4.75±0.25^{ef}
T4	73.13±1.00^{ab}	20.00±1.00^{cd}	105.75±1.09^{bcd}	6.00±0.25^{abc}
T5	73.00±2.00^{abc}	20.17±1.26^{bc}	105.67±0.76^{cd}	5.92±0.25^{abc}
T6	73.17±0.63^{ab}	19.17±0.38^{de}	107.10±0.56^{a}	4.50±0.25^{f}
T7	71.88±0.13^{bc}	21.00±0.00^{ab}	105.67±0.28^{cd}	6.17±0.38^{ab}
T8	71.33±0.80^{c}	21.25±0.25^{a}	104.92±0.58^{d}	6.33±0.52^{a}
T9	73.33±1.53^{ab}	19.83±0.58^{cd}	107.03±0.26^{a}	5.42±0.29^{cde}
T10	73.67±1.03^{ab}	19.33±0.58^{cde}	107.00±0.00^{ab}	5.00±0.25^{def}
LSD	1.60	0.97	2.80	0.66

S. macrocarpon L. plant according to the collective data was observed in T8 (21.25 nos.) followed by T7 (21.00 nos.) which was statistically at par with T5 (20.17 nos.) and T4 (20.00 nos.), whereas, all the other treatments conceded approximately 19± flowers except T1 (control) which produced least number of flowers i.e. (18.67 nos.).

The maximum average number of fruits were recorded in plants treated with T8 (6.33 nos.), T7 (6.17 nos.) T4 (6.0 nos.), T5 (5.92 nos.) were statistically at par with T8, T2, T9 and T10 produced (5.50 nos.), (5.42 nos.) and (5.00 nos.) respectively while the plants in T1 produced the lowest number of fruits per plant (3.58 nos.). The plants in plot treated with T2 (104.83 DAP) and T8 (104.92 DAP) required minimum days taken to harvesting. Maximum days taken (up to 107± DAP) to produce fully mature fruits were recorded in T1, T6, T9 and T10.

Table 4. Effect of organic manures on number of fruit weight, fruit yield and TSS of *S. macrocarpon* L.

Treatments	Fruit weight (g)	Fruit yield (T/ha)	Fruit TSS (^{0}Brix)
T1	52.28±4.43^{d}	5.41±0.51^{g}	3.13±0.14^{c}
T2	62.90±3.46^{abc}	7.66±0.06^{cd}	3.39±0.08^{abc}
T3	61.77±1.80^{abc}	6.57±0.40^{ef}	3.13±0.19^{c}
T4	63.34±1.86^{abc}	8.30±0.61^{bc}	3.42±0.43^{abc}
T5	63.99±1.85^{ab}	8.30±0.36^{bc}	3.75±0.12^{abc}
T6	61.69±0.93^{bc}	6.16±0.55^{fg}	3.69±0.25^{abc}
T7	63.22±2.10^{abc}	8.60±0.70^{ab}	3.95±0.12^{ab}
T8	64.16±1.60^{a}	9.33±0.58^{a}	4.05±0.28^{a}
T9	62.32±1.68^{abc}	7.40±0.60^{cde}	3.33±0.15^{abc}
T10	61.43±2.13^{c}	6.83±0.35^{def}	3.23±0.12^{bc}
LSD	2.47	0.90	0.65

The average weight of mature fresh fruit varied between 52.28 g and 64.16 g. The lowest (52.28 g) was recorded in T1 control and highest (64.16 g) was in treatment T8. Similarly, the average fruit weight of African brinjal in plots treated with T7, T5 and T4 was ±63 g with no significant difference and were statistically at par. T10 produced fruits weighing up to 62.32g, whereas, the maximum yield of 9.33 t/ha and 8.60 t/ha were registered in T8 and T7 respectively, whereas minimum yield 5.41 was observed in control T1.

According to the data collected in Table 4, the results revealed that there was no significant difference in the T.S.S content of mature African brinjal fruits in all the treatments. However, T8 (4.05 °brix) accommodated slightly higher value of T.S.S, and the minimum T.S.S was observed in T1 and T3 both with the same value (3.13 °brix).

DISCUSSION

The effect of organic manure at different combinations on the growth parameters like plant height (71.92 cm), number of branches (5.25 nos.), stem girth (11.83 mm) and number of leaves (21.33 nos.) of *Solanum macrocarpon* L. was recorded maximum in T8 (FYM 40t/ha, vermicompost 2 t/ha and Arka microbial consortium 10 kg/ ha). However, FYM @40 t/ha and Arka microbial consortium 10kg/ ha along with two different doses of vermicompost i.e., 2 t/ha

and 1t/ha did not show any significant difference in plant height. This brings to the assumption that the dose of vermicompost and biofertilizers may not be as significant when the plants are planted with maximum amount of FYM. In case of number of branches per plant and stem girth, all the plants treated with FYM@ 40 t/ha attained the maximum value. The similar trend was observed for number of leaves as recorded in plant height due to different treatments. Considering the facts given in the Table 2, this shows that T7 is ideal for growth of the plant as the treatment consisting reduced level of vermicompost is significantly producing similar pattern of growth compared to treatments consisting of maximum amount of fertilizer inputs. The significant increase in the growth attributing characters of African brinjal is because FYM on an average contains 0.6% of nitrogen, whereas, vermicompost are rich in organic carbon content (47%) and humus substances which helps in building soil structure and stimulating plant growth particularly that of roots and contains 3% N on an average, Vermicompost being rich in bacteria, increases nitrogen fixation in the soil, AMC on the other hand contains efficient strains of N fixing bacteria, these bacteria at prevailing atmospheric temperature and pressure , fixes the atmospheric Nitrogen that are being diffused in the soil and makes them available to the plant in exchange of sugars. Nitrogen plays a big role in the plant's growth as it is a part of the chlorophyll and amino acids which makes proteins, thus the availability of efficient amount of N through the mentioned organic fertilizer stimulated plant root and growth development, encouraged above ground vegetative growth, governed the utilization of potassium, phosphorus and other constituents to the desirable degree.

All the crops treated with FYM @40 t/ha took the similar number of days taken for 50% flowering it may be due to the reason that, according to the research carried by Singh *et al.* (2013) it is an unavoidable fact that FYM increases photosynthetic efficiency, thus increased rate of photosynthesis leads to the production of carbohydrates. It has been established that the transition stage of plant is influenced by Carbohydrate: Nitrogen ratio (C: N ratio), which means if the C: N ratio is optimum, it favored the flower induction thus when plants were applied with FYM @ 40t/ha the rate of photosynthesis increased and lead to early flowering. The late flowering causing to maximum days taken for 50% flowering was seen in the crops treated with minimum level of lone FYM@15t/ha. From the discussion it is clear that may be T8 performed better due to application of FYM along with vermicompost and AMC because of effective action of FYM in increasing photosynthetic activity and AMC which contains efficient strains of Phosphorus solubilizing bacteria which possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids, the availability of Phosphorus is essential for cell division and significant for photosynthesis and production of carbohydrates which ultimately leads to the induction of flowers. Prodhan *et al.* (2014) stated that vermicompost helps in induction of flowers earlier because vermicompost undergoes mineralization and imparts adequate amount of NPK and small quantity of micronutrients and helps in rapid plant growth and flowering. Olle (2016) also stated that, vermicompost increase the growth of plants and reduces the days taken to flowering in tomato. As expected, by seeing the early flowering in T8, the plants grown with the organic manures detailed in T8 gave the early harvesting i.e., 104.83 days DAT. Following the flowering pattern recorded in days taken to 50% flowering, all the crops treated with FYM @40t/ha took the minimum days for first harvesting. Number of harvesting days was reduced in T2 and T8 i.e., 104.83 days and 104.92 days respectively. This signifies that application of full dose FYM can alone have significant effect in earliness in harvest than vermicompost and Arka microbial consortium, because although T2 consisted of FYM 40t/ha and T8 was manure combination of FYM, vermicompost and consortium the plant performance was observed to be almost same in both the treatments. Maximum number of days for harvesting was observed in T1 (107.47), T6 (107.10), T9 (107.03), T10 (107.00) which was at par with T7 (105.67), T3 (106.25), T4 (100.75), T5 (105.67). The reason behind the earliness to harvest observed in T8 is due to optimum C: N ratio, and also due to the reason that, the soils containing high organic matter are rich in organic forms of phosphorus which induced early flowering leading to early harvest of the fruits.

The increased numbers of flowers/plant in T8 and

T7 might be due to the reason of cumulative effect of FYM which has highest C: N (Carbon to Nitrogen ratio) 20: 1 in light bedding and 40: 1 in heavy bedding which creates faster availability of Nitrogen for the plants, vermicompost and AMC. Vermicompost plays the role of "nutritive organic fertilizer" rich in NPK and micro- nutrients, beneficial mycorrhizal fungi and beneficial soil microbes like nitrogen fixing bacteria; which promote the vigour and flowering of vegetable crops. AMC on the other contains strains of nitrogen fixing bacteria's, potassium mobilizing bacteria and plant growth regulating bacteria whose overall performance increases the flower numbers in crops by synthesizing more carbohydrates and proteins.

The average weight of fruits and fruit yield was recorded highest in T8 64.16 g/fruit and 9.33 t/ha whereas it was lowest in T1 52.28 g/ fruit and 5.41t/ ha, this may happen due to availability of more N through the application of full dose of FYM, vermicompost and biofertilizer. These lines are in partial agreement with the reports of Sridhar *et al.* (2014) that substitution of 100% N through FYM gives higher yield. Thus, to increase the yield attributing characters and yield of *Solanum macrocarpon* L. FYM 40t/ ha, Vermicompost 2t/ha and Arka microbial consortium 10kg/ ha is recommended. The optimum C: N ratio in FYM i.e., up to 20:1 to 40:1 leads to the rapid break down of carbon material by microorganisms and release of nitrogen in the soil, Nitrogen further encourages above ground vegetative growth and leads to the utilization of carbohydrates within plants during the process of photosynthesis for production of food. Nitrogen also directs the utilization of phosphorus and potassium. Whereas phosphorus is important for flower and fruit initiation and potassium activates the enzyme responsible for metabolism of energy, synthesis of starch and reduction of nitrate. Potassium is also essential for photosynthesis and translocation of sugars. Thus, the NPK content in FYM @ 40t/ha and vermicompost @ 2t/ha is relatively high than the FYM and vermicompost at low level and AMC as a carrier based biofertilizer makes the inert nutrients in organic fertilizer available to the plants as AMC contains efficient strains of N fixing, Zn and P solubilizing, potassium mobilizing and plant growth regulating bacteria leading to the higher yield of vegetable crops.

CONCLUSION

According to the close perusal of results and discussion, it is clear that among all the treatments, optimum overall performance (growth attributing and yield attributing characters) was observed in T8 and T7. It can be observed that almost all the treatment combination which includes FYM @ 40 t/ha (T2, T4, T5,) performed well and was at par with T8 and T7 as compared to the rest of the treatment combination which consisted FYM @ 15 t/ha and 20t/ha (T1) and (T3, T6, T9, T10) respectively, thus it can be deduced that FYM plays an important role in increasing the growth and yield performance of *Solanum macrocarpon* L., along with the desired level of vermicompost. The significant effect of AMC was seen in the combined treatments which consisted full dose of FYM i.e., @ 40t/ ha and so as accord to the above results and experimental findings, the manure combination of 40t/ha FYM, 1-2 t/ha Vermicompost along with the incorporation of 10kg/ha Arka- microbial consortium may be recommended to the farmers for bio nutrient management in *S. macrocarpon* L. (Thulo Bihi) in the hills of our blessed and beautiful Sikkim. The production potential of *Solanum macrocarpon* L. with this recommended dose of organic input with good B:C ratio also assert for recommending the crop for commercial cultivation in the hills of Sikkim as one of the cash and nutritive crops.

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