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Raising Summer Onion Seedlings in the Seedbed Through Organic Soil Amendments

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Abstract

This study aims to investigate the effects of various organic soil amendments on the growth, germination, and survival of summer onion seedlings, conducted during the 2019-2020 cropping seasons at the Spices Research Centre (SRC), Shibganj, Bogura, Bangladesh. The research was performed on sandy loam soil under the subtropical climatic conditions prevalent in the region. Having experiment tested five different soil treatments. Results indicated that the organic amendments significantly influenced seedling growth, with the treatment incorporating a combination of sandy loam, FYM, and cocopeat yielding the best overall performance. The highest germination rate of 91.03% was observed in this treatment, while it also exhibited the tallest seedlings (17.20 cm), the highest number of leaves (5.30 cm), longest roots (6.17 cm) and the greatest root number (7.57). Furthermore, this treatment recorded the highest seedling vigor index (1453.00) and survival rate (88.67%), signifying its effectiveness in promoting robust seedling development. These enhancements positively influenced seedling emergence and establishment, leading to improved seedling vigor and survival. Consequently, the study concluded that organic soil amendments, specifically the combination of FYM with cocopeat and vermicompost, are highly beneficial in improving onion seedling growth and health. This approach can be recommended for the cultivation of summer onions, as it not only supports vigorous seedling establishment but also contributes to sustainable agricultural practices through the use of natural soil enhancements.

Keywords: Crop, Nursery management, Seedbed, Summer Seedlings

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Introduction

Raising onion (*Allium cepa L.*) seedlings on seedbeds is a widely practiced method to ensure uniform germination and healthy seedling establishment. However, summer onion seedling production is often constrained by high temperature, rapid moisture loss, and poor soil physical conditions, which result in low germination, weak seedlings, and high mortality. Onion seedlings are particularly sensitive to these environmental stresses during early growth stages, making nursery management during summer a major challenge (Singh et al., 2015).

Conventional soils used in summer seedbeds generally contain low organic matter and exhibit poor structure, inadequate aeration, and limited water-holding capacity. These conditions restrict root development and seedling vigor, negatively affecting transplant establishment and crop performance. Although seedbeds allow better utilization of water, fertilizers, and labor and support timely crop establishment, improvement of the growing medium is essential to achieve these benefits under summer conditions (Sharma et al., 2017).

The incorporation of organic amendments into seedbeds offers a sustainable approach to improving summer onion seedling production. Organic materials such as farmyard manure (FYM), vermicompost, and cocopeat improve soil structure, enhance moisture retention and aeration, and support nutrient availability, thereby creating a favorable environment for seedling growth under high-temperature conditions. Therefore, this study was conducted to evaluate the effectiveness of selected organic amendments in improving germination, growth, and vigor of onion seedlings raised on summer seedbeds.

Materials and Methods

Study Area: In this study, we conducted a deep evaluation of raising summer seedlings on seedbed. The aim was to examine the performance of seedbed with different compositions. The research spanned two consecutive years, from 2019 to 2020, and was conducted at Spices Research Centre (SRC), Shibganj, Bogura of Bangladesh with sandy loam soil and subtropical climate. Seedbed size and layout: Seedbeds of 3m×1m×15 cm (height) each thrice per treatment.

Seed selection: Seed of BARI piaz-5, a summer onion variety was selected. Before sowing, seeds were soaked in hot water (50°C) for 12 hours. For summer cultivation, seeds were sown on seedbed during march-April.

Treatments:

T_1: 100% sandy loam soil (control).

T_2: Sandy loam soil + well-decomposed farmyard manure (FYM) (3:1 ratio).

T_3: Sandy loam soil + FYM + vermicompost (2:1:1 ratio).

T_4: Sandy loam soil + FYM + cocopeat (2:1:1 ratio).

T_5: Sandy loam soil + FYM + sawdust (2:1:1 ratio).

Seedbed Preparation: Brick gravel and sand occupied 3 cm layer at the below part. Beds prepared with treatments was outlined below:

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Treatment (T_1): The soil was loosened to a depth of 15–20 cm using a spade. Big clumps were broken to ensure a fine soil texture. Sandy loam provided good drainage but lacked nutrients. 50 g/m² of NPK (10:26:26) basal fertilizer was incorporated before sowing. The surface was leveled for uniform sowing.

Treatment (T_2): 3 parts sandy loam soil with 1-part well-decomposed farmyard manure were mixed thoroughly. The mixture was evenly spread across the seedbed area. The soil was loosened to a depth of 15-20 cm, ensuring proper incorporation of manure. The seed bed was leveled and lightly moistened for planting. For 30g/m² of NPK (10:26:26) basal fertilizer was used as supplement.

Treatment (T_3): 2 parts sandy loam soil with 1-part FYM and 1 part vermicompost was combined. They were mixed thoroughly to ensure uniform distribution. The mixture was evenly spread over the seedbed, breaking any clumps. The soil was loosened to 15–20 cm depth, applied then level it for sowing. 20 g/m of due to NPK (10:26:26) basal fertilizer was used as supplement.

Treatment (T_4): 2 parts sandy loam soil with 1-part FYM and 1-part cocopeat were mixed. They were properly blended and spread to create a light and airy texture. The soil was loosened to 15–20 cm depth and level it. Cocopeat ensures better aeration and moisture retention. 20 g/m² of NPK (10:26:26) basal fertilizer was applied during final preparation.

Treatment (T_5): 2 parts sandy loam soil with 1-part FYM and 1 part sawdust were mixed. It should be ensured that the sawdust was well-rotted. The mixture was spread and incorporated into the soil by loosening it to 15–20 cm depth. The seedbed was leveled and moistened for planting. A light dose of 20 g/m² NPK (10:26:26) basal fertilizer was added to the seedbed.

It was noted that the seedbed was free of weeds and debris. The soil should be moist but not waterlogged. After preparation, the seedbed was lightly watered if needed and allowed it to settle for sowing.

Seed and sowing: 10 grams of onion seeds per square meter were used. For a 3 m² area, 30 grams of seeds were needed. High-quality seeds with good germination rates (above 80%) was chosen. Seeds were sown at the depth of 2 cm followed by light watering. Seeds were spaced 2 cm apart within rows to avoid overcrowding.

Seedling Management Practices: Intercultural operations are vital part thorough out the period of raising vigorous seedlings. There were some intercultural operations that taken for growing healthy seedlings.

Irrigation: Adequate moisture was maintained for uniform germination. Seedbed was watered lightly with a sprinkler immediately after sowing. Subsequent watering should be done once the topsoil appears dry. Waterlogging condition should be avoided as it led to fungal diseases like damping-off.

Weed control: Manual weeding was conducted at 15 days after germination and repeated as necessary. Mulching: A thin layer of straw mulch was applied to minimize weed growth and retain moisture.

Pest and disease management: Proper care should be maintained to raise the healthy seedlings. The following care should be taken for raising seedlings.

Common Pests: Spinosad (1 ml/liter) was sprayed for thrips and Chlorpyrifos (2.5 ml/liter) was applied around the seedbed.

Diseases: Soil was drenched with Captan (0.2%) to control damping-off disease. Mancozeb (2 g/liter) was sprayed at regular intervals.

Protective Coverings: 50% shading nets was used to protect seedlings from direct sunlight, heavy rain, and strong winds. It regulated temperature, which was critical during summer. Proper air circulation was ensured under the polyshade to avoid fungal growth. Coverings were removed during early morning and late afternoon to expose seedlings to sunlight for hardening.

Data Collection: Data were recorded on the following parameters: Germination percentage, Seedling height (cm), Number of leaves per seedling, Root length, Number of roots, Seedling vigor index, seedlings survival rate.

Statistical Analysis: The collected data were statistically analyzed using R software. Analysis of variance (ANOVA) was performed to assess the significance of the treatments, and mean comparisons were done using the appropriate post-hoc tests.

Results and Discussion

Table 1. Comparative analysis of seedling growth and germination in various soil mixtures

Treatments	Germination percentage	Seedling height (cm)	Number of leaves per seedling	Root length (cm)	Number of roots	Seedling vigor index	Seedlings survival rate
T_1	75.43c	12.23c	3.53c	4.10c	5.03c	1043.33c	70.00c
T_2	82.50bc	14.43bc	4.23bc	5.13b	6.03bc	1186.00bc	77.33bc
T_3	88.17ab	16.10ab	4.87ab	5.80ab	7.00ab	1341.67ab	85.67ab
T_4	91.03a	17.20a	5.30a	6.17a	7.57a	1453.00a	88.67a
T_5	84.70ab	14.93ab	4.63ab	5.43ab	6.53ab	1249.33abc	80.00ab
CV (%)	4.95	9.10	9.89	10.16	10.29	9.0	6.80
L.S.	**	**	**	**	**	**	**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

Note: $T_{1=}$ 100% sandy loam soil (control), $T_{2=}$ Sandy loam soil + well-decomposed farmyard manure (FYM) (3:1 ratio), $T_{3=}$ Sandy loam soil + FYM + vermicompost (2:1:1 ratio), $T_{4=}$ Sandy loam soil + FYM + cocopeat (2:1:1 ratio), $T_{5=}$ Sandy loam soil + FYM + sawdust (2:1:1 ratio)

Seed germination percentage: The study evaluated the effect of different soil amendments on seed germination percentage. The control treatment with T_1 exhibited the lowest germination percentage (75.43%), indicating that the physical and chemical properties of sandy loam alone may not be sufficient Raising Of Summer Onion Seedlings in the Seedbed

to support optimal Germination (Table 1). This aligns with findings by Kumar et al. (2020), who reported that soil structure and nutrient availability significantly affect seed germination rates.

Incorporating T_2 treatment improved germination to 82.50%, likely due to enhanced nutrient availability and better soil structure. Similar improvements were observed in T_3, resulting in better germination rates of 88.17% and 91.03%, respectively (Table 1). The superior performance of T_4 can be attributed to its high water-holding capacity and aeration properties, which are essential for seedling development (Sharma et al., 2018).

The treatment with T_5 showed a germination rate of 84.70%. Although higher than the control, this was lower compared to vermicompost and cocopeat treatments (Table 1). This could be due to sawdust's tendency to immobilize nitrogen during decomposition, which can limit nutrient availability for germinating seeds (Patel & Desai, 2019).

The coefficient of variation (CV) was 4.95%, indicating low variability in the experimental data, suggesting consistency across replicates (Table 1). The presence of statistically significant differences between treatments, as indicated by the least significant difference (L.S.), underscores the impact of organic amendments on seed germination.

Seedling height: The experiment assessed the impact of different soil treatments on seedling height. The T_1 treatment produced the shortest seedlings (12.23 cm) (Table 1), indicating that the physical properties and nutrient content of sandy loam alone are insufficient for optimal seedling growth. This finding aligns with Kumar et al. (2020), who emphasized the importance of organic amendments for improving soil fertility and plant growth.

The addition of T_2 treatment increased seedling height to 14.43 cm (Table 1). FYM improves soil structure, enhances nutrient availability, and increases microbial activity, contributing to better seedling growth.

The combination of T_3 further enhanced seedling height to 16.10 cm (Table 1). Vermicompost is rich in essential nutrients like nitrogen, phosphorus, and potassium, and contains growth-promoting substances that stimulate plant development (Sharma et al., 2018).

The highest seedling height (17.20 cm) was recorded in the treatment with T_3 (Table 1). Significantly improves soil aeration and water retention, providing an ideal environment for root development and plant growth. This result supports the findings of Patel & Desai (2019), who highlighted the role of cocopeat in enhancing seedling vigor.

The treatment with sawdust in combination with T_5 resulted in a seedling height of 14.93 cm (Table 1). Although better than the control, this was less effective than T_3 and T_4 treatments. Sawdust may lead to nitrogen immobilization during decomposition, limiting nutrient availability for seedlings.

The coefficient of variation (CV) was 9.10% (Table 1), indicating moderate variability in the results. The presence of statistically significant differences between treatments, as indicated by the least significant difference (L.S.), confirms the effectiveness of organic amendments in promoting seedling growth.

Number of leaves per seedling: The study investigated the influence of various soil treatments on the number of leaves per seedling. The control treatment with T_1 produced the fewest leaves (3.53) (Table 1), indicating that sandy loam alone lacks sufficient nutrients and organic matter to support optimal leaf development. This is consistent with findings by Kumar et al. (2020), who noted that nutrient-poor soils often result in reduced vegetative growth.

Incorporating T_2 increased the number of leaves to 4.23 (Table 1). FYM enriches the soil with organic matter, improving nutrient availability and enhancing plant growth.

Further enhancement was observed in T_4 treatment resulting in 4.87 leaves per seedling (Table 1). Vermicompost is rich in essential nutrients and beneficial microorganisms that promote vigorous vegetative growth, as highlighted by Sharma et al. (2018).

The highest number of leaves (5.30) was recorded in the treatment combining T_4 (Table 1). Cocopeat improves soil aeration and moisture retention, which are critical for supporting sustained vegetative growth and leaf production. This supports the observations made by Patel & Desai (2019), who reported increased leaf proliferation in crops grown in cocopeat-amended soils.

The treatment with T_5 resulted in 4.63 leaves per seedling (Table 1), while this was an improvement over the control, it was less effective than the vermicompost and cocopeat treatments. The lower performance could be due to nitrogen immobilization by sawdust during decomposition, limiting nitrogen availability for plant growth (Gupta & Rao, 2017).

The coefficient of variation (CV) was 9.89% (Table 1), indicating moderate variability in the data. The statistically significant differences between treatments, indicated by the least significant difference (L.S.), confirm the positive effects of organic amendments on leaf production.

Root length: The study examined the effect of different soil treatments on root length. The control treatment with T_5 produced the shortest roots (4.10 cm) (Table 1), suggesting that the limited nutrient and water-holding capacity of sandy loam alone restricts root development. This aligns with findings from Kumar et al. (2020), who reported that soil lacking organic amendments often results in stunted root growth due to poor nutrient availability.

Incorporating T_2 improved root length to 5.13 cm (Table 1). FYM enhances soil fertility by improving nutrient content and soil structure, leading to better root penetration and elongation.

The combination of T_3 further increased root length to 5.80 cm (Table 1). Vermicompost is rich in essential nutrients like nitrogen and phosphorus, and its microbial activity stimulates root development. This is supported by Sharma et al. (2018), who highlighted vermicompost role in promoting robust root systems in various crops.

The longest roots (6.17 cm) were observed in the treatment with T_4 (Table 1). Cocopeat significantly improves soil aeration and moisture retention, creating ideal conditions for root growth. The increased water-holding capacity ensures consistent moisture availability, facilitating deeper and healthier root systems. This observation is consistent with Patel & Desai (2019), who reported enhanced root elongation in cocopeat-amended soils.

The treatment combining T_5 resulted in a root length of 5.43 cm (Table1). While this was an improvement over the control, it was less effective compared to vermicompost and cocopeat treatments. This could be due to nitrogen immobilization caused by sawdust during its decomposition process, which temporarily reduces nitrogen availability for plant uptake, as noted by Gupta & Rao (2017).

The coefficient of variation (CV) was 10.16% (Table1), indicating moderate variability in the results. The statistically significant differences between treatments, indicated by the least significant difference (L.S.), confirm the effectiveness of organic amendments in enhancing root growth.

Number of roots: The experiment assessed the effect of different soil treatments on the number of roots per seedling. The control treatment with T_1 produced the fewest roots (5.03) (Table1), suggesting that sandy loam alone lacks sufficient nutrients and structure to promote robust root development. This is in line with Kumar et al. (2020), who found that nutrient-poor soils limit root proliferation, ultimately affecting overall plant growth.

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When T_2 treatment applied the number of roots increased to 6.03 (Table1). FYM improves soil fertility by increasing organic matter, which enhances nutrient availability and microbial activity, thus promoting root growth.

Further enhancement was seen when T_3 were combined, leading to 7.00 roots per seedling (Table1). Vermicompost is rich in nutrients and beneficial microorganisms that stimulate root growth by improving soil structure and nutrient availability (Sharma et al., 2018).

The highest number of roots (7.57) was observed in the treatment T_4 (Table 1). Cocopeat enhances soil aeration and water retention, both of which are crucial for optimal root development. The increased moisture retention promotes deeper and more extensive root systems, as reported by Patel & Desai (2019).

The treatment with T_5 resulted in 6.53 roots (Table1), while this was an improvement over the control, it was less effective than the vermicompost and cocopeat treatments. Sawdust may cause nitrogen immobilization during decomposition, reducing nutrient availability for plants (Gupta & Rao, 2017).

The coefficient of variation (CV) was 10.29% (Table1), indicating moderate variability in the data. Statistically significant differences between treatments, as indicated by the least significant difference (L.S.), confirm that organic amendments positively influence the number of roots.

Seedling vigor index: The seedling vigor index is an important indicator of seedling growth and health, reflecting the combined effect of germination and early growth. In this study, the control treatment with T_5 resulted in the lowest vigor index (1043.33) (Table1), indicating that sandy loam alone is not optimal for seedling growth, likely due to its poor nutrient-holding capacity and lack of organic matter. This observation is consistent with findings by Kumar et al. (2020), who reported lower seedling vigor in soils without organic amendments.

The addition of T_2 improved the seedling vigor index to 1186.00 (Table1), suggesting that FYM enhances nutrient availability and microbial activity in the soil, leading to better overall seedling development. This aligns with the work of Sharma et al. (2018), which highlighted the positive impact of organic matter on seedling vigor.

A more significant increase in seedling vigor was observed when T_3 was combined, resulting in a vigor index of 1341.67 (Table1). Vermicompost provides a rich source of nutrients, including nitrogen, phosphorus, and potassium, and contains growth-promoting microorganisms that enhance seedling vigor, as described by Patel & Desai (2019).

The highest seedling vigor index (1453.00) was recorded in the treatment with T_4 (Table1). Cocopeat improves soil aeration, water retention, and nutrient-holding capacity, creating an ideal environment for seedling growth. This finding is in line with research by Patel & Desai (2019), who observed increased seedling vigor in cocopeat-amended soils due to better moisture and nutrient availability.

The treatment combined with T_5 resulted in a seedling vigor index of 1249.33 (Table1), which was higher than the control but lower than the vermicompost and cocopeat treatments. Sawdust can cause nitrogen immobilization during its decomposition process, potentially limiting nutrient availability for seedlings (Gupta & Rao, 2017).

The coefficient of variation (CV) was 9.0% (Table1), indicating low variability in the results. Statistically significant differences between treatments, as indicated by the least significant difference (L.S.), confirm that the organic amendments positively affected seedling vigor.

The seedling survival rate is a crucial indicator of the overall health and adaptability of seedlings in different soil treatments. In this study, the control treatment with T_1 resulted in the lowest survival rate (70.00%) (Table1). Sandy loam alone often lacks essential nutrients and organic matter, which can limit seedling establishment and survival. This finding is consistent with the work of Kumar et al. (2020), who reported that nutrient-deficient soils lead to higher seedling mortality.

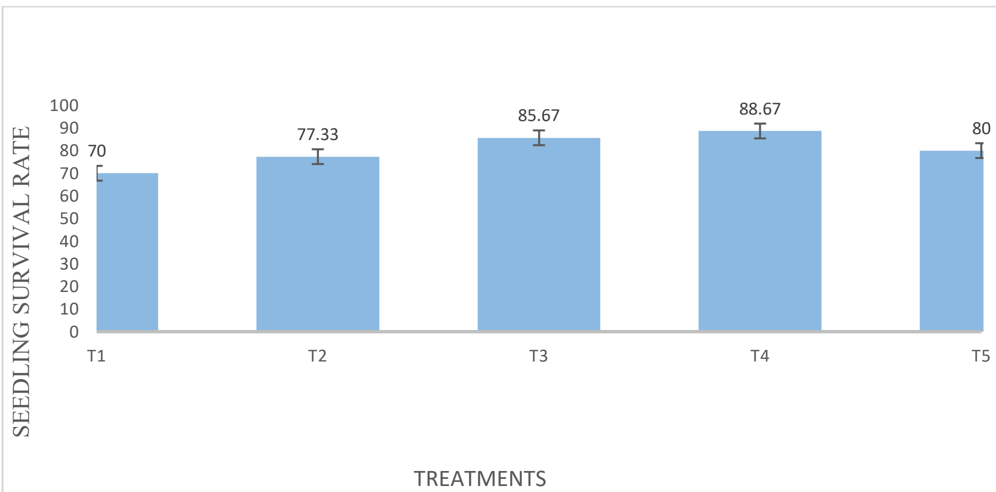
Incorporating T_2 treatment improved the survival rate to 77.33% (Table1). FYM is known to enhance soil fertility, increase microbial activity, and improve soil structure, all of which contribute to better seedling survival. Sharma et al. (2018) similarly observed increased survival rates in plants grown in soils amended with organic matter.

The treatment with T_3 led to a further improvement in survival rate, reaching 85.67% (Table1). Vermicompost is rich in nutrients and beneficial microorganisms, which support seedling growth and boost survival. This result aligns with Patel & Desai (2019), who found that vermicompost enhanced seedling survival and vigor by improving nutrient uptake and soil health.

The highest seedling survival rate (88.67%) was observed with T_4 treatment (Table1). Cocopeat improves soil aeration, moisture retention, and nutrient availability, creating optimal conditions for seedling establishment and survival. This finding corroborates the results of Patel & Desai (2019), who reported improved seedling survival in cocopeat-amended soils due to enhanced moisture retention and root development.

The treatment, when combined with T_5, resulted in a survival rate of 80.00% (Table1), which was higher than the control but lower than the vermicompost and cocopeat treatments. Sawdust can cause nitrogen immobilization during its decomposition, which may temporarily reduce nitrogen availability to plants, potentially affecting seedling survival (Gupta & Rao, 2017).

The coefficient of variation (CV) was 6.80% (Table1), indicating low variability in the results. Statistically significant differences between treatments, as indicated by the least significant difference (L.S.), confirm that the organic amendments played a key role in improving seedling survival.



Note: T_1= 100% sandy loam soil (control), T_2= Sandy loam soil + well-decomposed farmyard manure (FYM) (3:1 ratio), T_3= Sandy loam soil + FYM + vermicompost (2:1:1 ratio), T_4= Sandy loam soil + FYM + cocopeat (2:1:1 ratio), T_5= Sandy loam soil + FYM + sawdust (2:1:1 ratio)

Fig. 1. Seedling Survival rate of summer onion

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Plate 1. Summer onion seedling highest at Sandy loam soil + FYM + cocopeat (2:1:1 ratio)

Plate 2. Summer onion seedling at control condition

Conclusion

Based on the findings of Table 1 and Figure 1, incorporation of organic amendments significantly improves onion seedling germination, growth and survival. Among the treatments T_4 produced the highest seedling vigor, root development and survival rate, indicating its superior effectiveness in promoting healthy onion seedlings under summer seedbed conditions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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