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Effects of *in-situ* and *ex-situ* vermicomposting on morphology, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali under high density planting

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Abstract
The present experiment was conducted at horticulture garden, Bihar Agricultural university, Sabour Bhagalpur, Bihar during 2014-15 and 2015-16 to find out the Effects of *in-situ* and *ex-situ* vermicomposting on morphology, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali under high density planting. The experiment was laid out in Randomized Block design with three treatment replicated thrice with two tree per replication. The treatment consisted as three different doses of vermicompost *i.e. In-situ* vermicomposting and Vermicompost @ 4.0 kg/tree and Control. The two years pooled data indicated that the highest morphological characters like per cent increase in tree height (25.42%), canopy spreads (N-S 13.82%, E-W 12.54%), canopy volume (13.04%) and physical parameters of fruits like fruit width (6.50cm), weight (169.29g) and volume (167.45cm^3), as well as pulp weight (108.17 g/fruit), stone weight (27.21 g/fruit), peel weight (28.28 g/fruit) and bio-chemical compounds of fruits like TSS (21.99 ^{0}B), total sugars (17.22%), total carotenoids content (17.65 mg/100g pulp) and ascorbic acid content (35.70 mg/100g pulp) were observed with *in-situ* vermicomposting (V_2). Whereas, fruiting behaviour *i.e.* highest fruit set (13.96%) and bio-chemical compound *i.e.* TSS/acidity ratio (132.31), minimum titrable acidity (0.172 %) and yield (9.89 kg/tree) were recorded with the application of vermicompost @ 4.0 kg/tree (V_1).

Keywords: *In-situ* Vermicomposting, Morphology, Yield, Quality, Mango and High density planting

Introduction
Mango (*Mangifera indica* L.) is a member of Anacardiaceae family. Mango is acclaimed as king of fruits, grown over an area of 2263.0 thousand hectares with the total production of 1968.7 thousand MT in India (NHB, 2017) [7]. Mango is a good source of vitamin A and C apart from the usual contents of minerals other vitamins. Beside, table purpose mango can be used for the preparation of pickles, preserves, jam, amchur and mango leather etc, (Singh, 1992) [15].

Vermicomposting is an efficient process to stabilize the organic waste into nutrients rich material with the joint action of earthworms and microorganisms (Suthar, 2009) [16]. *In-situ* composting is the production of compost from the residues generated from the field which effectively utilize farm waste in the field itself and thereby cut down waste management cast drastically and improve soil health at the planting site.

Vermicompost is rich in microbial populations and plant nutrients that act as suitable plant growth media for sustainable agriculture. The quality of vermicompost depends on various factors like types of organic residues, aeration, temperature, humidity, pH, and earthworm species that use during vermicomposting. Vermicompost has higher base exchange capacity and rich in total organic matter, phosphorus, potassium and other nutrients as compared with ordinary compost. Vermicompost enhance the degree of polymerisation of humic substance along with minimization of ammonium N and increase the nitric N (Bansal and Kapoor 2000) [3].

Material and methods
The present investigation on "Effects of *in-situ* and *ex-situ* vermicomposting on morphology, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali under high density plnting" was carried out at horticulture garden, Bihar Agricultural University, Sabour Bhagalpur, Bihar during 2014-15 and 2015-16, was laid out in Randomized block design comprising of three treatments which were replicated in thrice with two tree per replication. The spacing fallowed for the investigation was 3.0m×2.5m in rectangular planting system. There were three treatments *i.e.* in *in-situ* vermicomposting, *ex-situ* vermicomposting (application of vermicompost @ 4.0 kg/tree) and without vermicomposting. Rearing of

earthworm (*Eisenia foetida*) and application of vermicompost was done at month of September during both of the year. All the cultural practices like weeding, hoeing, irrigation, pest and disease management were provide uniformly in each treatment.

The increased in morphological characters like tree height, canopy spread and canopy volume were measured with the help of measuring tape at initial and harvesting stage during both of the years. At the time of harvesting, ten fully developed fruits were selected randomly from each replication for observation of physical parameters of fruits like fruit width, fruit weight and fruit volume. Widths of fruits were measured transversely with the help of vernier callipers, mean value per fruit calculated and expressed in cm. The weight of selected fruits were also recorded with the help of physical balance and expressed as g fruit^{-1}. The fruit volume was determined through water displacement method and average volume of fruit was expressed as cm^3.

Total soluble solids (T.S.S.) of fruits were determined by digital hand refractometer. The values were corrected at 20 ^{0}C and expressed ^{0}B T.S.S. in fruit pulp. The ascorbic acid content was examined by diluting the known volume of juice with 3.0 per cent of metaphosphoric acid and titrate with 2, 6 dichlorophenol indophenol dye solution. The values were noted as mg per 100 g of fruit juice (A.O.A.C., 1990) [1]. The total carotenoids were determined by a mixture of petroleum ether and acetone (3:1) and inquired calorimetrically using spectrophotometer (Roy, 1973) [13]. Total sugars were analysed as suggested by Lane and Eynone (1923).

Results and Discussion

Morphological characters

The data presented in table-1 exhibited that morphological characters like per cent increase in tree height, canopy spreads and canopy volume were significantly influenced with *in-situ* and *ex-situ* vermicomposting. The data indicated that highest per cent increased in tree height (25.42%), canopy spreads N-S (13.82%), canopy spread E-W (12.54%) as well as canopy volume (13.04%) was noted with the application of V_2 (*in-situ* vermicomposting). However, the lowest tree height (20.59%), canopy spread N-S (10.88%), canopy spread E-W (9.83%) and canopy volume (9.91%) were recorded under V_0 (vermicompost @ 0 kg/tree). The increase in the morphological parameters with *in-situ* vermicomposting, might be *in-situ* vermicompost enhanced plant growth with improving soil aeration, root growth, enriched soil by micro-organisms and added plant hormone such as auxins and gibberellic acid in high amount. The results of present investigation are in the accordance with the work of Suthar, 2009 [16]; Parthasarathi, 2010 [8] and Parthasarathi *et al.*, 2016 [9].

The data in respect of fruit set percent varied significantly due to vermicomposting. The plant getting vermicompost @ 4.0 kg/tree (V_1) resulted highest fruit set (13.96 %) which was statistically at par with *in-situ* vermicomposting (13.77%) (V_2). The increase of fruit set might be due to presence plant hormone and chemical release during biological activities promoted by the vermicompost in soil and retention of nutrients for longer period of time that accelerate the process of synthesis and accumulation of food material that reduce flower and fruit drop caused by hormonal imbalance, hence maximizing fruit setting. The results of present findings are in the accordance with the work of Yadav *et al.;* (2011) [18] in mango variety Amrapali, Kumar and Kumar (2013) [6] in Dashehari mango, Prakash *et al.;* (2010) [10] in mango cv. Langra.

Table 1: Effects of *in-situ* and *ex-situ* vermicomposting on morphology and fruiting characters of mango cv. Amrapali under HDP (Pooled data of two years).

Treatment	Tree Height increased (%)	Canopy Spread N-S (%)	Canopy Spread E-W (%)	Canopy Volume (%)	Fruit set (%)
V_0- vermicomposting@ 0 kg/tree	20.59	10.88	9.83	9.91	13.18
V_1- vermicompost @4.0 kg/tree	21.78	12.09	10.89	10.63	13.96
V_2- *in-situ* vermicomposting	25.42	13.82	12.54	13.04	13.77
CD (P=0.05)	0.72	0.34	0.44	0.48	0.35

Yield and Yield Attributes

The data accumulated on account of yield and yield attributes were significantly influenced by the application of *in-situ* and *ex-situ* vermicomposting (Table-2). The tree grown under *in-situ* vermicomposting (V_2) attained maximum fruit width (6.50 cm) which was noted as at par with application of vermicompost @ 4.0 kg/tree (V_1). The perusal of data in respect of maximum fruit weight (169.26 g), fruit volume (167.45cm^3), and pulp weight (108.17 g) were noted as statistically at par with application of vermicompost @ 0 kg/tree (V_0) that gave the value of fruit weight 167.53 g, 165.30 cm^3 and 108.15 g respectively. The minimum stone weight (26.25 g/fruit) was recorded with the application of vermicompost @ 4.0 kg/tree which was noted as statistically equal with *in-situ* vermicomposting (V_2) and without vermicomposting (V_0) that gave the value of stone weight 26.59 g/fruit and 27.21 g / fruit, respectively. The minimum peel weight (26.24 g) also recorded with vermicomposting @ 4.0 kg/tree which was statistically at par with vermicomposting @ 0 kg/tree (V_0).

Table 2: Effects of *in-situ* and *ex-situ* vermicomposting on yield and yield attributes of mango cv. Amrapali under HDP (Pooled data of two years).

Treatment	Fruit width (cm)	Fruit weight (g)	Fruit volume (cm^3)	Pulp weight (g/fruit)	Stone weight (g/fruit)	Peel weight (g/fruit)	Yield (kg/tree)
V_0-vermicomposting@ 0 kg/tree	6.11	167.53	165.30	108.15	26.59	26.53	9.17
V_1- vermicompost @4.0 kg/tree	6.44	163.26	160.14	104.11	26.25	26.24	9.89
V_2- *in-situ* vermicomposting	6.50	169.29	167.45	108.17	27.21	28.28	9.65
CD (P=0.05)	0.20	4.29	4.85	3.63	1.07	1.38	0.35

The analysed data indicated that the *in-situ* and *ex-situ* vermicomposting showed significant effects on yield (kg/tree) (Table-2). The application of vermicompost @ 4.0 kg/tree (V_1) produced significantly maximum fruit yield (9.89

kg/tree) which was at pat with *in-situ* vermicomposting that gave fruit yield of 9.65 kg/tree. The integration of organic sources of nutrients occurred due to accelerated mobility of photosynthates from source to sink. The similar results also observed by Ghosh and Bauri (2004) [4] in mango cv. Himsagar, Sharma *et al.* (2016) [14] in guava cv. L-49 and Thakur and Thakur (2014) in plum cv. Santarosa.

Quality Attributes

All the quality attributes were found significant with *in-situ* and *ex-situ* vermicomposting. The data has presented in table-3, the maximum value of TSS (21.99 B^0) was noted with *in-situ* vermicomposting (V_2) which was statistically at par with vermicomposting @ 4.0 kg/tree. The data indicated that maximum total sugars (17.22 %), ascorbic acid content (35.70 mg/100g pulp), total carotenoids (17.65 mg/100g pulp) and minimum titratable acidity (0.184 %) were noted with *in-situ* vermicomposting (V_2). However, the values of total sugars, ascorbic acid, and total carotenoids were noted as statistically at par with vermicomposting @ 4.0 kg/tree (V_1). Whereas; the highest TSS/acidity ratio (132.31) was recorded with the application of vermicompost @ 4.0 kg/tree (V_1). In-situ vermicomposting process always favoured formation of humic acids rich in polysaccharides, which might have resulted in the translocation of assimilates. These rustles are in accordance with findings of Athani *et al.* (2007) [2] in guava cv. Sardar, Reddy *et al.* (2012) [12] in papaya cv. Surya, Humin Xiang *et al.* (2017) in papaya and Ram and Nagar (2004) [11] in guava cv. Allahabad Safeda.

Table 3: Effect of *in-situ* and *ex-situ* vermicomposting on quality attributes of mango cv. Amrapali under HDP (two year pooled data)

Treatment	TSS (B^0)	Titratable acidity (%)	Total sugars (%)	Ascorbic acid content (mg/100 g pulp)	Total carotenoids (mg/100g pulp)	TSS/Acidity Ratio
V_0-vermicomposting@ 0 kg/tree	21.59	0.249	16.87	34.21	17.33	89.30
V_1- vermicompost @4.0 kg/tree	21.98	0.172	17.20	35.43	17.64	132.31
V_2- *in-situ* vermicomposting	21.99	0.184	17.22	35.70	17.65	123.26
CD (P=0.05)	0.30	0.002	0.17	0.49	0.17	1.63

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