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Effect of biochar and nutrients on growth and yield of pigeonpea (*Cajanus cajan* (L.) Millsp.)

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ABSTRACT

A field experiment was conducted during *kharif* 2025-26 at the Diggi Block, College of Agriculture, Bheemarayanagudi, University of Agricultural Sciences, Raichur, Karnataka, India, to evaluate the effect of biochar, alone and in combination with farmyard manure (FYM) and vermicompost, on the growth and yield of pigeonpea (*Cajanus cajan* (L.) Millsp., cv. GRG-152). The experiment comprised ten nutrient management treatments laid out in a Randomized Complete Block Design (RCBD) with three replications. Growth parameters (plant height, number of primary and secondary branches, total dry matter production, leaf area and leaf area index) and yield attributes (number of pods Plant⁻¹, seed yield Plant⁻¹, hundred seed weight, seed yield and stalk yield) were recorded at harvest. Application of the recommended dose of chemical fertilizer (RDCF) together with vermicompost @ 2.5 t ha⁻¹ and biochar @ 2.5 t ha⁻¹ (T8) recorded significantly higher plant height (165.8 cm), number of primary branches (13.8 Plant⁻¹), number of secondary branches (18.2 Plant⁻¹), total dry matter production (206.6 g Plant⁻¹), leaf area (53.1 dm² Plant⁻¹) and leaf area index (1.97) over all other treatments. The same treatment also recorded significantly superior yield attributes, with the higher number of pods Plant⁻¹ (115), seed yield Plant⁻¹ (38.6 g), hundred seed weight (9.9 g), seed yield (1285 kg ha⁻¹) and stalk yield (3212 kg ha⁻¹), whereas the lower values for all parameters were recorded with sole application of biochar @ 1.25 t ha⁻¹ (T3). The results clearly demonstrate that the conjunctive use of biochar with vermicompost and recommended chemical fertilizer improved the vegetative growth, dry matter accumulation and productivity of rainfed pigeonpea, and can be recommended as a sustainable nutrient management practice for pigeonpea-growing tracts of the semi-arid tropics.

Keywords: Pigeonpea, Biochar, Vermicompost, FYM, Growth, Yield, Dry matter

Introduction

Pulse crops occupy a pivotal place in Indian agriculture, not only as a rich source of dietary protein but also as a means of sustaining the productivity and ecological stability of cropping systems through biological nitrogen fixation (BNF). India is the world's largest producer and consumer of pulses, accounting for about 33 per cent of global pulse area and 22 per cent of world production. Among the pulse crops, pigeonpea (*Cajanus cajan* (L.) Millsp.) ranks second in importance after chickpea and is cultivated over 4.04 million hectares in India, producing about 3.9 million tonnes at an average productivity of 861 kg ha⁻¹ (Anonymous, 2024) [1]. Its deep and extensive root system, drought tolerance and ability to function as a "biological plough" make it particularly suited to rainfed and marginal lands (Egbe et al., 2006) [2]. Sustaining soil fertility under continuous cultivation and intensive chemical fertilization remains a major challenge, particularly under rainfed conditions where organic carbon depletion and declining nutrient-use efficiency are common. Organic manures such as farmyard manure (FYM) and vermicompost supply nutrients gradually and improve soil physical and biological properties, but their large bulk requirement and slow mineralization often limit large-scale adoption (Liu et al., 2024) [3]. Biochar, a stable, porous, carbon-rich material produced through the pyrolysis of biomass under limited-oxygen conditions at 350-600 °C (Amonette et al., 2009) [4], offers a complementary and more persistent option for improving soil organic carbon, nutrient retention and moisture-holding capacity (Glaser et al., 2002) [5]. Its physicochemical properties vary with feedstock and pyrolysis conditions (Masek, 2009; Mukherjee et al., 2014) [6, 7], so biochar derived from locally available crop residues such as pigeonpea stalks offers an attractive avenue for recycling agricultural waste while enhancing soil quality.

While the individual effects of biochar, FYM and vermicompost on crop performance have been documented in several crops, comparative and combined information on their effect on pigeonpea under the rainfed agro-ecological conditions of northeastern Karnataka is scanty. Keeping this in view, the present investigation was carried out to evaluate the effect of biochar, alone and in conjunction with FYM, vermicompost and chemical fertilizer, on the growth and yield of pigeonpea.

Materials and methods

Experimental site

A field experiment was conducted during *kharif* 2025-26 at the Diggi Block of the College of Agriculture, Bheemaranagudi, University of Agricultural Sciences, Raichur, situated in the North Eastern Dry Zone of Karnataka (Zone-II) at 16.72° N latitude and 76.79° E longitude, at an altitude of 412 m above mean sea level. The soil of the experimental site was red sandy loam (*Alfisol*), slightly alkaline in reaction (pH 7.54), medium in available nitrogen (250.9 kg ha⁻¹), available phosphorus (33.4 kg ha⁻¹) and available potassium (415.2 kg ha⁻¹).

Treatments and experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments replicated thrice. The treatments comprised: T₁ - RDCF + FYM @ 6 t ha⁻¹; T₂ - RDCF + Vermicompost @ 2.5 t ha⁻¹; T₃ - RDCF + Biochar @ 1.25 t ha⁻¹; T₄ - RDCF + Biochar @ 2.5 t ha⁻¹; T₅ - RDCF + FYM @ 6.0 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹; T₆ - RDCF + FYM @ 6.0 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹; T₇ - RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹; T₈ - RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹; T₉ - 75 % RDCF + FYM @ 6 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ and T₁₀ - 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹, where RDCF refers to the recommended dose of chemical fertilizer (25:50:125 kg N: P₂O₅: K₂O ha⁻¹). The pigeonpea variety GRG-152, a medium-duration, bold-seeded and wilt/SMD-tolerant variety, was sown at 90 cm × 30 cm spacing, with a gross plot size of 7.2 m × 4.5 m and a net plot size of 3.6 m × 3.3 m.

Observations recorded

Five randomly tagged plants per net plot were used to record plant height, number of primary and secondary branches per plant, dry matter accumulation and leaf area at 45, 90, 135 days after sowing (DAS) and at harvest. Leaf area (dm² plant⁻¹) was determined by the disc method on a dry-weight basis following Vivekanandan *et al.* (1972) [8], and leaf area index (LAI) was computed as the ratio of leaf area to the land area occupied by the plant, following Sestak *et al.* (1971) [9]. At harvest, yield attributes *viz.*, number of pods plant⁻¹, number of seeds pod⁻¹, seed yield plant⁻¹, hundred-seed weight, seed yield and stalk yield (both expressed on a kg ha⁻¹ basis) were recorded from the net plot.

Statistical analysis

The data generated for each character were statistically analysed by Fisher's method of analysis of variance as outlined by Panse *et al.* (1967) [10]. The level of significance used in the 'F' test was 5 per cent probability, and wherever the 'F' test was significant, the critical difference (C.D.) was worked out to compare treatment means.

Results and discussion

Growth parameters

Plant height (cm)

Data on plant height as influenced by different nutrient management practices at harvest are presented in Table 1. application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ recorded significantly higher plant height (165.8 cm) than all the other treatments followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (164.7 cm), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (163.4 cm) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (161.2 cm). Significantly lowest plant height (133.4 cm) was recorded with the application of RDCF + Biochar @ 1.25 t ha⁻¹ compared to other treatments.

The superior plant height observed under the better-performing nutrient management practices may be attributed to improved availability of essential nutrients throughout the crop growth period. The combined use of organic manures and biochar could have improved soil

fertility, nutrient retention and root-zone conditions, thereby promoting vigorous vegetative growth in pigeonpea. Adequate nutrient availability during the early and active growth stages might have enhanced cell division and elongation, resulting in greater plant height. Ramesh *et al.* (2006) [11] reported that application of organic manures improved plant growth in pigeonpea, with vermicompost or phosphocompost @ 3 t ha⁻¹ resulting in better crop growth. Patil *et al.* (2007) [12] also reported that application of FYM @ 5 t ha⁻¹ significantly improved plant height and other growth parameters in pigeonpea. Similarly, Kumawat *et al.* (2013) [13] observed significantly higher growth and yield attributes in pigeonpea with integrated nutrient management involving recommended fertilizer dose and vermicompost. The present finding is further supported by He *et al.* (2023) [14], who reported that biochar application significantly increased plant height and shoot dry weight in peanut.

Number of primary branches Plant⁻¹

The number of primary branches plant⁻¹ at harvest (Table 1) was significantly influenced by the nutrient management treatments. RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ recorded significantly higher number of primary branches (13.8), followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (13.2), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (12.9) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (12.4). While, RDCF + Biochar @ 1.25 t ha⁻¹ recorded significantly lower number of primary branches plant⁻¹ (10.2).

The higher number of primary branches per plant observed under the superior nutrient management practices may be attributed to better availability of essential nutrients and favourable soil conditions, which promoted vigorous vegetative growth and branch initiation. The combined application of organic amendments and biochar might have improved nutrient retention and nutrient availability in the root zone, thereby supporting sustained plant growth and development. Improved vegetative growth could have resulted in greater formation of primary branches, providing more sites for reproductive growth and contributing to better yield formation in pigeonpea. The number of primary branches per plant ranged from 10.2 to 13.8, with significant differences among the nutrient management practices. Ramesh *et al.* (2006) [11] reported that application of organic manures improved crop growth and yield attributes in pigeonpea. Patil *et al.* (2007) [12] also reported significant improvement in plant height, number of branches per plant and other growth parameters with FYM application in pigeonpea. Similarly, Kumawat *et al.* (2013) [13] observed significantly higher growth and yield attributes in pigeonpea with integrated nutrient management involving recommended fertilizer dose and vermicompost.

Number of secondary branches Plant⁻¹

Data presented in Table 1 revealed that the number of secondary branches plant⁻¹ at harvest was significantly higher with RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (18.2), followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (17.8), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (17.7) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (17.0). Whereas, significantly lower number of secondary branches plant⁻¹ was recorded with the RDCF + Biochar @ 1.25 t ha⁻¹ (12.4).

The improvement in secondary branches per plant may be attributed to enhanced vegetative growth resulting from improved nutrient availability and favourable soil conditions. Application of organic amendments along with the recommended fertilizer dose could have promoted nutrient supply and root activity, thereby supporting the development of additional secondary branches. The increased branching may subsequently provide more sites for flowering and pod formation, contributing to better yield formation in pigeonpea. The number of secondary branches per plant varied from 12.4 to 18.2, indicating a favourable response to the different nutrient management practices, with the treatment differences being statistically significant. Hussain *et al.* (2017) [15] reported higher branches per plant with the applica

tion of FYM at 10 t ha⁻¹. Similarly, Arunkumar *et al.* (2020) [16] observed that the combined application of biochar, FYM and RDF improved growth and the number of pod-bearing auxiliary branches per plant in greengram. Pandiyan *et al.* (2020) [17] also recorded higher growth and yield attributes, including number of branches per plant, with integrated application of vermicompost and NPK. Further, Mithu *et al.* (2022) [18] reported that biochar application significantly increased the number of branches per plant in mungbean compared with the control.

Total dry matter production (g Plant⁻¹)

Total dry matter (TDM) production at harvest (Table 1 and Fig. 1), among all the treatments significantly higher total dry matter production (206.6 g plant⁻¹) was observed with the application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹, followed by the treatments, RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (203.7 g plant⁻¹), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (199.7 g plant⁻¹) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (195.7 g plant⁻¹). The significantly lower total dry matter production was recorded in the treatment with RDCF + Biochar @ 1.25 t ha⁻¹ (144.6 g plant⁻¹).

The higher total dry matter production may be attributed to the cumulative improvement in leaf, stem and reproductive biomass under integrated nutrient management. Improved availability of nutrients, particularly nitrogen, phosphorus and potassium, might have promoted vegetative growth, photosynthetic activity and efficient translocation of assimilates, resulting in greater overall biomass accumulation. The addition of organic amendments along with inorganic fertilizers may have further improved nutrient availability and soil conditions, thereby supporting sustained crop growth and dry matter production. The greater accumulation of dry matter in leaves and stems could have enhanced the source strength of the crop, while improved partitioning of photosynthates towards reproductive structures might have contributed to higher total biomass at harvest. Similar findings were reported by Revell *et al.* (2012) [19], who observed substantially higher dry matter production of maize with cow manure biochar. Ali *et al.* (2019) [20] also reported increased biological yield with biochar application in wheat. Likewise, Niranjan *et al.* (2020) [21] recorded improved growth and biomass production with integrated application of RDF and biochar in finger millet. Simfukwe *et al.* (2023) [22] reported that biochar improved soil physical and biological properties, thereby promoting crop growth and biomass production.

Leaf area (dm² Plant⁻¹)

Leaf area at harvest (Table 1) significantly higher leaf area (53.1 dm² plant⁻¹) was observed with the application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹, followed by the treatments

RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (51.6 dm² plant⁻¹), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (49.8 dm² plant⁻¹) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (48.9 dm² plant⁻¹). The significantly lowest leaf area (32.8 dm² plant⁻¹) was recorded in the treatment with RDCF + Biochar @ 1.25 t ha⁻¹.

The greater leaf area may be attributed to improved nutrient availability and enhanced vegetative growth under integrated nutrient management. A balanced supply of nutrients might have promoted leaf initiation, expansion and maintenance, thereby resulting in the development of a larger photosynthetic canopy. The favourable soil conditions created by the combined use of organic amendments and inorganic fertilizers may have further supported nutrient availability and moisture retention, contributing to sustained leaf growth. The increased leaf area would have provided a greater photosynthetic surface, facilitating enhanced assimilate production and supporting overall crop biomass accumulation. Jaishankar and Wahab (2005) [23] reported that integrated nutrient management involving recommended NPK and vermicompost improved leaf area and dry matter production, indicating the importance of balanced nutrient availability in promoting canopy development. Similarly, He *et al.* (2023) [14] observed improved shoot growth with biochar application, which was associated with favourable soil nutrient conditions and enhanced crop growth.

Leaf area index (LAI)

The leaf area index at harvest (Table 1) followed a trend similar to leaf area, being significantly the higher leaf area index (1.97) was observed with the application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹, followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (1.91), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (1.84) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (1.81). The significantly lower leaf area index (1.21) was recorded in the treatment with RDCF + Biochar @ 1.25 t ha⁻¹.

The higher LAI under combined organic-biochar nutrient management reflects a greater proportion of ground area covered by foliage, resulting from enhanced leaf expansion and retention under adequate nutrient availability. A higher LAI increases light interception and photosynthetic efficiency, which, in turn, supports greater assimilate production and dry matter accumulation. Jaishankar and Wahab (2005) [23] similarly reported a higher LAI with integrated NPK and vermicompost application, while Ali *et al.* (2019) [20] observed improved chlorophyll content and biological yield with biochar application, reflecting the positive influence of improved canopy development on crop growth.

Table 1. Plant height, number of primary branches per plant, number of secondary branches per plant, total dry matter production, leaf area and leaf area index of pigeonpea at harvest as influenced by different nutrient management practices

Treatments	Plant height (cm)	Number of Primary branches (plant ⁻¹)	Number of Secondary branches (plant ⁻¹)	Total dry matter production (g plant ⁻¹)	Leaf area (dm ² plant ⁻¹)	Leaf area index (LAI)
T ₁ : RDCF + FYM @ 6 t ha ⁻¹	140.6	10.8	14.9	160.3	34.8	1.29
T ₂ : RDCF + Vermicompost @ 2.5 t ha ⁻¹	161.2	12.4	17.0	195.7	48.9	1.81
T ₃ : RDCF + Biochar @ 1.25 t ha ⁻¹	133.4	10.2	12.4	144.6	32.8	1.21
T ₄ : RDCF + Biochar @ 2.5 t ha ⁻¹	138.2	10.6	14.5	155.8	33.6	1.24
T ₅ : RDCF + FYM @ 6.0 t ha ⁻¹ + Biochar @ 1.25 t ha ⁻¹	149.1	11.6	15.8	175.4	38.7	1.43
T ₆ : RDCF + FYM @ 6.0 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	150.9	12.1	16.1	179.0	41.2	1.53
T ₇ : RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 1.25 t ha ⁻¹	164.7	13.2	17.8	203.7	51.6	1.91

(continued on next page)

T ₈ : RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	165.8	13.8	18.2	206.6	53.1	1.97
T ₉ : 75 % RDCF + FYM @ 6 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	146.9	11.1	15.4	167.6	37.2	1.38
T ₁₀ : 75 % RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	163.4	12.9	17.7	199.7	49.8	1.84
S.E.m.±	5.5	0.6	0.7	6.8	1.6	0.06
C.D. (P = 0.05)	16.2	1.7	2.1	20.2	4.7	0.17

Note: RDCF: Recommended Dose of Chemical Fertilizer (25:50:125 kg N: P₂O₅: K₂O ha⁻¹); FYM: Farm Yard Manure; S.E.m.±: Standard Error of Mean; C.D.: Critical Difference

Yield parameters

Number of pods Plant⁻¹

Data on number of pods plant⁻¹ (Table 2) revealed significant differences among treatments. Significantly higher number of pod plant⁻¹ (115) was recorded with the application of RDCF + Vermicompost @

2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ compared to all other treatments, followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (109), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (108) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (102). In contrast significantly lower number of pods plant⁻¹ (66) was observed in the treatment with RDCF + Biochar @ 1.25 t ha⁻¹ compared to other treatments.

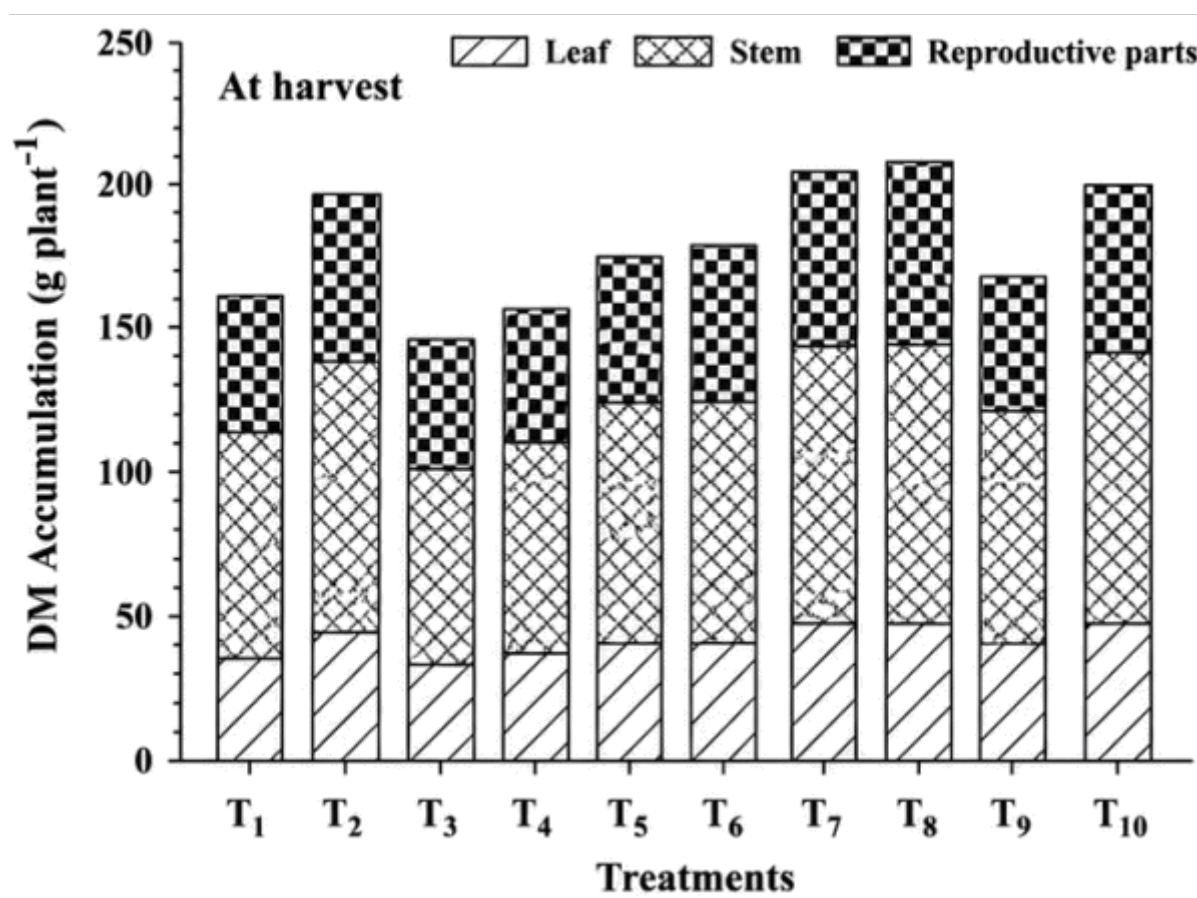


Figure 1. Total dry matter production (g plant⁻¹) of pigeonpea at harvest as influenced by different nutrient management practices

The higher number of pods per plant may be attributed to better vegetative growth, greater branching and improved nutrient availability under integrated nutrient management. Adequate availability of nutrients might have supported flowering, pod setting and subsequent pod development, while improved vegetative growth and assimilated production could have contributed to greater pod formation. The observed variation in number of pods per plant from 66 to 115 indicates a favourable response of pod formation to the different nutrient management practices. Jat *et al.* (2010) [24] reported a significant improvement in yield and yield attributes of pigeonpea with the application of FYM under pigeonpea + groundnut intercropping. Kumawat *et al.* (2013) [13] reported significantly higher number of pods per plant and other yield attributes in pigeonpea with integrated nutrient management involving recommended fertilizer dose and vermicompost. Similarly, Pal *et al.* (2016) [25] observed higher growth and yield at

tributes, including number of pods per plant, with the application of 100 per cent recommended dose of fertilizer along with vermicompost in pigeonpea.

Seed yield Plant⁻¹ (g)

Seed yield plant⁻¹ (Table 2) was significantly higher with the application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (38.6 g plant⁻¹) when compared to all other treatments, which was on par with RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (38.2 g plant⁻¹), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (37.1 g plant⁻¹) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (35.7). Whereas, significantly lower seed yield plant⁻¹ (25.7 g plant⁻¹) was observed under RDCF + Biochar @ 1.25 t ha⁻¹. The greater seed yield per plant may be attributed to the combined improvement in pod formation, seed development and efficient accumulation of assimilates under balanced nutrient availability. Enhanced

vegetative growth and photosynthetic activity could have increased assimilate production, while adequate nutrient supply might have facilitated efficient translocation towards developing reproductive organs. Consequently, better pod formation and seed filling resulted in greater seed yield per plant. The seed yield per plant ranged from 25.7 to 38.6 g, with significant differences among the nutrient management practices. Sharma *et al.* (2010) [26] reported improved yield attributes and productivity under integrated nutrient management in pigeonpea. Meena *et al.* (2015) [27] also reported higher seed yield with integrated application of fertilizer and vermicompost in cowpea. Similarly, Mahabub *et al.* (2016) [28] reported that application of cow dung manure increased seed yield along with other yield attributes in mungbean.

Hundred seed weight (g)

The hundred-seed weight (Table 2) was significantly higher with the application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (9.9 g), followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (9.7 g), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (9.5 g) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (9.3). Whereas, significantly lower hundred seed weight (8.2 g) was recorded with the application of RDCF + Biochar @ 1.25 t ha⁻¹.

The higher hundred seed weight may be attributed to improved seed filling resulting from adequate nutrient availability and efficient assimilate accumulation during seed development. Balanced phosphorus and potassium nutrition might have enhanced the translocation of photosynthates towards developing seeds, while adequate nitrogen availability could have supported protein synthesis and seed development. The improved soil environment under organic amendment-based nutrient management may have further favoured efficient nutrient uptake and better seed development. In the present study, hundred seed weight ranged from 8.2 to 9.9 g, with significant differences among the nutrient management practices. Mahabub *et al.* (2016) [28] also reported an increase in 1000-seed weight of mungbean with cow dung manure application, while Pal *et al.* (2016) [25] observed improved yield attributes of pigeonpea under integrated nutrient management involving vermicompost.

Seed yield (kg ha⁻¹)

Seed yield (Table 2 and Fig. 2). Application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ resulted in significantly higher seed yield (1285 kg ha⁻¹) when compared to all other treatments, followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (1250 kg ha⁻¹), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (1230 kg ha⁻¹) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (1190 kg ha⁻¹). Whereas, lower seed yield (987 kg ha⁻¹) was observed in the treatment with RDCF + Biochar @ 1.25 t ha⁻¹ and was significantly lower than the other treatments.

The variation in seed yield of pigeonpea may be attributed to the differences in nutrient availability and their utilization by the crop. In the present investigation, seed yield ranged from 987 to 1285 kg ha⁻¹, with significant differences among the nutrient management practices. Higher seed yield could be associated with improved plant growth, branching, pod formation and seed development under favourable nutrient conditions. Adequate availability of nutrients might have enhanced photosynthetic activity and dry matter production, resulting in greater translocation of assimilates towards developing pods and seeds. The improvement in individual seed weight along with better reproductive growth may have further contributed to higher seed yield.

The beneficial effect of integrated nutrient management may also be attributed to the complementary role of organic and inorganic nutrient sources. Vermicompost provides nutrients in a gradually available form and improves the soil environment, while biochar can enhance

nutrient retention and provide favourable conditions for root activity and nutrient uptake. Such improvements may have resulted in sustained nutrient availability and better utilization of applied nutrients, thereby supporting crop growth and reproductive development. Patil *et al.* (2007) [12] reported improved growth and yield attributes along with higher grain yield of pigeonpea with FYM application. Similarly, Kumawat *et al.* (2013) [13] observed significantly higher growth, yield attributes and grain yield of pigeonpea under integrated nutrient management involving fertilizer and vermicompost. The present findings are also supported by Pal *et al.* (2016) [25], who recorded higher growth and yield attributes and grain yield of pigeonpea with recommended fertilizer dose combined with vermicompost. Meena *et al.* (2015) [27] reported significantly higher seed yield in cowpea with fertilizer and vermicompost application, while Hussain *et al.* (2017) [15] observed increased seed yield of mungbean with biochar and FYM application. Thus, the higher seed yield observed in the present investigation may be attributed to improved soil fertility, nutrient availability, nutrient retention and efficient utilization of nutrients, which collectively promoted better growth, yield attributes and seed production.

Stalk yield (kg ha⁻¹)

Stalk yield (Table 2 and Fig. 2) followed a similar trend to seed yield, application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ resulted in significantly higher stalk yield (3212 kg ha⁻¹) when compared to other treatments, followed by RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ (3175 kg ha⁻¹), 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ (3125 kg ha⁻¹) and RDCF + Vermicompost @ 2.5 t ha⁻¹ (2960 kg ha⁻¹). Whereas, significantly lower stalk yield (2477 kg ha⁻¹) was observed under RDCF + Biochar @ 1.25 t ha⁻¹.

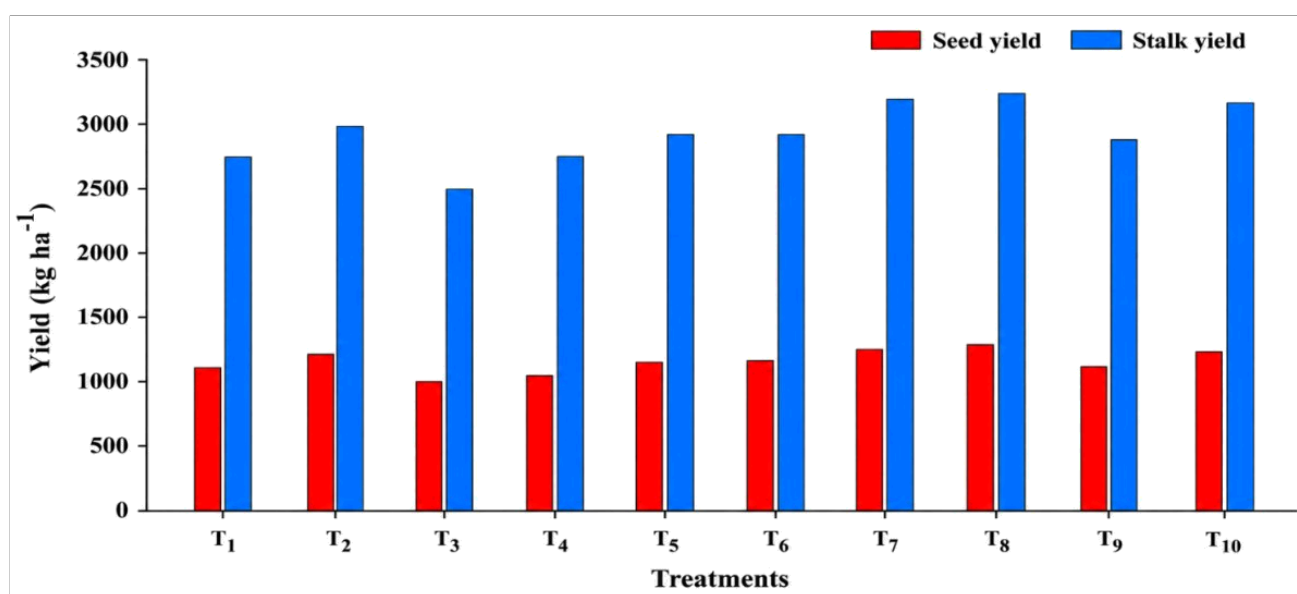
The variation in stalk yield of pigeonpea may be attributed to differences in vegetative growth and dry matter accumulation under different nutrient management practices. In the present investigation, stalk yield ranged from 2477 to 3212 kg ha⁻¹, with significant differences among the nutrient management practices. Higher stalk yield could be associated with greater plant height, branching, leaf area and total dry matter production, which resulted in greater accumulation of vegetative biomass. Adequate and balanced nutrient availability might have promoted vigorous vegetative growth and increased assimilate production, thereby contributing to greater biomass accumulation in the stalk. The favourable effect of integrated nutrient management may be related to the complementary contribution of mineral fertilizers, vermicompost and biochar. Mineral nutrients provide an immediate supply of essential nutrients, while vermicompost contributes nutrients gradually and improves the soil environment. Biochar may further enhance nutrient retention and improve the conditions for root growth and nutrient uptake. These effects could have supported sustained vegetative growth and greater dry matter accumulation, ultimately resulting in higher stalk yield. Revell *et al.* (2012) [19] reported substantial improvement in dry matter yield with biochar application, while Yooyen *et al.* (2015) [29] observed improved crop growth, dry matter production and yield with biochar application in soybean.

The present findings are also supported by Pal *et al.* (2016) [25], who reported superior growth and yield attributes along with higher stalk yield of pigeonpea with fertilizer and vermicompost application. Mahabub *et al.* (2016) [28] also observed increased seed and stover yield of mungbean with organic manure application. Similarly, Kumawat *et al.* (2013) [13] recorded significantly higher growth and yield attributes and grain yield of pigeonpea under integrated nutrient management involving fertilizer and vermicompost. Thus, the higher stalk yield in the present investigation may be attributed to improved nutrient availability, favourable soil conditions, enhanced vegetative growth and greater dry matter accumulation resulting from integrated nutrient management.

Table 2. Number of pods plant⁻¹, seed yield plant⁻¹, hundred seed weight, seed yield and stalk yield of pigeonpea as influenced by different nutrient management practices

Treatments	Number of Pods plant ⁻¹	Seed yield plant ⁻¹ (g)	Hundred seed weight (g)	Seed yield (kg ha ⁻¹)	Stalk yield (kg ha ⁻¹)
T ₁ : RDCF + FYM @ 6 t ha ⁻¹	81	29.7	8.4	1095	2717
T ₂ : RDCF + Vermicompost @ 2.5 t ha ⁻¹	102	35.7	9.3	1190	2960
T ₃ : RDCF + Biochar @ 1.25 t ha ⁻¹	66	25.7	8.2	987	2477
T ₄ : RDCF + Biochar @ 2.5 t ha ⁻¹	76	29.4	8.4	1030	2710
T ₅ : RDCF + FYM @ 6.0 t ha ⁻¹ + Biochar @ 1.25 t ha ⁻¹	92	33.8	8.6	1135	2885
T ₆ : RDCF + FYM @ 6.0 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	96	34.4	8.8	1155	2897
T ₇ : RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 1.25 t ha ⁻¹	109	38.2	9.7	1250	3175
T ₈ : RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	115	38.6	9.9	1285	3212
T ₉ : 75 % RDCF + FYM @ 6 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	84	30.6	8.5	1115	2872
T ₁₀ : 75 % RDCF + Vermicompost @ 2.5 t ha ⁻¹ + Biochar @ 2.5 t ha ⁻¹	108	37.1	9.5	1230	3125
S.E.m.±	5	1.2	0.3	42	105
C.D. (P = 0.05)	14	3.6	1	123	311

Note: RDCF: Recommended Dose of Chemical Fertilizer (25:50:125 kg N: P₂O₅: K₂O ha⁻¹); FYM: Farm Yard Manure; S.E.m.±: Standard Error of Mean; C.D.: Critical Difference

**Figure 2.** Seed yield and stalk yield (kg ha⁻¹) of pigeonpea as influenced by different nutrient management practices

Conclusion

On the basis of the present investigation, it can be concluded that application of RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹ significantly improved the growth parameters (plant height, number of primary and secondary branches, total dry matter production, leaf area and leaf area index) as well as the yield attributes (number of pods plant⁻¹, seed yield plant⁻¹, hundred seed weight, seed yield and stalk yield) of pigeonpea over the remaining nutrient management practices, and was statistically on par with RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 1.25 t ha⁻¹ and 75 % RDCF + Vermicompost @ 2.5 t ha⁻¹ + Biochar @ 2.5 t ha⁻¹. The lowest performance for all growth and yield parameters was consistently recorded with the sole application of biochar @ 1.25 t ha⁻¹, indicating that biochar alone, without an accompanying readily-available nutrient source, was inadequate for optimum pigeonpea productivity. The conjunctive use of vermicompost and biochar along with the recommended dose of chemical fertilizer can therefore be recommended

as a scientifically sound and sustainable nutrient management strategy for enhancing the growth, yield and productivity of rainfed pigeonpea in the semi-arid tropical conditions of northeastern karnataka.

References

- Anonymous. Agricultural Statistics at a Glance 2024. New Delhi: Government of India, Ministry of Agriculture and Farmers Welfare; 2024.
- Egbe OM, Kalu BA. Farming systems study: Participatory rural appraisal of pigeonpea cropping systems in Southern Guinea Savanna of Nigeria. J. Environ. 2006;5(1):37-47.
- Liu Y, Lan X, Hou H, Ji J, Liu X, Lv Z. Multifaceted ability of organic fertilizers to improve crop productivity and abiotic stress tolerance: Review and perspectives. Agronomy. 2024;14(6):1141.
- Amonette JE, Joseph S. Characteristics of biochar: Microchemical properties. In: Lehmann J, Joseph S, eds. Biochar for Environmental Management: Science and Technology. London: Earthscan; 2009:33-52.

5. Glaser B, Lehmann J, Zech W. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – A review. *Biol. Fertil. Soils*. 2002;35:219-230.
6. Masek O. Biochar production technologies. In: Lehmann J, Joseph S, editors. *Biochar for Environmental Management: Science and Technology*. London: Earthscan; 2009.
7. Mukherjee A, Zimmerman AR, Harris W. Surface chemistry variations among a series of laboratory-produced biochars. *Geoderma*. 2014;163(3-4):247-255.
8. Vivekanandan AS, Gunasena HPM, Sivanayagam T. Statistical evaluation of the accuracy of three techniques used in the estimation of leaf area of crop plants. *Indian J. Agric. Sci.* 1972;42(9):857-860.
9. Sestak Z, Catsky J, Jarvis PG. *Plant Photosynthetic Production: Manual of Methods*. Dr W. Junk N.V. Publishers, The Hague; 1971.
10. Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. 2nd ed. Indian Council of Agricultural Research, New Delhi; 1967.
11. Ramesh P, Singh M, Panwar NR, Singh AB, Ramana S. Response of pigeonpea (*Cajanus cajan*) varieties to organic manures and their influence on fertility and enzyme activity of soil. *Indian J. Agric. Sci.* 2006;76(4).
12. Patil AB, Padmani DR. Effect of integrated nutrient management on growth and yield of pigeonpea (*Cajanus cajan* (L.) Millsp.). *Int. J. Agric. Sci.* 2007;3(2):49-51.
13. Kumawat N, Singh RP, Kumar R, Om H. Effect of integrated nutrient management on the performance of sole and intercropped pigeonpea (*Cajanus cajan*) under rainfed conditions. *Indian J. Agron.* 2013;58(3):309-315.
14. He K, Liu Q, Zhang J, Zhang G, Li G. Biochar enhances the resistance of legumes and soil microbes to extreme short-term drought. *Plants*. 2023;12(24):4155.
15. Hussain Z, Khan N, Ullah S, Liaqat A, Nawaz F, Khalil AUR, Ali M. Response of mung bean to various levels of biochar, farmyard manure and nitrogen. *World J. Agric. Sci.* 2017;13(1):26-33.
16. Arunkumar BR, Thippeshappa GN. Residual effect of levels of biochar and FYM on growth, yield and nutrient uptake by green gram (*Vigna radiata* L.) crop in sandy loam soil. *Int. J. Curr. Microbiol. Appl. Sci.* 2020;9(2):695-707.
17. Pandiyan CV, Balaji K, Saravanan S, Gunasekaran S, Srinivasan GR, Saghana PRK, Manivel G. Effect of vermicompost application on soil and growth of the plant *Sesamum indicum* L. *Agric. Sci. Agron.* 2020;doi:10.20944/preprints202002.0080.v1.
18. Mithu MMH, Mia S, Suhi AA, Tahura S, Biswas P, Kader MA, Kassim S, Makino T. Biochar enriched compost elevates mung bean (*Vigna radiata* L.) yield under different salt stresses. *Crop Pasture Sci.* 2022;74(2):79-89.
19. Revell KT, Maguire RO, Agblevor FA. Influence of poultry litter biochar on soil properties and plant growth. *Soil Sci.* 2012;177(6):402-408.
20. Ali K, Wang X, Riaz M, Islam B, Khan ZH, Shah F, Munsif F, Haq SIU. Biochar: an eco-friendly approach to improve wheat yield and associated soil properties on sustainable basis. *Pak. J. Bot.* 2019;51(4):1255-1261.
21. Niranjan BN, Prakasha HC, Meena HM, Kiran SK, Yadawad B. Effect of biochar on growth, yield and nutrient uptake by finger millet in acidic soil. *J. Pharmacogn. Phytochem.* 2020;9(5):1061-1067.
22. Simfukwe P, Mwanaute S, Bulwilo V, Chaiwa C. Effect of biochar on soil physical properties, growth parameters and yield of soybeans on a five-year fallow. *Afr. J. Agric. Res.* 2023;19(12):1121-1130.
23. Jaishanker S, Wahab K. Effect of integrated nutrient management on growth, yield component and yield of sesame. *Sesame Safflower Newsl.* 2005;20:732.
24. Jat RA, Ahlawat IPS. Effect of organic manure and sulphur fertilization in pigeonpea (*Cajanus cajan*) + groundnut (*Arachis hypogaea*) intercropping system. *Indian J. Agron.* 2010;55(4):276-281.
25. Pal AK, Singh RS, Shukla UN, Singh S. Growth and production potential of pigeonpea (*Cajanus cajan* L.) as influenced by intercropping and nutrient management. *J. Appl. Nat. Sci.* 2016;8(1):179-183.
26. Sharma Arjun, Pandit S, Rathod P, Chavan M. Integrated nutrient management in pigeonpea (*Cajanus cajan*) based intercropping systems under rainfed conditions. *karnataka J. Agric. Sci.* 2010;23(4):584-589.
27. Meena JS, Verma HP, Pancholi P. Effect of fertility levels and bio-fertilizers on the growth and yield of cowpea (*Vigna unguiculata* L. Walp) on sandy loam soil of Rajasthan. *Asian J. Soil Sci.* 2015;10(1):55-58.
28. Mahabub ST, Khan MSH, Maed H, Sarker S, Tereque H. Effect of cow manure on growth, yield and nutrient content of mung-bean. *Asian Res. J. Agric.* 2016;2(1):1-6.
29. Yooyen J, Wijitkosum S, Sriburi T. Increasing yield of soybean by adding biochar. *J. Environ. Res. Dev.* 2015;9(4):1066-1074.

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