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Parvin Banu A
PG Scholar, Department of Seed Science and Technology, Agriculture College and Research Institute, TNAU, Madurai, Tamil Nadu, India

K Sujatha
Professor and Head, Department of Seed Science and Technology, Agriculture College and Research Institute, TNAU, Madurai, Tamil Nadu, India

R Geetha
Professor, Department of Seed Science and Technology, Agriculture College and Research Institute, TNAU, Madurai, Tamil Nadu, India

P Kannan
Assistant Professor, Department of Soils and Environment, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Corresponding Author:
K Sujatha
Professor and Head, Department of Seed Science and Technology, Agriculture College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Biochar coating and its effect on seed quality and biochemical parameters in black gram (*Vigna mungo* L.) var. VBN 11

Parvin Banu A, K Sujatha, R Geetha and P Kannan

Abstract
Seed coating with biomass derived biochar has potential to overcome moisture, nutrients and hormonal constraints on initial and early germination and growth. An experiment was conducted with different bioinoculants *viz*., *Rhizobium*, Phosphobacteria, Potash Releasing Bacteria along with biochar to study the effect of biochar coating on seed quality and biochemical properties and evaluated for its quality and biochemical parameters under laboratory condition. The results revealed that among the treatments, biochar coating @ 200 g/kg of seed performed well and increased the seedling growth, vigour and biochemical parameters.

Keywords: Biochar, black gram, biofertilizer, germination

1. Introduction
Pulses are most significant crop in India due to its low cost and high-quality protein. It has roughly three times the amount of high-quality protein compared to cereals. Black gram aids to enhance the income of many small-scale farmers and contributes to soil fertility maintenance by fixing nitrogen. Poor management and reduced soil fertility are the main causes of low seed yield in black gram (Tiwari and Shivhare, 2016) [23]. In dryland farming, moisture stress is a severe limitation during the initial stages, affecting crop establishment and yield. A number of seed augmentation strategies have been developed to attempt the address of these conditions. Among all, seed coating provides drought resistance and necessary nutrients for plant establishment and growth during the early stages of germination.
Seed coating using any biological compound is termed as bio coating. Seed coating technologies incorporating nutritional materials and biostimulants can enhance seedling growth (Qiu *et al.*, 2020) [19].
Biochar is a kind of charcoal manufactured under high temperature by using crop remains, animal manure or any type of organic waste materials (Kelsi, 2010) [6]. Mostly it is used as soil amendment in order to increase the crop productivity, enhance the soil physical and chemical properties, increase the carbon sequestration in the soil and filtrate percolating soil water (Oh *et al.*, 2017) [15]. In recent years, organic agriculture is getting popularized. Among the various strategies were employed to improve the seedling establishment, biochar coating increased the seedling performance under water limited conditions. With this background research, experiments were conducted to identify the effect of biochar coating on seed quality and biochemical parameters in black gram.

2. Materials and Methods
Black gram variety VBN 11 seeds were collected from Agricultural Research Station, Paramakudi. The bioinoculants *viz*., *Rhizobium*, *Bacillus megaterium* (Phosphobacteria), KRB (Potash Releasing Bacteria -*Peanibacillus mucilaginosus*) were obtained from the Department of Agricultural Microbiology, Agricultural College and Research Institute, Madurai. Biochar made from green waste of Prosopsis plant was obtained from Department of Soils and Environment, Agricultural College and Research Institute, Madurai. The laboratory studies were carried out at Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai.The black gram seeds were bio primed in three different bioinoculants with three different concentrations *viz*., 3%, 5%, 10%. The treatments were T_0-untreated seeds (control), T_1-hydropriming, T_2-seeds bioprimed with *Rhizobium* 3%, T_3-seeds bioprimed with *Rhizobium* 5%, T_4-seeds bioprimed with *Rhizobium* 10%, T_5-seeds bioprimed

with *Bacillus* 3%, T_6- seeds bioprimed with *Bacillus* 5%, T_7- seeds bioprimed with *Bacillus* 10%, T_8- seeds bioprimed with KRB 3%, T_9- seeds bioprimed with KRB 5%, T_{10}- seeds bioprimed with KRB 10%, T_{11}-seeds coated with biochar @50g per kg of seed, T_{12}- seeds coated with biochar @100g per kg of seed, T_{13}- seeds coated with biochar @200g per kg of seed. The coating was done using Starch (1%) as adhesive. Then the seeds were dried to the original moisture content. The germination test was conducted as per the ISTA (2015) procedure and evaluated for different quality parameters like germination percentage (%), shoot length (cm), root length (cm), dry matter production (g per 10 seedlings) and vigour index values. During the germination test, the speed of germination was also evaluated (Maguire, 1962) [11]. The electrical conductivity (Presley, 1958) [18] was measured by soaking 25 seeds in 25 ml of water for 3 h. Dehydrogenase activity (Kittock and Law, 1968) [7], Catalase activity (Luck, 1974) [10] and Peroxidase activity (Malik and Singh, 1980) [12] were also assessed for bio primed and coated seeds.

2.1. Statistical analysis

The data collected were statistically analyzed using AGRES software, according to Panse and Sukhatme's (1985) [16] techniques. Whenever necessary, the percent data was changed using the arcsine transformation, and the critical difference at the 5% level was determined.

3. Results and discussion

Seed coating technology have been evaluated with different crop plants such as cereals, legumes and vegetables with use of plant growth promoting bacteria shown that coating seeds with beneficial bio-inoculants can improve the crops in germination, seedling establishment and vigour of the crops (Rocha *et al.*, 2019) [20]. Among all treatments, seed coating with Biochar@200g/kg (T_{13}) recorded highest germination percentage (94%), root length (10.82 cm), shoot length (11.83 cm) followed by seeds bioprimed in Rhizobium 10% (T_4) with germination percentage (92%), root length (10.58 cm) and shoot length (11.80 cm). The lowest was recorded in untreated seeds (T_0) with the germination percentage (80%), root length (9.15 cm), shoot length (10.23 cm) (Table 1, Fig 1).

Table 1: Effect of Biochar coating on seed quality parameters of Black gram VBN 11

Treatments	Germination %	Dry matter production (g/10 seedlings)	Vigour index I	Electrical conductivity (dsm^{-1})
Control	80 (63.43)	0.171	1550	0.25
Hydropriming	80 (63.43)	0.187	1592	0.24
Rhizobium 3%	80 (63.43)	0.221	1699	0.20
Rhizobium 5%	82 (64.89)	0.248	1765	0.19
Rhizobium 10%	92 (73.57)	0.274	2059	0.14
Bacillus 3%	80 (63.43)	0.203	1693	0.21
Bacillus 5%	82 (64.89)	0.242	1778	0.18
Bacillus 10%	90 (71.56)	0.269	2006	0.15
KRB 3%	86 (68.02)	0.255	1829	0.17
KRB 5%	82 (64.89)	0.237	1691	0.22
KRB 10%	80 (63.43)	0.193	1634	0.23
Biochar 50g /kg seed	88 (69.73)	0.262	1884	0.16
Biochar 100g /kg seed	90 (71.56)	0.270	1967	0.15
Biochar 200g /kg seed	94 (75.82)	0.281	2129	0.13
Mean	85 (67.21)	0.237	1805	0.19
S.Ed	1.3586	0.0045	43.1434	0.0042
CD (P=0.05)	2.7830	0.0091	88.3775	0.0086

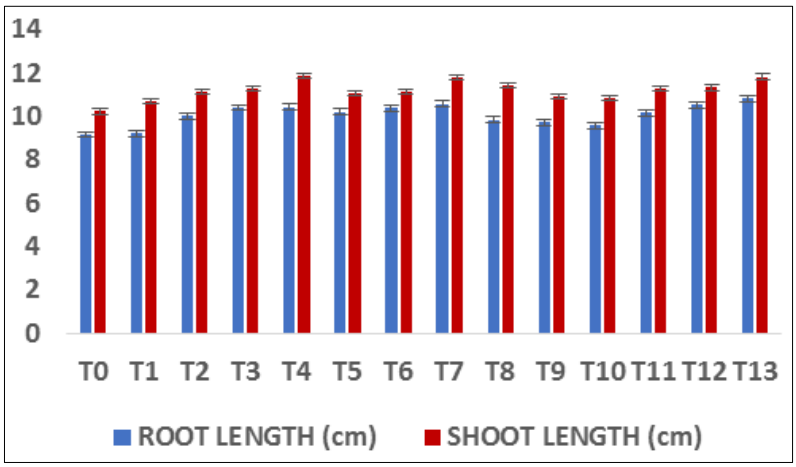

Fig 1: Effect of Biochar coating on root length and shoot length of Black gram VBN 11

Biochar contains minerals such as calcium, magnesium and other inorganic carbonates (Lehman, 2009) [9] involves in increasing radicle length (Novak *et al.*, 2009) [14], shoot length (Mendez *et al.*, 2017) [13] germination percentage and seedling dry weight (Das *et al.*, 2020) [2]. Biochar has been shown to encourage the growth helpful for microbes around seedlings.

The increase in root and shoot length may be due to the presence of high amount of macro- and microelements in biochar (Glodowsa *et al.*, 2016) [4] that provide nutrients to the developing seed. The speed of germination was highest in T_{13} (15.24) followed by T_4 (14.83) and the lowest was observed in T_0 (9.35) (Fig 2).

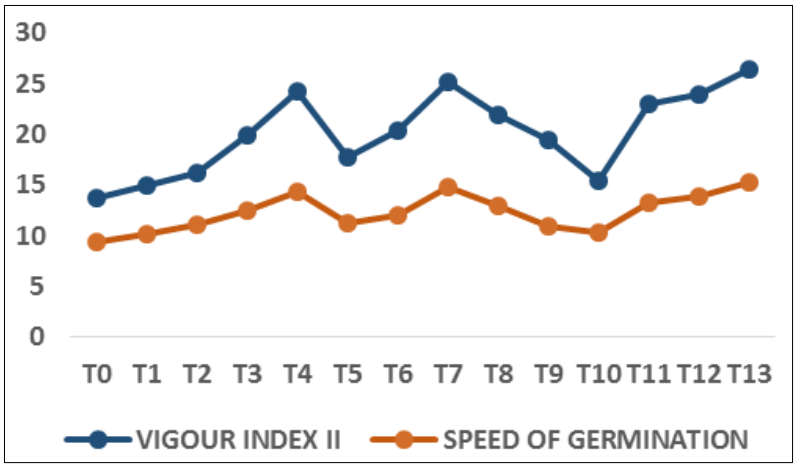

Fig 2: Effect of biochar coating on vigour index and speed of germination on Black gram VBN 11

Biochar not only increased germination rate but also increased the speed of germination. This result was in agreement with Wang *et al.* (2013) [24] in wheat. The fundamental benefit of using biochar was to increases water availability surrounding the seed, resulting in more favourable seedling environments (Pereira *et al.*, 2012; Akhtar *et al.*, 2014) [17, 1]. During the pyrolysis process, biochar produces certain volatile organic compounds (VOCs) i.e., ethylene and propylene that can help seeds germinate faster. (Solaiman *et al.*, 2012) [21]. Das (2019) [3] also proved that biochar made from sawdust and dry leaves improved wheat seed germination. Biochar coating showed the maximum dry weight accumulation (0.281 g) compared to control (0.171 g) (Table 1). Zhang *et al.* (2022) suggested that seed treatment with biochar had positive effect in growth attributes by increasing its seedling length and shoot dry weight. Early vigour and high germination percent were responsible for the increase in dry weight, since the seedlings reached the autotrophic stage earlier than the control (Srimathi *et al.*, 2007) [22]. The maximum vigour index was observed in T_{13} (2129) followed by T_4 (2059) and T_3 (2006) (Table 1). The reason for the rise in the vigour index was the stimulation of growth promoting substance and translocation of secondary metabolites.

Similarly, Dehydrogenase activity (0.583), Peroxidase activity (0.295 mg g^{-1} min^{-1}) were also higher in the seeds that are coated with biochar 200g/kg(T_{13}) and the untreated seeds(T_0) recorded lowest Dehydrogenase activity (0.507), Peroxidase activity (0.240 mg g^{-1} min^{-1}) (Fig 3).

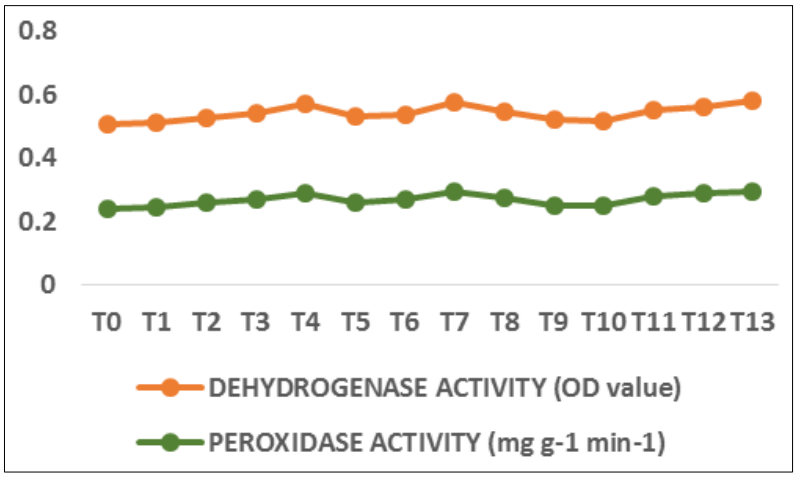

Fig 3: Effect of biochar coating on Dehydrogenase and Peroxidase activity on Black gram VBN 11

Peroxidase is important in determining seed quality because it protects against peroxide accumulation and causes hydrogen peroxide to decompose into water and oxygen (Zhang *et al.*, 1994) [25]. Klarod *et al.* (2021) [8] revealed that seed coating stimulated Total Dehydrogenase activity in tomato. The electrical conductivity of untreated seeds was high (0.25 dSm^{-1}) when compared to T_{13} (0.13 dSm^{-1}). Wang *et al.* (2013) [24] opined that increased proportion of biochar decrease the electrical conductivity.

Seed coated with biochar @ 200g/kg of seed recorded higher physiological characters, higher enzyme activity and low electrical conductivity compared to control (Fig 4). The recommended dose of biochar seed coating for black gram is 200g/kg of seed.

Control Biochar 200g/kg

Fig 4: Comparison between control and biochar coated seeds

4. Conclusion

This study concluded that biochar not only enhanced the soil properties on soil application, but also used to promote the seed quality characters through seed coating. Furthermore, this study revealed that among different coating, biochar coating with 200g/kg of black gram seed showed increased physiological and biochemical parameters. Further study may be explored using biochar for seed quality enhancement in various crops.

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