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Original Article

Comparative Performances of Organic Amendments on Germination, Growth and Yield Indices of Three Selected Okra [*Abelmoschus esculentus* (L.) Moench] Cultivars

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ABSTRACT

In recent years, organic amendments are getting prime importance as a source of plant nutrition under intensive cropping system due to its economic, environment friendly and agronomically sound nature. This study has been conducted to investigate the ameliorative role of three organic manures (cowdung, compost and vermicompost; 10, 5 and 5 tha^{-1}, respectively) with three okra varieties viz., BARI Dherosh-1, BARI Dherosh-2, and Pusha at the shed house condition between April to August, 2018 in Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The entire experiment was repeated three times following randomized complete block design. Result showed that organic manures improved plant growth and yield attributes in a significant manner. However, vermicompost followed by compost resulted in overall better plant performances among which SPAD value, green pod number $plant^{-1}$, green pod weight $plant^{-1}$, seed pod^{-1}, and total seed yield are important. The application of vermicompost dramatically improved seed germination parameters and seedling indices. In combination, BARI Dherosh-2 with 5 tha^{-1} vermicompost application resulted with the best plant performances. Considering the experimental outcomes, we may conclude that vermicompost promotes growth and yield attributes of okra.

Introduction

At the advent of the green revolution, use of chemical fertilizers and pesticides in agricultural production increased tremendously. Commercial use of chemical fertilizer that ignores agricultural productivity and soil fertility is rapidly lowering crop production and soil health (Muqtadir *et al*., 2019). Due to ever-increasing world population and high demand for food, farmers have to utilize inorganic fertilizers to increase crop yield. However, from the view of agricultural sustainability, use of organic amendments is eco-friendly, economically and agronomically good practice to uphold the better soil health and sound environment (Ogbemudia *et al*., 2020). In last couple of decades, use of organic fertilizers has been increased exponentially under intensive cropping system. Also, the concept of organic farming comprises cultivation of crops with biological materials and utmost reduction of artificial substances to maintain soil fertility and ecological balance thereby reducing pollution and wastage (Samiraja *et al*., 2021). Cowdung, compost and vermicompost are few forms of organic manures that helps in strengthening the soil fertility and thus are commonly used as organic amendments in different crop production. These organic manures are of differential structure and bulky in nature which can supply nutrients for crop development over a long duration. By binding soil aggregates with other soil molecular agents, organic manure improves soil texture and structure at the same time (Sarma and Gogoi, 2015). Plants require several nutrient elements for healthy nutrition, which can be provided by naturally occuring organic fertilizers.

Furthermore, organic nutrient sources aid in boosting the quality of green pods in vegetable crops. Therefore, farmers use cowdung, compost and vermicompost as an alternate, cheap but beneficial source of plant fertilization in different crop cultivation. Among the organic manures, vermicompost is a stable granular organic matter that loosen the soil and improves the soil aeration quality (Smriti and Ram 2018). It also indirectly provides growth-promoting substances to soil microbes, such as hormones, enzymes, vitamins, and other macronutrients, which in turn facilitates plant growth by supplying essential nutrient elements and thus increase plant output (Samiraja *et al*., 2021). Cowdung and compost are two important types of organic soil additives that aid in plant nutritional status and organic matter breakdown. Cowdung is basically made up of digested grass and grain and is high in organic materials and rich in nutrients. It contains about 3% nitrogen, 2% phosphorus, and 1% potassium (Sun *et al*., 2016). Organic associates boost soil health in a variety of ways, including increasing water and air filtration rates, cation exchange capacity (CEC), bulk density reduction, and micronutrient absorption by plants (Villa *et al*., 2021). Furthermore, organic matter increases soil phosphate availability, which benefits fertilizer efficiency, seed germination, seedling growth, soil pH, and soil microbial population, as well as reducing nitrogen losses due to sluggish nutrient release (Bano *et al*., 2020, Tadesse *et al*., 2013). The addition of cowdung to degraded soil improves the organic carbon content, which may lead to increased activity of beneficial soil microbes as well as improved soil fertility by improving the availability of nutrients for plants. (Zaman *et al*., 2017).

In tropical countries, okra (*Abelmoschus esculentus* L.) is a widespread vegetable crop. It has a high protein, carbohydrate, vitamin, and mineral content. It can be fried or cooked with the right ingredients. In the paper business, matured fruits and stems containing crude fibers are used for producing quality paper materials (Bano *et al*., 2020). Growth and development of okra largely dependent on two processes: seed germination and seedling development. Better seedling establishment is dependent on good seed germination, which results in larger yields (Sarma and Gogoi 2015). A small study on seed germination and plant development with organic amendments was done. In light of this, the current study examines the impact of several organic amendments on germination indices and yield attributes of okra as a potential source of plant nutrients and soil regeneration.

Materials and Methodology

Experimental site and plant materials

Between April to August, 2018, three cultivars V_1, V_2, and V_3; BARI Dherosh-1, BARI Dherosh-2, and Pusha, respectively, were tested in the shed house of the Agronomy field at Sher-e-Bangla Agricultural University, Dhaka-1207. Mature and pure seeds (V_1 and V_2) were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur-1701 and V_3 was collected from local market (Siddik bazar seed market).

Experimental design and treatment combination

A Randomized Complete Block Design (RCBD) with three replications was used to test two factor treatments (factor A; variety, and factor B; organic manure). Organic amendments; cowdung (Cd), Compost (Co) and Vermicompost (Vc) was used at a rate of 10, 5 and 5 tha^{-1}, respectively. For this we have calculated amount of soil ha^{-1} area and thus for 36 pots considering 20 Kg soil pot^{-1}. All the calculated amount of fertilizers and manures at mentioned doses were mixed during the final step of soil preparation.

Crop growth condition and crop husbandry

Pots were prepared well with mentioned doses of Cd, Co and Vc before seed sowing. Later on, six seeds were placed in each pot and after proper germination only four vigorous and healthy seedlings were allowed to grow. Different intercultural operations (weeding, mulching, irrigation) were performed on a timely basis as required.

Crop harvesting and data observation

Plant height was determined at two intervals, viz., 30 days after seedlings (DAS) and 60 DAS where Soil Plant Analysis Development (SPAD) value was taken at 60 DAS only. Green pod parameters were observed from two selected plants and rest two were kept for observing seed related data. Green pods were harvested 5 times at an interval of 4 days when they were tender, fresh and formed marketable size. To observe pod length, diameter and weight; 5 random pods from two plants were selected and data were averaged to derive the mentioned parameters. Other data viz. Green pod plant^{-1}, Green pod weight plant^{-1}, Green pod yield were recorded by following proper sampling method. To observe seed pod^{-1}, randomly selected 5 pods from two plants were properly dried and data were averaged to derive the seed pod^{-1}. Seed yield was determined by the final weight of seeds from two selected plants. Later on, randomly sorted 100 seeds were balanced and considered as the 100-seed weight value.

SPAD value

From each pot five leaves were randomly selected. The top, middle and base of each leaf were measured with the help of SPAD (Minolta Camera Co., Osaka, Japan) chlorophyll (chl) meter. Value were observed from five sample leaf and averaged. The conversion of SPAD units to total chl content yielded the total chl content (Yuan *et al*., 2016).

Determination of germination and seedlings parameters

For germination and seedlings trait, 20 seeds from individual treatments were placed for germination in petri dish. After germination, seedlings parameters viz. seedlings root, shoot length and seedlings root, shoot dry and fresh weight were counted from 5 randomly selected seedlings and averaged accordingly. Other parameters were observed by following the equations bellow-

Germination percentage (GP%)

Three days after 20 seed placements for germination, germination was observed daily up to the next 7 days. Seeds germination completed when the emerged radical gets a length of minimum 2 mm. GP% were calculated from the following formula-

$$GP\% = n/N \times 100\% \quad (1)$$

Here, n is the final number of seed germinated and N is the number of seed placed for germination

Germination rate (GR)

Germination rate (GR) were calculated by the following formula-

$$GR = n/(Dn) \quad (2)$$

Here, the number of germinated seeds is ‘n’, and the number of spent days from the start is ‘D’.

Germination rate index (GRI)

The following formula was used to calculate the Germination rate index (GRI)-

GRI=GR/GP (3)

Mean daily germination (MDG)

Mean daily germination was evaluated from the below formula-

MDG=GP%/Total no. days germination observed (4)

Mean emergence time (MET)

The following formula was used to determine MET-

MET= $\sum$Dn/$\sum$N (5)

Here, 'n' denotes the total number of seeds that germinated and 'N' denotes the total number of seeds that were sown, and 'D' denotes the number of days between planting and emergence.

Vigour (V)

Vigour was calculated from the below formula-

V=GP%× Seedlings DW (6)

Seedling vigour index (SVI)

Seedling vigour index was calculated from the below formula-

VI = (SL+ RL) ×GP/100 (7)

Here, SL=Average shoot length (cm), RL=Average root length (cm), GP=Germination percentage

Germination energy (GE%)

This data will be collected on the 4^{th} day after seed planting. It is given as a percentage of the total number of seedlings that emerged on the 4^{th} day.

Relative water content (RWC)

Five seedlings from each treatment were randomly collected, cleaned and weighed as fresh weight (FW). The weighed samples were immediately dipped into freshly prepared distilled water in Petri dish. After 24 hours, excess water from surfaces were removed and turgid weight (TW) were measured. After drying the samples in oven for 72 hours, dry weight (DW) was measured. The calculation was done by using the following formula-

RWC (%) = $(FW - DW)/(TW - DW)$ × 100 (8)

Statistical analysis

Analysis of variance (ANOVA) was done with statistix 10 (statistical software). Mean separation was done at 5% levels of significance ($p \leq 0.05$).

Results and discussions

Plant height (30 and 60 DAS)

In all cultivars, organic amendments notably improved the plant height at both intervals (30, 60 DAS). However, the highest increase of plant height was observed due to application of Vc. At 30 DAS, Vc increased plant height by 43, 45 and 33% in V_1, V_2 and V_3, respectively, compared to the respective controls (Table 1). The application of Co, on the other hand, resulted in the smallest increase in plant height. When compared to other cultivars, V_2 had the largest plant height (Table 1). This could have occurred as a result of manure's contribution to the soil's fertility state, as the soils had a low organic carbon content. Organic manures are readily available and rapidly absorbed by plant roots, resulting in an increase in plant morphological growth. Organic manures, particularly vermicompost, were found to improve plant height when compared to other kinds of manure in previous experiments (Muqtadir *et al.*, 2019, Adhikari and Piya 2012).

SPAD value

The use of various organic materials resulted in a considerable rise in SPAD value. Among, Cd, Co and Vc; vermicompost resulted with highest SPAD value in all three cultivars. In V_2 the highest (48%) SPAD value was observed due to Vc application whereas the lowest (2%) was found in V_1 due to Cd application. Although the Vc application resulted with highest SPAD value, use of Cd and Co showed statistically similar result (Table 1). Organic manure aids in raising plant height as well as the amount of leaves on the plant, resulting in more photosynthesis. This conclusion supports the earlier findings of Usha *et al*. (2021), who proposed that organic matter includes important nutrients associated with increased photosynthetic activities, which stimulate root and vegetable growth.

Pod length, weight, and diameter

Pod length was significantly improved due to application of organic matters. Among which Vc performed well. In addition, among varieties V_2 resulted with highest pod length due to application of organic amendments. However, the highest pod length (74%) was found at V_1Vc combination whereas the lowest (6%) was observed at V_2Co combination, compared to their respective controls (Table 1). Due to Vc application, pod weight was increased by 55, 88 and 43% in V_1, V_2 and V_3, respectively. However, the lowest pod weight (14%) was found in V_1 variety with Cd application compared to the control. In terms of pod length, Vc showed the highest result and both V_1 and V_2 resulted with highest pod weight (Table 1). Although in V_1 and V_2 organic amendments improved pod diameters significantly, but in V_3 organic manure reduced pod diameter compared to the respective controls. The highest pod diameter (42%) was observed in V_1Vc treatment and the lowest (-20%) was observed in V_3Cd treatment, compared to the respective control (Table 1). However, interestingly, there were no significant differences among the means of varieties. This result supports the earlier findings of Adhikari and Piya *et al*. (2020) that greater crop response due to organic manure application can be linked to improved physical and biological properties of the soil, which result in a better delivery of nutrients to the plants. When different tree litters were utilized, Khatun *et al*. (2010) saw a significant increase in fruit height, diameter, number of fruits per plant, and individual fruit weight.

Table 1. Effect of organic amendments on plant height, SPAD value and pod properties (length, weight, diameter) of different okra varieties.

Treatments		Plant height (cm)		SPAD value	Pod		
		30 DAS	60 DAS		Length (cm)	Weight (g)	Diam (cm)
V_1	C	23.51e	52.18g	23.78f	6.77f	9.49f	3.18d
	Cd	31.49c	60.50de	24.26e	7.71ef	10.82c-f	3.42cd
	Co	28.29d	62.51cde	29.52cde	10.49bc	12.41bcd	4.04abc

Treatments		Plant height (cm)		SPAD value	Pod		
		30 DAS	60 DAS		Length (cm)	Weight (g)	Diam (cm)
	Vc	33.59bc	67.81ab	33.12bc	11.78ab	14.75ab	4.52ab
V_2	C	26.59d	55.93fg	27.89cde	8.70de	8.99f	3.52cd
	Cd	32.00c	64.97bcd	31.42bcd	9.99cd	10.75c-f	3.55cd
	Co	32.23c	60.17ef	35.63ab	9.26cde	12.89bc	3.91bcd
	Vc	38.49a	71.48a	41.23a	12.49a	16.93a	4.70a
V_3	C	26.93d	52.12g	26.82de	7.66ef	8.52f	4.07abc
	Cd	33.26c	62.25cde	31.45bcd	9.86cd	9.78ef	3.26d
	Co	32.29c	59.92ef	27.97cde	10.19bcd	10.16def	3.84bcd
	Vc	35.70b	65.81bc	36.00ab	11.75ab	12.18b-e	3.88bcd

Here C, Cd, Co and Vc indicate control, cowdung, compost and vermicompost, respectively. Mean (±SD) was calculated from three replicates for each treatment. Values with different letters are significantly different at P ≤ 0.05 applying the Fisher's LSD test

Effect of organic manures on yield contributing traits of okra

Organic matter significantly increased the green pod number in all three varieties. However, Vermicompost followed by compost showed the comparatively better performances among three organic manures. Although in V_1, Co and Vc resulted with statistically similar value, in V_2 it was Vc which performed the best (95%) compared to the control. In V_3 application of cowdung resulted with no increase in pod number (Fig. 1A). The use of organic manures resulted in a considerable increase in green pod weight plant^{-1}. In okra, Vc and Co reported with higher green pod weight in all three varieties. However, the highest green pod weight (89%) was observed in V_2Vc treatment combination while V_3Cd showed the lowest (-11%) result compared to the respective controls (Fig. 1B). Among varieties, V_1 followed by V_2 performed well due to application of organic manures. It also supports the findings of Olaniyi *et al*. (2010), who discovered that NPK and organo-minerals significantly increased the quantity and weight of plant^{-1} fruits.

Green pod yield significantly influenced by the organic matter. Compared to the respective control, in V_1 and V_3 13% and 3% yield was reduced, respectively due to the application of compost and cowdung, accordingly. However, the highest yield was observed in V_2Vc treatment combination (36%) followed by V_2Cd and V_2Co (Fig. 1C). Organic matter has significant role in increasing seed number pod^{-1} (Fig. 1D). The highest seed pod^{-1} was observed in V_2Vc combination (62%) followed by V_3Vc (49%). The V2Co combination had the fewest number of seed pod^{-1} (4%). The use of organic amendments had a significant impact on seed yield. Among three organic matters, Vc increased highest seed yield 17, 28 and 10% in V_1, V_2 and V_3, respectively. However, in combination the highest value resulted in V_2Vc treatment while the lowest was in V_3Cd treatment (Fig. 1E). Both varietal and organic matters roles were observed in 100-seed weight of okra. In V_2 and V_3 cowdung and compost significantly reduced the 100-seed weight compared to their respective controls. Meanwhile, the highest 100-seed weight (32%) was observed in V_1Vc combination and the lowest (-6%) was found in V_3Co (Fig. 1F). Through the process of mineralization, which increases microbial activities in the soil, vermicompost may have enhanced nutrient availability and so loaded the okra pod with necessary macro nutrients. Another cause could be the increased activity of nitrate reductive enzymes, which aid in amino acid and protein synthesis (Bano *et al*., 2020). According to Singh *et al*. (2008), the enhancement in qualitative attributes of okra fruits due to vermicompost could be linked to their nutritional richness and stimulatory behaviour.

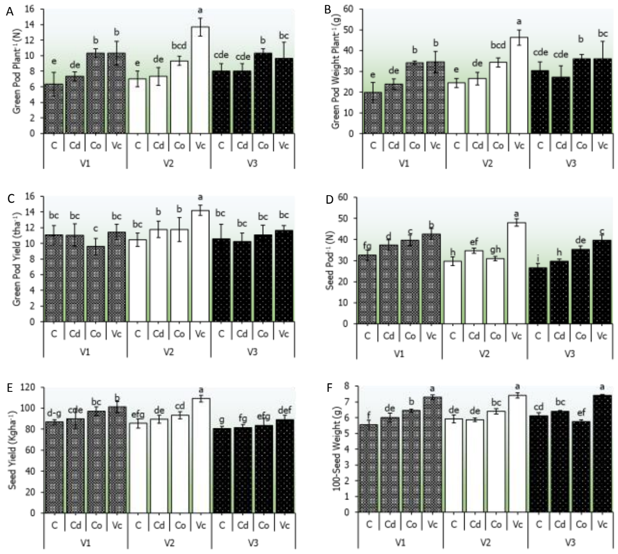

Fig. 1 Effect of organic amendments on yield contributing parameters (Green pod plant^{-1}, Green pod weight plant^{-1}, Green pod yield, Seed pod^{-1}, Seed yield, 100-seed weight) of different okra varieties. Here C, Cd, Co and Vc indicate control, cowdung, compost and vermicompost, respectively. Mean (±SD) was calculated from three replicates for each treatment. Values with different letters are significantly different at P ≤ 0.05 applying the Fisher's LSD test.

Effect of organic manures on germination traits of okra

No significant effect of organic matter was found on the varieties used in the experiment. In V_1 and V_2 due to compost application, germination reduced by 8%. On the other hand, in these varieties due to cowdung and vermicompost application no changes were observed in GP% (Table 2). The highest GP (25%) was found in V_3 due to vermicompost application compared to the control. Germination rate was significantly influenced by the use of organic matters. In V_1, organic matters reduced the GR compared to the control. In V_2 and V_3 organic matter increased the GR and the highest (19%) was observed in V_2Cd combination and the lowest (-19%) was from the V_1Cd treatment (Table 2). Significant increase in GRI was observed in V_2 due to application of organic matter. In V_2, 18, 16 and 14% increase of GRI was observed due to Cd, Co and Vc application respectively, compared to the control. However, the lowest (-19%) GRI was found in V_1cd treatment combination (Table 2). Organic matter showed a non-significant change in MDG. In V_3, 15, 15 and 25% increase of MDG was observed due to Cd, Co and Vc application, respectively. The lowest (-8%) MDG was observed in V_1Co and V_2Co treatment combinations (Table 2). Similarly, Sharma *et al*. (2015) observed that organic amendments significantly enhanced percent seed germination and emergence speed index compared to inorganic fertilizer in okra and Highest homogeneity of seed germination was observed in vermicompost.

Seed vigour was significantly influenced due to application of organic matter. In V_1 due to vermicompost application, highest (34%) vigour was observed whereas the lowest (-14%) was observed in V_2Co treatment combination, compared to the respective control (Table 2). The increase in seedling vigour in response to increasing vermicompost rate could be attributed to several growth promoters, enzymes, beneficial bacteria, and mycorrhizae found in vermicompost, which facilitated photosynthetic activities and increased assimilate portioning to the seed storage organ, resulting in a high seedling vigour index (Asgele *et al*., 2018).

Seedlings vigour index was significantly influenced by the application of organic matters. In V_2, vermicompost application resulted with highest (72%) SVI and the lowest (-3%) was found in V_3Cd treatment combination, compared to the control (Table 2). The presence of humic-like materials and other plant development-influencing compounds such as plant growth hormones produced by microorganisms during vermicomposting may be linked to observed germination and better germination indices in vermicompost modified pots (Sarma and Gogoi, 2015). The ability of vermicompost to provide water and other compounds during germination resulted in the highest mean daily germination value (Lazcano *et al*., 2010).

Table 2. Effect of organic amendments on seed germination indices (Germination percentage, Germination rate, Germination rate index, Mean daily germination, Vigour, Seedlings vigour index) of different okra varieties.

Treatments		GP%	GR	GRI	MDG	Vigour (V)	SVI
V_1	C	80.0a	27.81a	0.35a	11.43a	1.51abc	13.45c
	Cd	80.0a	22.39bc	0.28b	11.43a	1.66ab	15.89bc
	Co	73.3a	26.92ab	0.37a	10.48a	1.52abc	15.14bc
	Vc	80.0a	25.77abc	0.32ab	11.43a	2.03a	17.90ab
V_2	C	80.0a	21.62c	0.27b	11.43a	1.28bc	11.98c
	Cd	80.0a	25.77abc	0.32ab	11.43a	1.29bc	14.99bc
	Co	73.3a	23.30abc	0.32ab	10.48a	1.10c	15.70bc
	Vc	80.0a	25.10abc	0.31ab	11.43a	1.59abc	20.65a
V_3	C	66.6a	23.92abc	0.36a	9.52a	1.24bc	13.22c
	Cd	76.6a	24.75abc	0.33ab	10.95a	1.46bc	12.82c
	Co	76.6a	28.00a	0.37a	10.95a	1.34bc	12.15c
	Vc	83.3a	27.69a	0.33ab	11.90a	1.44bc	14.99bc

Here C, Cd, Co and Vc indicate control, cowdung, compost and vermicompost, respectively. Mean (±SD) was calculated from three replicates for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the Fisher's LSD test

Effect of organic manures on seedling traits of okra

Seedlings root and shoot length were significantly varied due to the application of organic matters. Although in V_1, V_2 all three organic matter increased the root length, in V_3 it reduced compared to the control. The highest root length (37%; RL) was observed in V_2Vc combination, whereas the lowest (-25%) was in V_3Vc compared to the control (Fig. 2A). On the other hand, highest shoot length (101%; SL) was found in as before in V_2Vc treatment combination and the lowest (-21%) was in V_3Cd combination, compared to the control (Fig. 2B). Root-shoot ratio was also influenced by the organic treatments. Except V_3Cd, in all varietal combination with organic matters resulted in reduced root-shoot length compared to the respective controls. However, the highest reduction (-29%) was found in V_3Vc combination, compared to the control (Fig. 2C). The importance of organic manure's soil binding capabilities in facilitating greater aeration and soil physical qualities is reflected in the increased root and shoot length. Baliah and Muthulakshmi (2017) looked at how using vermicompost in combination with microbial inoculants impacts the root and shoot lengths of okra plants.

Among cowdung, compost and vermicompost only vermicompost played significant role in increasing the seedlings FW and DW. In all varietal combination cowdung and compost slightly increased or decreased the FW and DW compared to the respective controls. The highest FW and DW (34%) observed in V_1Vc and the lowest FW and DW (-7%) was from V_3Vc combination (Fig. 2D, 2E). Due to organic amendments, no significant change in RWC was observed except the vermicompost. The highest RWC was found in V_3Co combination and the lowest (-33%) from V_1Vc treatment combination, compared to the respective controls (Fig. 2F). Increased FW, DW and RWC is strongly associated with the plant vegetative growth. The use of organic matter, particularly vermicompost, aided in the early germination of the plant and thereby enhanced vegetative growth by giving nutrients on demand. This finding backs up the prior findings of Oroka (2016).

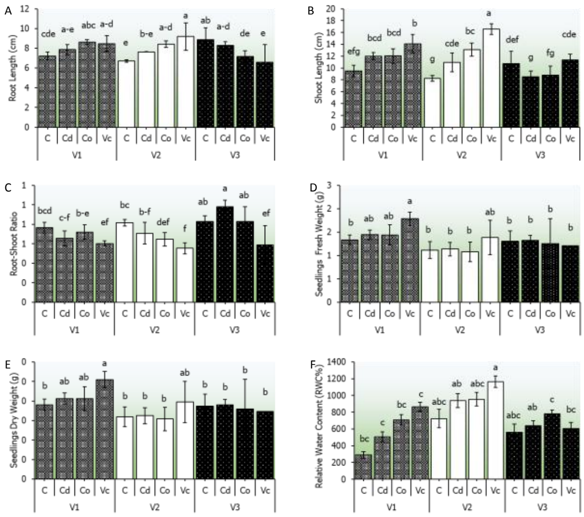

Fig. 2 Effect of organic amendments on yield contributing parameters (Seedlings root length, shoot length, Root-shoot ratio, Seedlings fresh weight, dry weight, Relative water content denotes as figure A, B, C, D, E and F, respectively) of different okra varieties. Here C, Cd, Co and Vc indicate control, cowdung, compost and vermicompost, respectively. Mean (±SD) was calculated from three replicates for each treatment. Values with different letters are significantly different at P ≤ 0.05 applying the Fisher's LSD test.

Conclusion

Since the green revolution, modern agriculture has been mostly relied on artificial fertilizers due to uphold the continuous supply of food. However, to replenish the soil health that distorted by synthetic fertilizers, use of organic amendment is a must to restore soil productivity. Among the several organic manures, vermicompost is the most effective at speeding up and fragmenting the substrate, substantially altering microbial activity. Organic matter treatments thus significantly improve okra output. In our study, BARI Dherosh-2 outperformed than other two cultivars in terms of plant growth, yield, germination, and seedling growth when combined with vermicompost. Plant growth and yield are greatly enhanced when organic fertilizers are used. Therefore, organic manures should be promoted as an effective and eco-friendly technology for ensuring good soil health, not only for safe vegetable crop production but also for a sound ecological balance that promotes environmental sustainability.

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Conflicts of interest

This research has never been published before in any way. According to the authors, there are no conflicts of interest.

Author's Contribution

A.A.C.M: conceptualization, manuscript preparation, statistical analysis, critical review and editing. S.A: investigation, manuscript preparation. A.K.M.R.A: design, investigation, supervision.

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