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SOIL & CROP SCIENCES | RESEARCH ARTICLE

Germination and seedling growth of Okra (*Abelmoschus esculentus* L.) as influenced by organic amendments

Banashree Sarma^{1*} and Nirmali Gogoi¹

Abstract: This study was designed to understand the effects of different soil organic amendments on germination and seedling vigour of Okra (*Abelmoschus esculentus* L.). Five treatments with organic amendments (farmyard manure, vermicompost and biochar) and mineral fertilizers were designed in randomized block design with three replications. Results showed that organic amendments significantly enhanced per cent seed germination and emergence speed index compared to inorganic fertilizer. Highest homogeneity of seed germination ($CV_{gt} = 20.74$) was observed in vermicompost. Plant height, root length and leaf area were higher in vermicompost and biochar than farmyard manure. Both allocation of biomass to above ground parts and Dickson quality index were highest in seedlings from the plots amended with vermicompost. The study revealed that compared to biochar, vermicompost and farmyard manure significantly enhanced the germination and growth of Okra seedling, but the stimulation was best in vermicompost-amended plots.

Subjects: Environment & Agriculture; Environmental Studies & Management; Food Science & Technology

Keywords: germination; Okra; organic amendments; plant growth; seedling quality

1. Introduction

Application of organic amendment is an environmentally, economically and agronomically sound practice which has already been established by many researchers (Carson & Peterson, 1990). Therefore, to achieve agricultural sustainability, the use of organic amendment is getting prime

ABOUT THE AUTHORS

Our research domain is basically plant physiology and biochemistry. Earlier, we did some work on greenhouse gas emission from rice field and its association with various plant morpho-physiological parameters. The author's research group has been involved from the last few years in soil fertility and stress physiology. We study the effects of different management practices (fertilizer and water regimes) on soil physicochemical health and its influence on plant growth and development. Based on the behaviour of these attributes under different practices, we try to select the most sustainable practice that maintains soil health as well as improves the crop growth to give better yield.

PUBLIC INTEREST STATEMENT

Application of organic amendments has been proved as an environment-friendly practice for improved crop production with sustainable soil health. Being, an important horticultural crop, Okra is widely grown in India. The work presented in this manuscript deals with the impacts of different organic amendments on Okra seed germination and seedling development as germination and seedling development is the pioneer steps for crop growth, development and yield. Findings of this study will be helpful in selecting the most promising organic amendment for successful cultivation of Okra.

importance in recent years, particularly under intensive cropping system. Farmyard manure, vermicompost, poultry manure and green leaf manure are commonly used organic amendments in agriculture. Compared to inorganic fertilizer, they are bulky in nature with differential texture. Vermicomposts have a much finer structure than composts and contain readily available forms of nutrients for plant uptake (Arancon, Edwards, Atiyeh, & Metzger, 2004). Biochar is also found to enhance plant growth by improving soil chemical (i.e. nutrient retention, nutrient availability), physical (i.e. bulk density, water holding capacity, permeability) and biological properties contributing to better crop productivity (Asai et al., 2009). Unlike inorganic fertilizer, the organic amendments are not a ready source of plant nutrient, therefore whole quantity of it is applied well ahead of seed sowing. Organic amendments such as vermicompost also add growth-influencing substances like plant hormones as observed by many researchers (Atiyeh, Subler, Edwards, & Metzger, 1999). Thus, the application of organic fertilizer-associated alterations in soil pH, porosity and bulk density may affect germination of seed and growth of seedling.

Okra (*Abelmoschus esculentus* L.), a popular vegetable crop of the tropical countries is also a good source of carbohydrate, protein, dietary fibre, minerals and vitamins. The seeds of Okra are normally sown at depths of 5–6 cm; hence, the germinating seeds are likely to encounter mechanical resistance when growing to the soil surface. Therefore, soil physical properties such as bulk density, water holding capacity, soil compaction play a great role in germination and emergence of seedling. Since germination and seedling development are the pioneer steps for crop growth, development and yield, study of germination indices and seedling quality has been shown to be highly indicative of subsequent performance of seed throughout the growing period (Khajeh-Hosseini, Lomholt, & Matthews, 2009).

Under this perspective, the present experiment was undertaken to investigate the effects of different sources of organic amendments on germination indices of Okra as a possible quick and reliable test to access the seedling quality and yield. This study will help to find out the suitable organic amendment for Okra cultivation.

2. Materials and methods

2.1. Experimental design and layout

The *in situ* experiment was carried out in the experimental field of Tezpur University located in north bank plain zone of Assam (26°14'N and 92°50'E), India. Okra (*A. esculentus* L. cv. OH-397) was grown under irrigated condition on experimental soil (typic endoaquepts: pH 6.16, Soil organic carbon 1.41%, Available N,P,K 275.97, 36 and 279.59 kg ha⁻¹ respectively, Bulk density 1.1 Mg m⁻³, Water holding capacity 44.4%). The experiment was conducted in randomized block design with three replicates with farmyard manure, vermicompost and biochar as organic amendments. The doses of organic and inorganic fertilizers were fixed based on the standard package of practices as suggested by Assam Agricultural University, Assam, India for the region. The recommended doses of organic and inorganic N:P:K fertilizers are 5 t ha⁻¹ and 50:50:50 kg ha⁻¹ respectively. The various treatments were: unfertilized control (CK); recommended inorganic fertilizer dose at the rate of 50:50:50 kg ha⁻¹ of N:P:K (RDF); farmyard manure at the rate of 5 t ha⁻¹ (FM); vermicompost at the rate of 5 t ha⁻¹ (VC) and biochar at the rate of 5 t ha⁻¹ (BC). The RDF treatment was applied to compare the organic fertilizer with the prevailing cultivation practice. Full dose of N, P and K was applied as basal dose at the time of sowing, while organic amendments were applied 10 days before sowing. Twenty-four pre-soaked (for 24 h) seeds were sown (5–6 cm deep) per plot with a spacing of 45 × 30 cm (row to row and plant to plant) and covered with soil.

Both vermicompost and biochar were prepared in the vermicompost and biochar unit of Tezpur University. Cow dung mixed with straw was used as farmyard manure. Vermicompost was prepared using crop residue and garden waste. The feed material was prepared by mixing waste and old cow dung and then earthworms (*Perionyx excavatus*) were introduced. The vermicompost was ready after 90 days. Biochar was prepared by pyrolysis of wood, then dried and ground before applying to the field. The physicochemical characteristics of the organic amendments are presented in Table 1.

Table 1. Characteristics of organic amendments

Parameters	Farmyard manure	Vermicompost	Biochar	LSD
Organic carbon (%)	12.5 ± 0.12	23.7 ± 0.24	71.5 ± 0.20	0.273
Total N (%)	1.09 ± 0.01	2.30 ± 0.12	0.96 ± 0.03	0.101
C/N ratio	11.40 ± 0.22	10.24 ± 0.62	74.54 ± 1.90	1.66
pH	7.8 ± 0.08	6.8 ± 0.15	7.2 ± 0.70	0.144
Bulk density (Mg m ⁻³)	1.3 ± 0.02	1.5 ± 0.01	0.8 ± 0.01	0.015
Water holding capacity (%)	53.03 ± 0.71	61.63 ± 0.76	59.37 ± 0.41	0.908

Note: Mean (n = 3) ± SE.

2.2. Germination study

Seed germination was recorded regularly until completion of the process (8 days after sowing). At the end of germination study, various germination indices such as per cent germination, emergence speed index, mean emergence time and co-efficient of variation of germination time (CV_{gt}) were calculated as given by Ranal and Santana (2006).

2.3. Seedling morphology and biomass

After 15 days of sowing, destructive sampling was done for measuring the morphological parameters. Plant height and root length were measured using a ruler, while vernier calliper was used to measure root collar diameter. The uprooted plants were washed to make them free from dust, separated into leaves, stem and root and oven dried for 48 h at 70°C. Leaf area was measured by laser leaf area meter (CI-203, USA). Dickson quality index was calculated using two quality indices ((i) slenderness index = plant height/root collar diameter and (ii) shoot/root ratio) according to the following equation as given by Dickson, Leaf, and Hosner (1960):

$$\text{Dickson quality index} = \frac{\text{Total dry weight of seedling}}{\text{slenderness index} + \text{shoot:root ratio}}$$

2.4. Statistical analysis

Standard errors of means (of three replicates) were calculated for all the parameters. Data obtained were subjected to one-way analysis of variance (ANOVA) in SPSS for windows 16.0.20. Least Significant Differences (LSD) among the means were used to test the significance of differences between treatment means at different levels of probability ($p \leq 0.05, 0.01$ and 0.001).

3. Results

3.1. Germination study

Seed germination parameters recorded up to 8 days after sowing are presented in Table 2. Different treatments significantly ($p < 0.001$) affected the germination of Okra (*A. esculentus*) seed. Compared to control, RDF showed better results, while BC exhibited germination per cent at par with CK. VC showed the highest per cent germination, while CK and BC recorded the lowest. Organic amendment exhibited significantly higher emergence speed index than RDF and CK. Among organic amendments, VC enhanced the emergence speed index, while BC showed the lowest. VC recorded the lowest mean emergence time, while CK showed the highest ($p < 0.05$). Highest CV_{gt} i.e. homogeneity in germination of seed was recorded by VC followed by FM ($p < 0.05$). BC recorded lower CV_{gt} than that of RDF. Significantly higher germination per cent and other germination indices were showed by vermicompost followed by farmyard manure compared to biochar.

3.2. Plant parameters

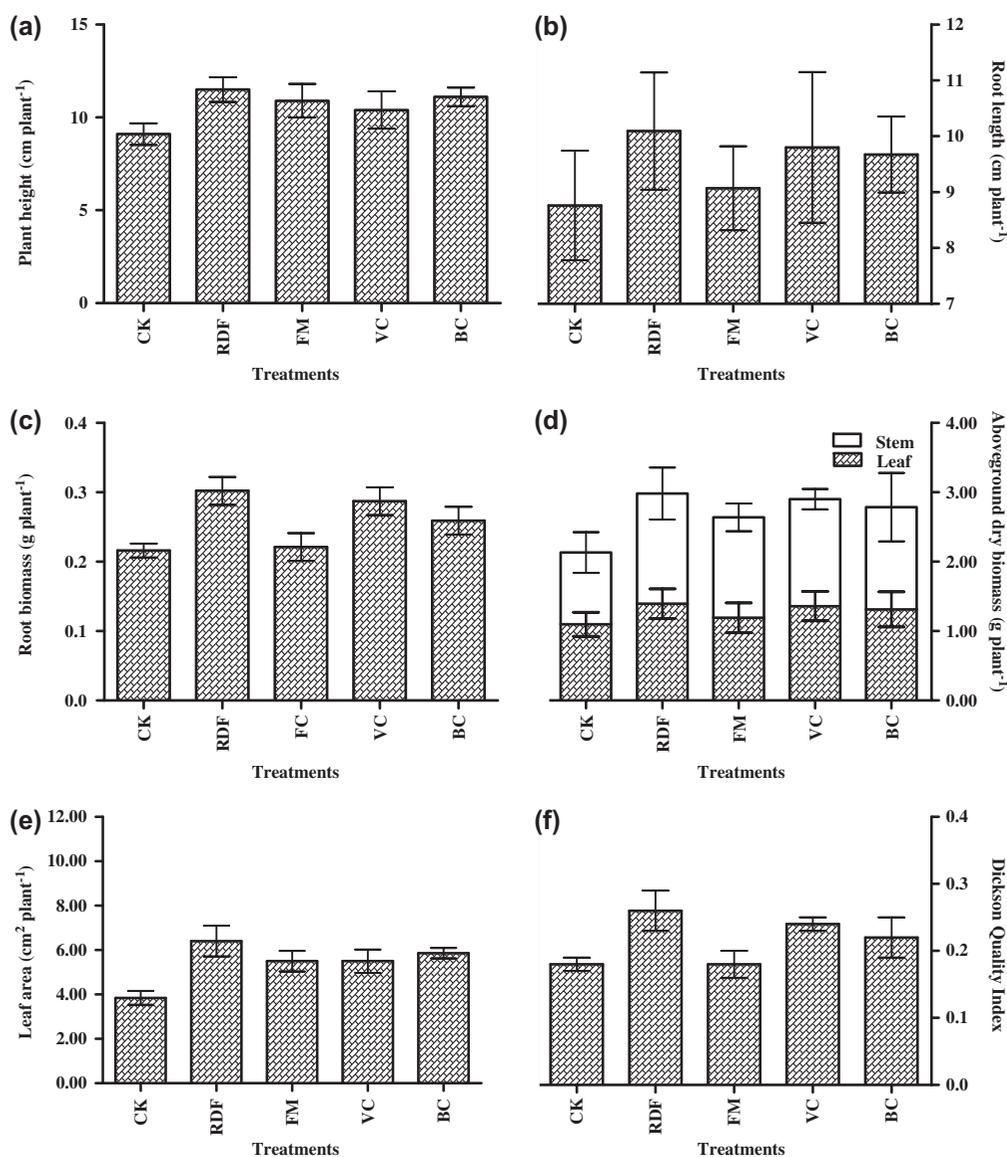
Plant height and root length were significantly affected in all the treatments ($p < 0.001$) as represented in Figure 1((a) and (b)). Plots with RDF and VC recorded higher values, while CK showed the lowest.

Table 2. Germination indices of Okra seed under different organic amendments

Treatments	Percent germination (%)	Emergence speed index (plants day ⁻¹)	Mean emergence time (day)	Coefficient of variation of germination time
CK	87.50 ± 4.17 ^b	8.92 ± 0.39 ^d	6.89 ± 0.02 ^a	14.71 ± 0.10 ^c
RDF	91.67 ± 2.40 ^{ab}	10.00 ± 0.03 ^{cd}	6.69 ± 0.03 ^b	18.38 ± 0.29 ^b
FM	97.22 ± 2.77 ^a	13.50 ± 0.24 ^b	6.48 ± 0.01 ^c	20.37 ± 0.17 ^a
VC	100.00 ± 0.00 ^a	15.17 ± 0.63 ^a	6.40 ± 0.05 ^c	20.74 ± 0.52 ^a
BC	87.50 ± 2.40 ^b	10.49 ± 0.66 ^c	6.67 ± 0.04 ^b	17.98 ± 0.44 ^b
LSD	3.83	0.642	0.047	0.484

Note: Mean (n = 3) ± SE; values followed by different superscript letters within a column differ significantly (LSD, α = 0.001).

Figure 1. Effects of organic amendments measured at 15 days after sowing on (a) Plant height; (b) Root length; (c) Root biomass; (d) Aboveground dry biomass; (e) Leaf area and (f) Dickson quality index (Mean ± SE) of Okra seedling.



The plant biomass of Okra (root and shoot) was significantly lower ($p < 0.001$) in control plots (Figure 1(c) and (d)). Both root and shoot biomass were higher in RDF followed by VC and BC. BC recorded higher leaf biomass. Among the organic fertilizer, vermicompost- and biochar-applied plots showed better accumulation of both root and shoot biomass.

Plant leaf area was significantly lower ($p < 0.001$) in control plants (Figure 1(e)), whereas the highest values were recorded in RDF followed by biochar- and vermicompost-treated plants. Considerable variations in leaf area were found due to application of different organic fertilizers ($p < 0.001$).

Significant differences of Dickson quality index were perceived between the treatments ($p < 0.001$) and ranged from 0.18 to 0.26 (Figure 1(f)). CK recorded the lowest Dickson quality index, while mineral fertilized plots (RDF) showed the highest. Among the organic fertilizers, VC demonstrated higher Dickson quality index followed by BC.

4. Discussion

Application of organic sources of fertilizer in soil affects positively on soil fertility and hence, the plant growth and this varies depending on the quality of raw materials used for the production of these fertilizers. Okra seeds require moist soil and around 25°C temperature for efficient germination and grow best in neutral to slightly alkaline soils (pH 6.5–7.5). The recorded 100% germination along with higher values of germination indices in vermicompost amended plots may be ascribed to high porosity, aeration, water holding capacity and presence of humic-like materials and other plant growth-influencing substances (such as plant growth hormones) produced by micro-organisms during vermicomposting (Arancon et al., 2004). C:N ratio between 10 and 20 is the most favourable for sustaining plant growth as it indicates increased rate of mineralization and hence, higher release of nutrients from the organic amendments. Therefore, the more favourable C:N ratio of VC (10.13) and FM (11.47) also plays an important role in seed germination. Reduced seed germination in biochar may be due to existence of free radical from the pyrolysis of parent material during biochar production (Liao, Pan, Li, Zhang, & Xing, 2014). Therefore, further study concerning the time of application of biochar as organic amendment is essential. The co-efficient of variation of germination time (CV_{gt}) that measures the germination uniformity or variability in relation to the mean germination time (Ranal & Santana, 2006) showed highest value under vermicompost application which may be because of its capacity to hold water and presence of growth-promoting substances (Arancon et al., 2004).

Plant height, root length, biomass accumulation and Dickson quality index of Okra seedlings which indicate the overall quality of the seedling varied significantly across the treatments. RDF resulted in greater (not significant) values as mineral fertilizers serve as a readily available source of nutrients. Compared to control, considerably higher plant height and root length was recorded in vermicompost-treated plots. This is supported by the higher content of available nutrients (especially N) and better rate of mineralization in vermicompost compared to other amendments. Highest biomass allocation to aerial parts was noted under vermicompost followed by biochar. As organic amendments improve the porosity and water holding capacity of soil which results in more root growth, this in turn enhances the nutrient uptake from soil and subsequently increases the aboveground biomass accumulation. Significant positive effect of vermicompost (Arancon et al., 2004) and biochar (Asai et al., 2009) on biomass and yield has already been documented. Dickson quality index, used as a reliable predictor of seedling performance, indicates plant potential for field survival and growth showed higher value in vermicompost indicating higher potentiality to survive with better growth and development of Okra seedling under this treatment.

5. Conclusion

We found that application of organic amendments has a significant effect on germination of Okra seed compared to inorganic fertilizers. Vermicompost showed more positive effects on germination as well as plant growth and development. However, farmyard manure had shown higher influence on germination than that of plant growth. While, biochar exhibited delayed seed germination but

enhanced plant growth. Among the studied organic amendments, the use of vermicompost could be a better option to achieve enhanced growth of Okra seedling.

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