



Germination and seedling growth of *Sesbania* species as influenced by seed size

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Abstract

An experiment was carried out at Plant Systematics Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh to find out the effect of seed size on germination and seedling growth of three *Sesbania* species. Seed size was graded as small (3.1–3.5 mm), medium (3.6–4.0 mm) and large (4.1–4.5 mm); and three *Sesbania* species viz. *S. bispinosa*, *S. cannabina* and *S. sesban*, were used as experimental materials. The treatments were arranged in factorial experiment laid in completely randomized design having four replications. Though the effect of seed size on germination and seedling growth parameters followed similar trend, significant differences were observed among these three *Sesbania* species. Medium-sized seed produced the highest percentage of emergence and germination, and large-sized seed produced the highest seedling length, vigour index, and total biomass; although the numerical values did not differ statistically. The small-sized seeds were poor performer in all aspect of germination and seedling growth descriptors. The correlation matrix analyses showed that seed size, both length and/or width, highly correlated with root and seedling length, base diameter, vigour index and biomass yield of *Sesbania* spp. The medium to large-sized seed sown at relatively higher seed rate could be helpful for higher biomass yield of *Sesbania* spp. especially at the early growth stages.

Key words: *Sesbania* species, seed size, germination, vigour, seedling growth

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Introduction

Quality seeds ensure a successful crop production and the crop yield may be increased up to 15-20% (Ambika *et al.*, 2014). Seed size is one of the most important seed quality traits, which affects the performance of crop production (Adebisi *et al.*, 2013). It is a widely accepted measure of seed quality and different seed size affects seedling emergence, germination and other agronomical aspects (Kaydan and Yagmur, 2008). The nutrient content of seeds depends on seed size and varies in species to species (Arunachalam *et al.*, 2003). Seed size has also been considered an important evolutionary trait that affects the reproductive outcome

of many plant species (Cordazzo, 2002). Seed size directly influences the germination time (Murali, 1997; Souza and Fagundes, 2014), germination percentage (Molken *et al.*, 2005; Souza and Fagundes, 2014) and seedling vigour (Yanlong *et al.*, 2007), which can indirectly determine plant distribution and abundance across different habitats (Silveira *et al.*, 2012). However, seed size produced by plants varies between and within plant species, sometimes by several orders of magnitude (Leishman *et al.*, 1995; Silvertown and Bullock, 2003; Moles and Westboy, 2006).

Germination and seedling growth may be accelerated by the larger seeds (Khan and Shankar, 2001). The effect of seed size on seedling vigour and seed yields has recently been reviewed by Ambika *et al.* (2014). Large seeds generally help in producing better seedling compared to medium and/or small sized seeds due to sufficient energy content in large seeds (Mishra *et al.*, 2014). Nevertheless, heavy-weighted seeds help in producing better performance on seed germination, survival and initial seedling growth compare to light seeds (Upadhaya *et al.*, 2007; Singh and Sexena, 2009; Sadeghi *et al.*, 2011). However, contradictory results have also been reported for many species. For example, small or medium-sized seeds germinate faster at higher percentages than large-sized seeds have been reported in *Sesbania* spp. (Marshall, 1986), in *Prunus jenkinsii* (Upadhaya *et al.*, 2007), in *Copaifera langsdorfii* (Souza and Fagundes, 2014), etc.

Three *Sesbania* species viz. *S. sesban* (L.) Merr., *S. bispinosa* (Jacq.) W. Wight [former *S. aculeata* (Wild.) Poir.] and *S. cannabina* (Retz.) Poir., are traditionally known as *dhaincha* in Bangladesh (Ahmed *et al.*, 2009). *Dhaincha*, a nitrogen-fixing plant belongs to the family Fabaceae, is used for various purposes like green manure, fodder/feed, wood, firewood, fuel, bio-fuel, raw materials of pulp and paper, sources of fiber, fencing material and medicinal uses as well (Ndoye *et al.*, 1990; Shahjalal and Topps, 2000; Hossain and Becker, 2001; Chotechaungmanirat, 2010; Sarkar *et al.*, 2017; Sarwar *et al.*, 2017). As a green manure crop, biomass yield of *Sesbania* spp. is the prime concern. And vigorous seedlings may produce higher biomass at the early growth stages (Geneve, 2008). The early seed germination generally helps to establish seedling earlier and may produce higher biomass compared to later germinated seeds. However, literature on the effect of seed size on germination and growth of *Sesbania* spp. is scanty (Marshall, 1986). The present work, therefore, was designed to evaluate the effect of seed size on germination, vigour and seedling growth descriptors of three *Sesbania* species.

Materials and Methods

The experiment was conducted at Plant Systematics Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the month of May to June 2017, to evaluate the effect of different seed sizes on germination, vigour as well as seedling growth in three *Sesbania* species viz. *S. bispinosa*, *S. cannabina* and *S. sesban*. Seeds were collected from the previous year plants raised on Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University and harvested seeds were stored in a polythene bag. Seeds were graded, based on length, into three categories viz. small (3.1–3.5 mm; 16.4g 1000-seed⁻¹), medium (3.6–4.0 mm; 16.8g 1000-seed⁻¹) and large (4.1–4.5 mm; 17.2g 1000-seed⁻¹) which were measured with digital slide callipers from each species. After seed size grading, 200 seeds in each size were weighed with digital electric balance. Healthy seeds were used as experimental materials. The treatments were arranged in a completely randomized design having four replications. In a Petri dish, 50 seeds from each group were sown in the mixture of sand: soil: compost in 1:1:1 ratio. Desired soil moisture was maintained using water up to ten days. The seedlings emergence was considered just after coming out of cotyledons above the soil surface (Mishra *et al.*, 2014). For the judgment of growth and dry weight, 10 randomly selected seedlings from each replication were harvested from each Petri dish. Shoot length, root length, base diameter, length & width of cotyledons and length & width of leaf were measured using a ruler scale and digital slide callipers. Fresh & dry weights of seedling were measured by electric digital balance at ten days of age. Fresh samples were oven dried at 72±2 °C for 72 hrs. The cumulative germination (CG) percentage of seeds was counted daily up to 10 days. The CG percentage of seeds was calculated by the following formula (Bewley and Black, 1994).

$$\% \text{ CG} = (\sum n / N) \times 100$$

Where n is the number of seeds germinated at each day and N is the total number of seeds sown.

Vigour index (VI) was considered based on the mean shoot and root length; multiplied by the percentage of seed germination on 10th day/final day (Shreelalitha et al., 2015).

VI= (Mean shoot length + Mean root length) × Germination percentage

The collected data were analyzed by using Statistix 10 software, arithmetic mean, standard deviation, the coefficient of variation of seeds and seedlings attributes of three *Sesbania* species were compared with Duncan's new Multiple Range Test (DMRT) at 5% probability. Matrix correlation and the relative contribution of seed and seedling parameters were done through Principal Component Analysis using the "R" software program.

Results and Discussion

Both the seed size and species have significant effect on germination and seedling growth of *Sesbania*. In all *Sesbania* species, medium-sized seed produced higher emergence and germination percentage than other sized seeds (Table 1). Similar results were found by Edwards and Hartwig (1971) in *Glycine max*. This may be due to the larger seeds have longer cotyledons, which encounter a greater soil resistance to emergence (Gardner et al., 1985). Again larger seeds having

higher moisture requirement and these seeds take a longer time to germinate due to seed coat impermeability (Pandey et al., 2003). Among the *Sesbania* species, both the emergence and germination percentage of *S. sesban* seeds were comparatively lower than two other species (Table 1). This may be due to the genetic make-up of specific species (Sarwar et al., 2015). The large-sized seed of *Sesbania* species produced higher seedling length (SL) and vigour index (VI) (Table 1). Seed vigour is the responsible for seed quality and early seedling growth (Geneve, 2008). However, vigour depends on crop genetics, environmental and ecological conditions during grain filling to harvest period (Rezapour et al., 2013). It may be due to the presence of higher amount of storage carbohydrates in the seed. The large and medium-sized seeds of *Sesbania* species produced statistically identical in SL and VI. Amin and Brinis (2013) reported that medium-sized seed of durum wheat showed higher germination percentage, however, large-sized seed showed higher shoot length, vigour index and total biomass production. Among the *Sesbania* species, *S. sesban* produced longer seedling and *S. bispinosa* seeds possessed vigorous seedlings compared to others (Table 1).

Table 1. Effect of seed size on germination (%) and other seedling characters of three *Sesbania* species

| Species | Seed size | Emergence (%) | Germination (%) | Seedling Length (cm) | Vigour Index |
|---------------------|---------------------|---------------|-----------------|----------------------|--------------|
| <i>S. bispinosa</i> | Small | 86.0 c | 84.0 c | 10.6 e | 892.2 c |
| | Medium | 93.7 ab | 92.7 ab | 12.4 cd | 1147.0 a |
| | Large | 91.0 ab | 89.0 b | 13.0 bc | 1158.7 a |
| <i>S. cannabina</i> | Small | 90.7 b | 89.3 b | 9.82 e | 880.2 c |
| | Medium | 95.3 a | 95.3 a | 10.6 e | 1007.2 b |
| | Large | 92.3 ab | 92.0 ab | 11.7 d | 1074.0 ab |
| <i>S. sesban</i> | Small | 71.0 e | 69.3 e | 12.4 cd | 860.7 c |
| | Medium | 77.3 d | 76.0 d | 13.4 b | 1021.1 b |
| | Large | 74.3 de | 71.3 de | 15.2 a | 1086.6 ab |
| | LSD _{0.05} | 2.10 | 2.33 | 0.43 | 45.93 |

Seed size and seedling growth of *Sesbania* species

The large-sized seed of *S. sesban* produced the highest fresh weight followed by *S. bispinosa* and *S. cannabina* (Figure 1). A similar trend was also observed in case of biomass (Figure 2). These results matched with the results of Chanda *et al.* (2017). They have reported that *S. sesban* seedlings produced higher biomass compare to *S. bispinosa* and *S. cannabina* up to 20 days after sowing.

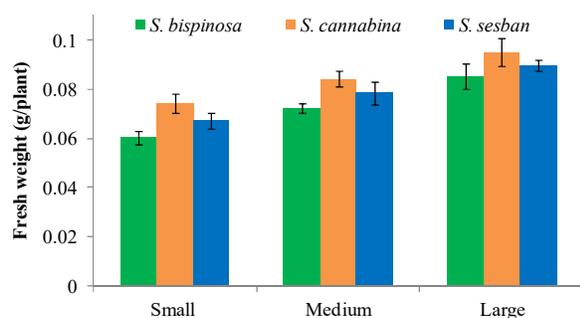


Figure 1. Effect of seed size on fresh weight of *Sesbania* seedling.

Results of the study showed a significant increase in shoot length (ShL), root length (RL), base diameter (BD), cotyledon length (CL), cotyledon width (CW), leaf length (LL) and leaf width (LW) with the increasing of seed size (Table 2). The highest ShL was recorded in the large-sized seed of *S. cannabina* and it

was significantly different than that of medium and small-sized seed. The large and medium-sized seed of *S. cannabina* produced higher RL followed by *S. bispinosa* and *S. sesban* seed. It may occur due to genetic effect of the species and large seed may contain much food in seed mass compare to small seed. Nevertheless, *S. sesban* seeds produced higher BD and *S. cannabina* produced higher CL and CW than others (Table 2). The large sized seed of *S. sesban* produced higher LL and LW followed by *S. cannabina* and *S. bispinosa*. Genetic factors may contribute to some in seedling growth characteristics i.e., shoot length, base diameter, root biomass (Carles *et al.*, 2009).

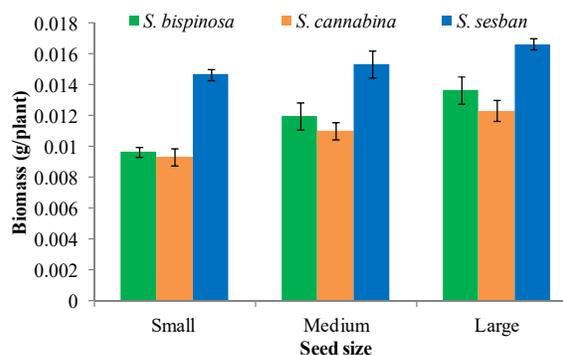


Figure 2. Effect of seed size on biomass of *Sesbania* seedling.

Table 2. Effect of seed size on growth parameter of three *Sesbania* species

| Species | Seed size | Shoot Length (cm) | Root Length (cm) | Base Diameter (cm) | Cotyledon Length (cm) | Cotyledon Width (cm) | Leaf Length (cm) | Leaf Width (cm) |
|---------------------|-----------|-------------------|------------------|--------------------|-----------------------|----------------------|------------------|-----------------|
| <i>S. bispinosa</i> | Small | 7.03 e | 2.79 bc | 0.44 b | 0.93 c | 0.35 c | 0.22 bc | 0.13 |
| | Medium | 7.91 de | 2.66 bc | 0.45 b | 0.98 c | 0.39 bc | 0.33 bc | 0.14 |
| | Large | 8.39 c-e | 3.30 b | 0.50 ab | 1.02 bc | 0.44 ab | 0.39 bc | 0.18 |
| <i>S. cannabina</i> | Small | 9.02 b-d | 3.39 b | 0.46 b | 1.11 ab | 0.46 ab | 0.11 c | 0.10 |
| | Medium | 9.00 b-d | 4.44 a | 0.49 ab | 1.17 a | 0.49 a | 0.18 bc | 0.10 |
| | Large | 10.6 a | 4.59 a | 0.50 ab | 1.19 a | 0.49 a | 0.42 bc | 0.21 |
| <i>S. sesban</i> | Small | 8.56 c-e | 2.06 c | 0.50 ab | 0.92 c | 0.33 c | 0.39 bc | 0.14 |
| | Medium | 9.91 a-c | 2.47 bc | 0.50 ab | 0.99 c | 0.35 c | 0.48 ab | 0.18 |
| | Large | 10.2 ab | 2.82 bc | 0.55 a | 1.01 bc | 0.36 c | 0.78 a | 0.20 |
| LSD _{0.05} | | 1.56 | 1.05 | 0.09 | 0.12 | 0.07 | 0.34 | 0.23 |

Correlation study can give a clear conception about the effect of seed size on the different variables including germination. The nine variables were significantly correlated at the 5% level of significance (Table 3). There were positive correlations among seed length with seed width, root length, seedling length, base diameter, total biomass and vigour index. The seed length was positively correlated with root length, seedling length, base diameter, vigour index and biomass yield. The positive correlations among seed size with root & shoot biomass and shoot length also reported in *Copaifera langsdorffii* (Souza and Fagundes, 2014). On contrary, seed width was positively correlated with seedling length and vigour index. Moreover, shoot length was positively correlated with seedling length, base diameter and biomass yield, and negatively correlated with root

length and germination percentage (Table 3). Germination percentage and vigour index was correlated with root length. The seedling length was positively correlated with base diameter, vigour index and biomass yield while negatively correlated with germination percentage (Table 3). The base diameter has a significant positive correlation with vigour index and biomass yield, but negative with germination percentage. Germination percentage was a significant negative correlation with biomass yield. The result revealed that seed length and seed width directly influence on shoot length, base diameter and seedling length of *Sesbania* species. Nevertheless, seedling length and germination percentage enhance vigour index. A similar result was found by Souza and Fagundes (2014).

Table 3. Correlation matrix with different seed & seedling attributes

| Variables | Seed Length (mm) | Seed Width (mm) | Shoot Length (cm) | Root Length (cm) | Seedling Length (cm) | Base Diameter (cm) | Germ-ination (%) | Vigour Index | Biomass (g/pl) |
|----------------------|------------------|-----------------|-------------------|------------------|----------------------|--------------------|------------------|--------------|----------------|
| Seed Length (mm) | 1.00 | | | | | | | | |
| Seed Width (mm) | 0.71* | 1.00 | | | | | | | |
| Shoot Length (cm) | 0.36 | 0.29 | 1.00 | | | | | | |
| Root Length (cm) | 0.38* | 0.13 | -0.42* | 1.00 | | | | | |
| Seedling Length (cm) | 0.60* | 0.39* | 0.87* | 0.08 | 1.00 | | | | |
| Base Diameter (cm) | 0.52* | 0.37 | 0.63* | 0.08 | 0.73* | 1.00 | | | |
| Germination (%) | 0.13 | 0.22 | -0.76* | 0.49* | -0.57* | -0.42* | 1.00 | | |
| Vigour Index | 0.80* | 0.64* | 0.21 | 0.62* | 0.57* | 0.40* | 0.35 | 1.00 | |
| Biomass (g/pl) | 0.49* | 0.32 | 0.81* | -0.16 | 0.80* | 0.74* | -0.66* | 0.25 | 1.00 |

* indicates significant at 5% level of probability.

Conclusion

The medium-sized seed produced the highest germination percentage in all three species of *Sesbania*, and the large seed produced the highest seedling length, vigour index and total biomass yield; although the numerical values did not differ statistically. The large-sized seed produced highest shoot & root length, base diameter, cotyledon length & width, leaf length and leaf width followed by medium and small-sized

seed. There were significant differences on germination and seedling growth parameters among the *Sesbania* species. The significant, both positive and/or negative, correlations were observed among the variables studied. It may be concluded that medium to large-sized seed sown at relatively higher seed rate could be helpful for higher biomass production of *Sesbania* spp. especially at the early growth stages.

Acknowledgement

We acknowledge the financial support of the Ministry of Science and Technology, Government of the People's Republic of Bangladesh.

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