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Article

Effect of seed rate on nodulation of Dhaincha (*Sesbania aculeata*)

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Abstract: A field experiment was conducted at The Agronomy Field, Patuakhali Science and Technology University (PSTU), Patuakhali during the period of May 2013 to August 2013. The experiment was conducted to find out the effect of seed rate on nodulation of dhaincha (*Sesbania aculeata*) under non-saline agro-ecosystem. The experiment comprised of seven different seed rates *viz.* 30, 35, 40, 45, 50, 55 and 60 kg ha^{-1}. The experiment was laid out in randomized complete block design with three replications. The seed rates had significant influence on different parameters of dhaincha plant. The maximum plant height was (4.109 m), maximum plant diameter was (0.9200 cm), maximum dry weight of nodule was (5.59 g plant^{-1}) were observed at the seed rate of 30 kg ha-1.In study period the maximum numbers of nodule plant^{-1} (39.60) at harvest and T_7 (60 kg ha^{-1}) showed minimum number of nodules plant^{-1} (30.33). It was observed that the highest number of abnormal nodules plant $^{-1}$ (19.87) while (30 kg ha^{-1}) gave the lowest number of abnormal nodules plant $^{-1}$ (12.47). It was found that the (30 kg ha^{-1}) observed the maximum dry weight of nodules (5.59 g plant^{-1}) and the minimum dry weight of nodules (3.61 g plant^{-1}) was found from (60 kg ha^{-1}). The highest plant population (336.0) was found in T_7 (60 kg ha^{-1}) while T_1 (30 kg ha^{-1}) showed the lower plant population (114.0). This result indicated that higher seed rate produced the maximum plant population than lower seed rate which ultimately resulted in higher production of biomass.

Keywords: seed rate; nodulation; dhaincha; *Sesbania aculeata*

1. Introduction

Sustainable agricultural production has gradually become the cornerstone of development policies in tropical, sub-tropical and Mediterranean countries. From the mid-sixties onward, the increase in agricultural production was based on the introduction of new high yielding varieties of crops, which required the application of large amounts of chemical fertilizers and pesticides. This policy, which underlay the green revolution, was successful in a number of Asian and South American countries. Nevertheless, it would not bring desirable benefit to many of the less favored areas where adequate fertilizers are not available and soils are very deficient in nutrients, especially N and P (Basu and Kabi, 1987). The nitrogen content of Bangladesh soils is typically very low. Nitrogen deficiency arises mainly due to rapid decomposition of organic matter induced by warm climate, losses of N due to denitrification and leaching and high removal by intensive cropping with modem varieties. Consequently, the use of bio fertilizers has increasingly been gaining global attention as one of the practices to restore and maintain soil fertility (Bhuiya *et al.*, 1995). In third world countries, fertilizer nitrogen is applied for cultivation of only a few cash crops and main dietary crops like rice and wheat. As a legume crop, dhaincha (*Sesbania aculeata*) has the unique ability of fixing and utilizing atmospheric nitrogen for its growth and enriching soil fertility as well as increasing the status of organic matter content of the soil. Such fixation of atmospheric nitrogen takes place through a biological process *i.e.* symbiotic association between *Sesbania* root and rhizobium bacteria. The nitrogen fixation potential of *Sesbania aculeata* has already been established and estimated as 176 kg N ha-1 in a period of 56 days (Furoc *et al.*, 1985). In addition, several workers (Tiwari *et al.*, 1980; Furoc *et al.*, 1985) have documented increased nodulation and high dry matter accumulation due to rhizobium inoculation. However, research work on the seed inoculation of *Sesbania* for effective nodulation, growth and biomass production and N_2-fixation received less attention in our country and nevertheless, it is necessary to identify the effective strains in terms of nodulation and nitrogen fixation ability of the host crop. Biological nitrogen fixation by tree legumes is important in relation to global environment. After Rio-De-Janerio earth summit in 1992 organized by United Nations, attention is focused on the global environmental problem. Heavy use of nitrogenous fertilizer is responsible for the ground water and surface water pollution through nitrate ions and destruction of ozone layer by gaseous oxides of nitrogen. But, biological nitrogen fixation is friendly to environment and it may reduce the use of nitrogen as chemical fertilizer. Therefore, it is necessary to develop bacterial bio fertilizer for tree legumes to reclaim environmental and soil hazards and to achieve sustainable agriculture. In the context of afforestation of marginal land, and nodulated nitrogen fixing tree legumes have a special advantage over other tree species. Wide ranges of leguminous N2-fixing trees are utilized in forestry, agroforestry and land reclamation (Dommergues, 1993). If the planting density is lower than its optimum value then total production will be lower and weeds will be higher (Allard, 1999). Higher the planting density, higher will be the canopy, which results in increased solar radiation capture. In addition, increasing planting density will also increase intra-specific competition among the plants, which affects the vegetative and reproductive growth of plants (Zhang *et al.*, 2006). Higher planting density also increases the relative humidity within canopy and leaf wetness by reducing air movement and sunlight penetration within canopy (Burdon and Chilvers, 1982; Tu, 1997). Thus, plant density could have significant impact on plant disease incidence (Burdon and Chilvers, 1982; Copes and Scherm, 2005). Reduction in seeds yield may be the result of lower number of pods, lower seeds weight or a combination of these components. In dense populations, many seeds may not develop. Jettner *et al.* (1999) stated that increasing yields at high sowing rate could be directly attributed to large plant population. There was strong relationship between economic optimum plant density and seed yield potential (Regan *et al.,* 2003). Increasing planting density is negatively correlated with fresh weightplant-1, the marketable fresh weight plant^{-1}and head size of the plants. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yields, for which it is important to know the effect of increasing planting densities on plant yield and biomass production. Keeping the above points in view, the present study was undertaken with the objective is to assess the optimum seed rate and the effect of seed rate on nodulation of dhaincha (*Sesbania aculeata*).

2. Materials and Methods

2.1. Description of the experimental site

2.1.1. Site selection

The experiment was conducted at the Patuakhali Science and Technology University farm during kharif season. The maximum area is covered by Gangatic tidal floodplains and falls under Agro ecological Zone “AEZ 13”. The area lies at 0.9 to 2.1 meter above mean sea level. This region occupies a vast area of tidal floodplain land in the north-west part of Patuakhali district.

2.1.2. Soil

Soil characteristics of the Patuakhali Science and Technology University farm are silty loams or alluvium. However, the soil of the experimental field was silty clay loam having pH value of 6.8. The characteristics of experimental soil was examined by the soil resource development institute (SRDI), regional laboratory, Barisal. The organic carbon content found 0.93% in most cases. Deficiency of nitrogen is acute and widespread. Status of exchangeable potassium is almost satisfactory. Phosphorus, Sulphurand other characteristics of soil status are also satisfactory.

2.2. Experimental crop

The crop used in the study was dhaincha (*Sesbania aculeata*). The seeds were obtained from the agronomy Field Laboratory, department of agronomy, Patuakhali Science and Technology University. The seeds were healthy, vigorous and well matured. The germination percentage of seeds was 90.

2.3. Lay out of the experiment

The experiment was laid out in a randomized complete block design with three replications. Each replication represents a block. Each block was subdivided into seven unit plots. The treatments were randomly distributed to the unit plots in each block. Total numbers of plots were 21 and the unit plot size was 4m x 2.5m = $10m^2$. Plot to plot distance was 0.5 m and block-to-block distance was 1.00 m.

2.4. Treatments

There were seven treatments with different seed rates. Treatments were as follows:

1. T_1: 30 kg seed ha^{-1}
2. T_2: 35 kg seed ha^{-1}
3. T_3: 40 kg seed ha^{-1}
4. T_4: 45 kg seed ha^{-1}
5. T_5: 50 kg seed ha^{-1}
6. T_6: 55 kg seed ha^{-1}
7. T_7: 60 kg seed ha^{-1}

2.5. Experimental details

2.5.1. Land preparation

The land was prepared by ploughing with the help of a power tiller. Laddering was done properly after each ploughing for breaking the clods and leveling the land. Weeds, stubbles and crop residues were removed from the field before final ploughing and leveling.

2.5.2. Sowing of seeds

Seeds were broadcasted on 22May 2013 before 8 PM and were covered by soils soon after seeding.

2.5.3. Germination of seeds

Germination of seeds started from 3 DAS and continued up to 10 DAS. High percentage of germination was more than 80 and on the 11th day, nearly all plants came out of the soil.

2.5.4. Intercultural operations

2.5.4.1. Weeding

The experimental plots were infested by some weeds which were uprooted from the field twice at 15 and 30 days after sowing.

2.5.4.2. Application of fertilizers and insecticides

During land preparation TSP, MoP and DAP were applied at the rate of 45 kg ha^{-1}, 30 kg ha^{-1}, 35kg ha^{-1} which mixed with soil properly to improve soil properties. The crop was infested with insect which was controlled by applying Sevin 60 EC insecticide once.

2.5.5. Data collection

Five plants were randomly selected from each plot to record nodulation, shoot growth, root growth and total growth character at 30, 45 and 60 days of sowing. Plant samples were collected from the plots before maturation of seed. From each plot, five plants were carefully uprooted with soil, so that no nodule was left in the soil. The collected nodulated plants were washed in a slow stream of tap water and were finally cleaned with a soft camel hairbrush to ensure the removal of soil particles adhering to the root surface. The nodules from the root system of each plant were separately collected and counted. The shoot portion of each plant was then separated from the root and the length of each plant was recorded. The root, shoot and nodules were air-dried and then oven dried at 65°C for 72 hours. The oven dry weight of roots, shoots and nodules were recorded and the shoot and root samples were stored for analysis. Shoot growth, root growth and total growth obtained from each plot after final harvest were dried and weighed carefully.

2.6. Harvesting

Harvesting was started when 80% of the plant population of each plot reached to the seed maturity and showed physiological maturity symptoms.

2.7. Statistical analysis

Data obtained from the field experiment were analyzed statistically by the method of analysis of variance of Gomez and Gomez (1984). The treatment means of different characters were compared following duncan'snew multiple range test (DMRT).

3. Results and Discussion

3.1. Effect of seed rate

3.1.1. Plant height

Different seed rates had significant effect on plant height of dhaincha at harvest. It was found that T_1 (30 kg ha^{-1}) recorded the tallest plant (4.11 m) followed by T_4 (45 kg ha^{-1}) while T_7 (60 kg ha^{-1}) gave the smallest plant (3.66 m) (Figure 1). These results revealed that 30 kg ha^{-1} was more efficient than other seed rate regarding plant height. Similar result was also obtained by Zhang *et al.* (2006) in case of soybeans. Figure followed by same letter(s) are statistically similar as per DMRT at 5%.

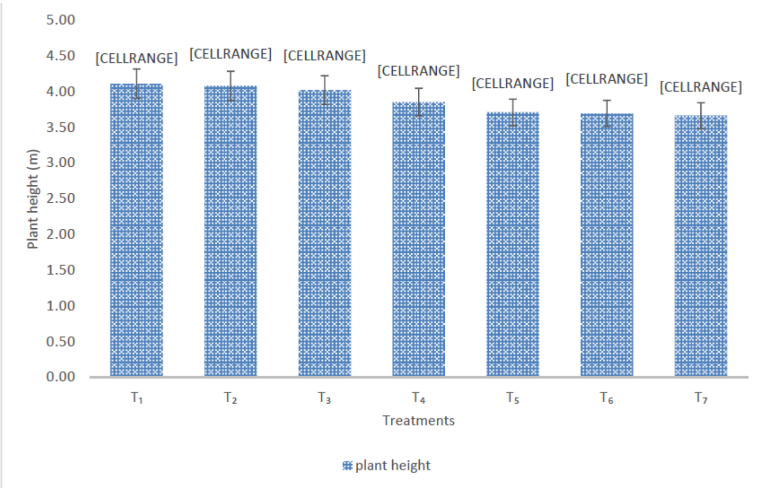

Figure 1. Effect of seed rate on plant height ($S_{\bar{X}}$ = 0.063).

3.1.2. Plant diameter

Effect of different seed rate significantly influenced plant diameter at harvest where T_1 (30 kg ha^{-1}) produced significantly the maximum plant diameter (0.92 cm) at harvest while the lowest plant diameter was obtained from T_6 (55 kg seed ha^{-1}) (0.79) (Figure 2). Similar study was also done by Venkanna (2014) who reported similar result in case of dhaincha. Figure followed by same letter(s) are statistically similar as per DMRT at 5%.

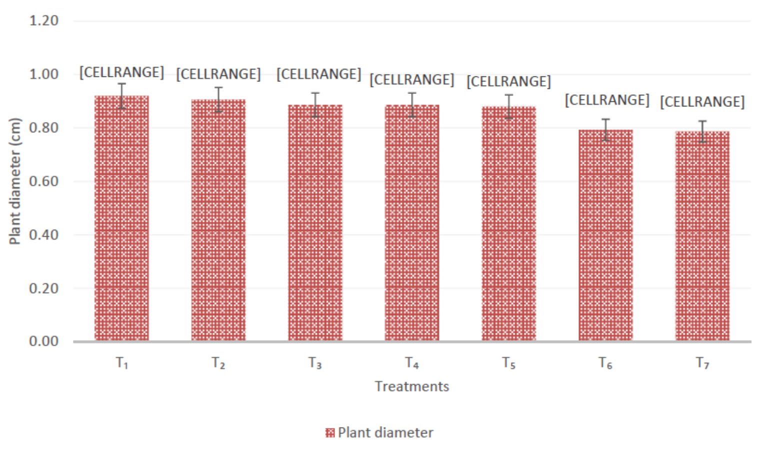

Figure 2. Effect of seed rate on plant diameter ($S_{\bar{X}}$= 0.037).

3.1.3. Number of nodules plant^{-1}

Different seed rates significantly influenced number of nodules plant-1 before harvest where T_1 (30 kg ha^{-1}) produced significantly the maximum numbers of nodule plant^{-1} (39.60) at harvest and T_7 (60 kg ha^{-1}) showed minimum number of nodules plant^{-1} (30.33) (Figure 3). These results revealed that higher crop density showed better performance to produce more nodule than lower crop density. Venkanna *et al.* (2013) found the same result in case of dhaincha. Figure followed by same letter(s) are statistically similar as per DMRT at 5%.

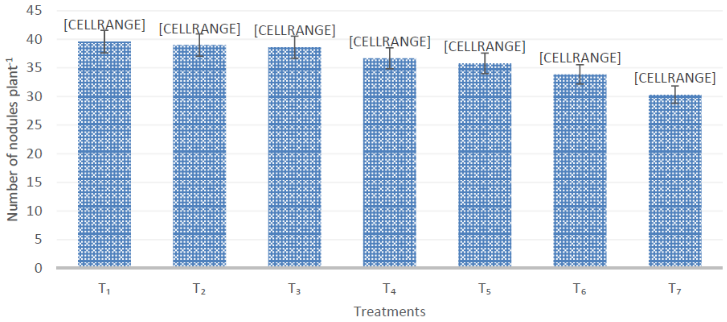

Figure 3. Effect of seed rate on number of nodules plant^{-1} ($S_{\bar{X}}$= 0.25).

3.1.4. Number of abnormal nodules plant^{-1}

It was found that the T_7 (60 kg ha^{-1}) recorded the highest number of abnormal nodules plant $^{-1}$ (19.87) while T_1 (30 kg ha^{-1}) gave the lowest number of abnormal nodules plant $^{-1}$ (12.47). These results revealed that 60 kg ha^{-1} was more efficient than other seed rate regarding to abnormal nodules due to lower plant population (Figure 4). Similar findings were obtained by Regan *et al.* (2003) who found that the lower crop density performed better than higher crop density produced lower number of abnormal nodules plant^{-1}in chickpea. Figure followed by same letter(s) are statistically similar as per DMRT at 5%.

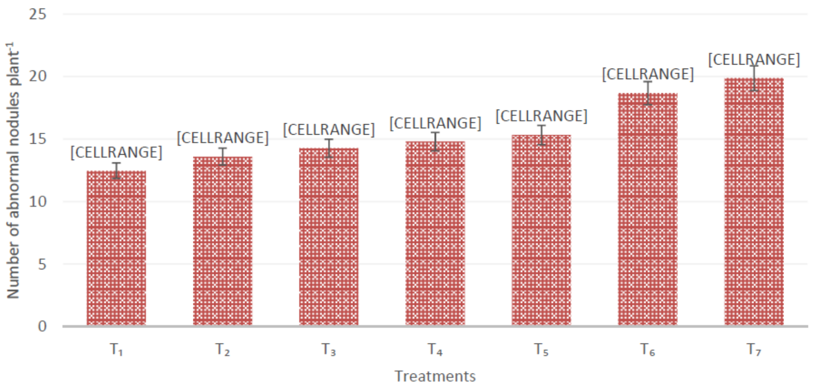

Figure 4. Effect of seed rate on number of abnormal nodule plant^{-1} ($S_{\bar{X}}$= 0.33).

3.1.5. Dry weight of nodules

Dry weight of nodules plant^{-1} differed significantly among the treatments at harvest (Table 1). From the Table 1, it was found that the T_1 (30 kg ha^{-1}) observed the maximum dry weight of nodules (5.59 g plant^{-1}) and the minimum dry weight of nodules (3.61 g plant^{-1}) was found from T_7 (60 kg ha^{-1}) which was statistically similar with T_6 (55 kg ha^{-1}). These results revealed that dry weight of nodules increased significantly with the increasing the rate of seed up to 30 kg ha^{-1}. So, the application of 30 kg ha^{-1} recorded highest dry weight of nodules due to more effectiveness to produce proper microclimate in soil and kept the proper moisture and fertility of the soil. These findings were similar to Jettner *et al.* (1999) for desi chickpea (*Cicer arietinum* L.).

3.1.6. Plant population

Plant population showed significant variation due to different seed rates (Table 2) where significantly the highest plant population (336.0) was found in T_7 (60 kg ha^{-1}) while T_1 (30 kg ha^{-1}) showed the lower plant population (114.0). This result indicated that higher seed rate produced the maximum plant population than lower seed rate which ultimately resulted in higher production of biomass. Similarly, Morrisson *et al.* (1990) reported that significantly the highest plant population was obtained in higher seed rate in summer rape.

Table 1. Effect of seed rate on fresh weight m^{-2}, dry weight of nodule plant^{-1} and below biomass ground m^{-2}.

Treatments	Fresh weight of plant(kg m^{-2})	Dry weight of nodulesplant^{-1} (g)
T1	1.93 f	5.59 a
T2	2.31 e	5.263b
T3	2.68 d	5.18 b
T4	3.00 c	4.48 c
T5	3.17 c	3.93 d
T6	3.50 b	3.79 de
T7	4.10 a	3.61 e
$S_{\bar{X}}$	0.077	0.080
CV (%)	4.52	3.01
Level of significance	**	**

Table 2.Effect of seed rate on plant population and number of branches plant^{-1}.

Treatments	Plant population (m^{-2})	Number of branches plant^{-1}
T_1	114.0 g	23.93 a
T_2	128.0 f	11.93 b
T_3	153.0e	11.33 bc
T_4	185.7 d	11.13 bc
T5	228.3 c	10.87 cd
T_6	278.0 b	10.07 d
T_7	336.0 a	7.933 e
$S_{\bar{X}}$	2.143	0.303
CV (%)	1.83	4.21
Level of significance **		**

** denotes significant at 1% level of significance, significant at 5% level of significance and non significant, respectively.

4. Conclusions

The research work was conducted at the Agronomy field, Patuakhali Science and Technology University, to investigate the effect of different seed rates on growth, nodulation, and yield, and yield performance of dhaincha during the period from May 2013 to August 2013. The research work consisted of seven treatments viz. 30, 35, 40,45,50,55, 60 kg ha^{-1}. Form this study it is clear that the lowest Plant diameter (0.79) and lowest number of pods branch^{-1} (17.07) were observed at the seed rate of 60kgha^{-1}. Dry weight of nodules(3.61g plant^{-1}),below ground biomass production m^{-2} (0.193) and hundred seed weight (3.18) were lowest at the seed rate of 60 kgha^{-1}.Dry weight of nodule (3.61), below ground biomass production m^{-2} (0.1933) and hundred seeds weight (3.18g) resulted lowest at the seeds rate was 60 kgha^{-1}. It is also clear that seed rate influenced the growth and yield-attributing traits of dhaincha where the seeds 30 kgha^{-1}performed the best over other treatments in respect of seed production. Therefore, seed rate of 30kgha^{-1} would be appropriate for the seed production and seed rate 60 kg ha^{-1} was the best for biomass production of dhaincha under Agro-ecological region of Patuakhali (AEZ 13).

Conflict of interest

None to declare.

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