ISSN: 2572-5971

Research Article

Advances in Nutrition & Food Science

Plant Density Effects on Yield and Yield Attributes of Two Soybean Varieties in *Kharif-II* Season of Bangladesh

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Submitted: 28 Mar 2019; **Accepted**: 29 June 2019; **Published**: 15 July 2019

Abstract

The present study was undertaken with a view to study the effect of plant density on yield and yield attributes of two soybean varieties in kharif–II season. The experiment was conducted in kharif-II season 2012 at mymensingh with two soybean varieties, namely PB-1 (Shohag) and G-2 (Bangladesh soybean-4) and six plant densities, viz; 20, 40, 60, 80, 100 and 120 plants m^{-2} established using an equidistant (square) planting pattern of 22.4cm x 22.4 cm, 15.8 cm x 15.8 cm, 12.9 cm x12.9 cm, 11.2 cm x 11.2 cm, 10 cm x 10 cm and 9.1 cm 9.1 cm, respectively. The experiment was laid out in a split-plot design with varieties in main-plots and plant densities in sub-plots. The treatments were replicated three times. Increased plant density increased plant height, number of nodes $plant^{-1}$, total dry matter, seed yield (1.02 t ha^{-1}) and Stover yield (1.15 t ha^{-1}) 80 to 100 plants m^{-2} and then decreased with increased plant density. Again increased plant density linearly decreased in number of branches $plant^{-1}$, fertile pods $plant^{-1}$, non-fertile pods $plant^{-1}$, number of seeds $plant^{-1}$, seed yield $plant^{-1}$ and 100-seed weight up to 120 plants m^{-2} depending on variety and season. The study concludes that the highest yield of soybean in kharif –II season could be obtained from varietyPB-1 with a plant density of 100 plants m^{-2} and 80 plants m^{-2}in G-2.

Keywords: Variety, Plant density, Seed yield, *khari II* season and Interaction

Introduction

Soybean [*Glycine max* (L) Merril] is the world's most important oil producing grain legume crop in terms of total production and international trade. It is a leguminous crop and has a tremendous value in agriculture as a good source of high quality plant protein. It is also an important source of vegetable oils and phytochemicals in the USA and in many Asian countries [1]. For its nutritive value, soybean has been called as Miracle Golden Bean, the Golden nugget, the nugget of nutrition etc. Soybean being a good source of protein, unsaturated fatty acids, minerals like Ca and P, and vitamin A, B, C and D can meet up different nutritional needs [2]. Soybean is also referred to as "the protein hope of the future". Soybean seed contains about 42-45% protein, 20-25% edible oils, 24-26% carbohydrate [3]. A number of nutritious food items like soya-dal, soya chatni, soya-khichuri, soya-pollao, soya-bori, soya-porata, soya-milk, soya-cakes, soya-biscuits, soya-bread, soya-flour and roasted soybean snacks etc can be made from soyabean [4,5]. Soybean seed is used as feed for fish and poultry. The demand of soybean as human food as well as feed for animal and fish are increasing day by day. The crop is grown throughout the world with the largest production in the United States, Brazil and Peoples Republic of China, Mexico, Indonesia and Argentina. The world production of soybean as estimated in 1999 was 161.99 million mt. from an area of 73.44

million hectares and 196 million mt. in 84 million ha with the average production of 2.33 t ha^{-1} [6]. The annual production of soybean in Bangladesh is around only 3000 mt. which is negligible compared to its huge demand [7]. Currently, Bangladesh has to import soybean cooking oil worth US $ 180 million and soybean meal of about US $ 25.51 million per year [7]. Despite suitable climatic and edaphic conditions, the yield of soybean is very low in Bangladesh. The average yield of soybean in the world is about 3.0 t ha-1 while that in Bangladesh is only 1.2 t ha^{-1} [8]. Planting density is one of the main factors that has an important role on growth and yield of soybean. Within certain limits, increase of Plant Population Density (PPD) decreases the growth and yield per plant but the reverse occurs for yield per unit area [9]. Under the temperate environment of Canterbury, New Zealand, increase of Plant Population Density (PPD) up to 40 plants m^{-2} gave the highest yield but above this PPD no yield advancement was achieved [10]. In Bangladesh most of the farmers follow broadcast method or line sowing method without maintaining proper spacing for growing soybean. The row spacing recommended in Bangladesh is 30 cm in rabi season and 40 cm in *kharif* season with a target of having 66 plants m^{-2} for soybean [11]. There are two general concepts to describe the relationship between plant density and seed yield. Firstly, irrespective of plant spacing within and among rows, plant density must be such that the crop develops a canopy able to intercept more than 95% of the incoming solar radiation during early reproductive growth, and so maximize seed yield [12]. Secondly, a nearly equidistant plant arrangement minimizes interplant competition and produces maximum seed yield [13]. The optimum plant density to attain highest yield may vary with the genotype and geographical location. In the USA, the optimum plant density varies from 30 to 50 $plantsm^{-2}$ [14]. In South Korea, Kang et al., reported the highest yield at 33 to 53 plants m^{-2} while the Cho and Kim, obtained highest yield at 66 plants m^{-2} [15,16]. Again, Singh reported the highest yield with 66 plants m^{-2} while from the study of Mehmet it was 29 plants m^{-2} [17,18]. The optimum plant density reported in Kenya was 45 plants m^{-2} while that in Ethiopia was 40 plants m^{-2} [19, 20]. In Iran, the highest yield of soybean is obtained at 60 plants m^{-2} [21]. Determination of optimum plant density of a specific cultivar is necessary for successful seed crop production. Soybean is grown for seed in the *kharif-II* season but research reports on the effect of plant density on soybean seed yield in any of the seasons are scarcely available. Therefore, the present study was conducted to find out the optimum of plant densities and to see the interaction, if any, between variety and plant density on yield and yield attributes of two soybean varieties in *kharif- II* season.

Materials and Methods

An experiment was conducted at Bangladesh Agricultural University, Mymensingh (latitude 24°75'N, longitude 90°5'E, altitude 18m) during the period from July to November 2012. The site belongs to the Sonatola soil series of Non-calcareous Dark Grey Floodplain soil under the Old Brahmaputra Floodplain Agro-ecological Zone (AEZ-9) [22]. The experimental field was a high land having sandy loam soil with pH 6.9. The total rainfall during the period of study was 1715.4 mm while the maximum and minimum monthly total rainfall recorded in August and November were 499.3 mm and 0.00 mm, respectively. The Sun shine (hrs.) recorded was maximum in November (223.5) and minimum in August (87.7). Two soybean varieties Shohag (PB-1) and G-2 (Bangladesh Soybean-4) were used as test crop. Soybean variety PB-1 and G-2 were released by the National Seed Board (NSB) in 1991 and in 1994 for cultivation both in Rabi and *Kharif* seasons in Bangladesh. The plant height ranges from 36-42 cm in variety PB-1 and 60-80 cm in variety G-2. The crop requires 95-100 days in variety PB-1 and 90-120 days in variety G-2 from seeding to maturity. The seed color of PB-1 is creamy white and that in G-2 is greenish. These varieties (PB-1 and G-2) give an average yield of 1.6-1.8 t ha^{-1} and 1.6-2.5 t ha^{-1}, respectively. (BARI 2005). 6 (Six) plant density 20 plants m^{-2}(22.4 cm x 22.4 cm), 40 plants m^{-2}(15.8 cm x 15.8 cm), 60 plants m^{-2}(12.9 cm x 12.9 cm), 80 plants m^{-2}(11.2 cm x 11.2 cm), 100 plants m^{-2}(10 cm x 10 cm) and 120 plants m^{-2} (9.1 cm x 9.1 cm) were used in this experiment. The experiment was laid out in a split-plot design with variety in the main plot and plant density in the sub-plot. Treatments were replicated three times. The total numbers of plots were 36 and size of each plot was (4.4 m x 2.53 m). The distances kept between replications and that between main plots were 1m and 0.51m, respectively. Fertilized with N, P_2O_5, K_2O, S, and Zn @ 23, 69, 60, 16 and 1 kg ha^{-1}, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the time of final land preparation [23]. The seeds were inoculated by Rhizobiuminoculum @ 30g of inoculums per kg^{-1} seed to develop proper coating [24]. Before sowing the seeds were placed in a dry and shady place and then were sown immediately. Seed was sown on 28 July 2005 giving four to five seeds $hill^{-1}$ at 2 to 3 cm depth. Finally one plant was kept after final thinning. Intercultural operations such as weeding, thinning, gap filling, drainage and spraying of insecticides were done as and when required. Weeding followed by thinning was done at 20, 40 and 60 days after sowing (DAS). No irrigation was required but drainage was done when needed. The crop was infested with hairy caterpillars (*Spilarctia oblique*) which was successfully controlled by spraying Dimathion 50 EC @ 1 L ha^{-1} at 65 DAS. No disease infestation was observed in the experimental field and therefore, no disease control measure was needed. The crop was harvested by hand from 6.36 m^2 central area of each unit plot on 27 October and 14 November 2012 at full maturity (when about 95% pods become brown in color) for G-2 and PB-1, respectively. Just before harvesting, ten sample plants (excluding border) were selected randomly from the central harvesting area of each unit plot and were uprooted for recording necessary data on crop characters and yield attributes. After harvesting the crop was then brought to the threshing floor and dried for four consecutive days in the sun. Threshing was done by beating with sticks. The seeds were then cleaned and dried in the sun for 3-4 consecutive days. The seed yield was recorded plot- wise after adjusting the seed moisture content of about 10 % moisture level. Yield and yield attributes were recorded accordingly. The data were analyzed using analysis of variance (ANOVA) technique and the mean difference among the treatments were adjudged by Duncan's Multiple Range Test with a computer Package program me MSTAT-C [25].

Results and Discussion

Plant Height

Effect of Variety: Plant height varied significantly between two varieties (Table 1). Plant height was higher in variety PB-1 (33.54 cm) compared with variety G-2 (27.75 cm). The plant height variation between two varieties is related to their genetic makeup. Pannusway et al., found that plant height differed between varieties having taller plants in variety Co 1 (50.30 cm) compared with variety PK-472 (37.80 cm).

Effect of Plant Density: Plant height was significantly influenced by plant density (Table 1). The plant height was highest (36.35 cm) with the crop at 100 plants m^{-2}, while the shortest plant (26.02 cm)

was observed for the crop at 20 plants m^{-2}. The result clearly showed that plant height increased with increasing plant density. Sumadi et al., also observed that plant height increased with increasing plant population [26]. Again, Khelkar et al., also found that soybean cv. MACS-13 and Monetta's plant height was significantly increased at higher plant densities [27].

Interaction Effect of Variety and Plant Density: There was a significant effect of interaction between variety and plant density on plant height (Table 2). The tallest plant (42.58 cm) was found with variety PB-1 from 100 plants m^{-2} while the shortest plant (24.82 cm) was found with variety G-2 at 20 plants m^{-2}. Nijafi et al., observed that plant height of cultivar Williams and Harcor reduced in narrow rows with later sowing [28].

Number of Nodes Plant^{-1}

Effect of Variety: The number of nodes plant-1 differed significantly between the varieties. Variety PB-1 had higher number of nodes plant^{-1} (12.40) than that (11.12) of variety G-2 (Table 1). The result indicated that the number of nodes plant^{-1}vary from variety to variety. Similar result was obtained by Nahid.

Effect of Plant Density: There was significant difference in number of nodes plant^{-1} due to plant densities (Table 1). The highest number of nodes plant^{-1} (12.35) was produced at 100 plants m^{-2}, which was statistically identical to those at 80 and 60 plants m^{-2}. The lowest number of nodesplant^{-1} (10.81) was found with 20 plantsm^{-2}. The number of nodes plant^{-1} increased with each increase in planting densities from 20 to 100 plants m^{-2} but further increased in plant density number of nodes plant^{-1} with decreased. The increased in plant density increased the number ofnodes plant^{-1}[15].

Interaction Effect of Variety and Plant Density: Number of nodes plant^{-1} was significantly influenced by the interaction of plant density and variety (Table 2). The highest number of nodes plant^{-1} (12.90) was found in variety PB-1 when sown at 100 plants m^{-2}, which was statistically similar with those at 40, 60, 80 and 120 plants m^{-2}, respectively. The lowest number of nodes plant^{-1} (10.36) was observed in variety G-2 at 120 plants m^{-2}, which was statistically similar with the same variety at 20 plantsm^{-2}.

Number of Branches Plant^{-1}

Effect of Variety: Number of branches plant^{-1} was influenced significantly by variety (Table 1). Variety PB-1 produced higher number of branches plant-1 (1.02) than the variety G-2 (0.68). Islam (2004) observed that branches plant-1 differed significantly between two soybean genotypes.

Effect of Plant Density: The number of branches plant^{-1} was affected significantly by planting density (Table 1). The highest number of branches plant^{-1} (1.08) was obtained when sown at 20 plants m^{-2}. The lowest number of branches plant^{-1} (0.60) was found with the crop sown at 120 plants m^{-2}. The increase in number of branches plant-1 might be attributed to the availability of nutrients and solar radiation for low population crops as compared to those under higher plant population. Nijafi et al., showed that branch number plant-1 was greater in wide rows in soybean cv. Harcor and Williams [28].

Interaction Effect of Variety and Plant Density: Significant variation was observed in number of branches plant^{-1} due to interaction effect of variety and plant density (Table 2). The highest number of branches plant^{-1} (1.33) was found in PB-1 at 20 plants m^{-2} and the lowest number of branches plant^{-1} (0.63) was produced with G-2 at 120 plants m^{-2}.

Total Dry Matter

Effect of Variety: The effect of variety on total dry matter was significant (Table 1). The higher total dry matter (211.60 g m^{-2}) was obtained in variety PB-1 than that (116.42 g m-2) in variety G-2.

Effect of Plant Density: There was significant difference in total dry matter due to plant density (Table 1). The highest total dry matter (217.29 g m^{-2}) was found at 100 plants m^{-2} and the lowest (105.18 g m^{-2}) at 20 plants m^{-2}. Rahman and Miah observed highest dry matter per unit area at high population in mungbean [29].

Interaction effect of variety and plant density: Variety and plant density interacted significantly for total dry matter (Table 2). The highest total dry matter (294.83 g m^{-2}) was observed in variety PB-1 at 100 plants m^{-2}. The lowest total dry matter (83.75 g m^{-2}) was observed at 40 plants m^{-2} in variety G-2 and similar result was observed with the same variety at 20 plants m^{-2}. Bisht and Chandel showed that increase in plant density decreased dry matter plant^{-1} in six soybean cultivars [30].

Yield and Yield Attributes

Number of Fertile Pods Plant^{-1}

Effect of Variety: The effect of variety on number of fertile pods plant^{-1} was significant (Table 3). Higher number of fertile pods plant^{-1} (18.38) was obtained from variety PB-1 than variety G-2 (11.76). The result revealed that the number of fertile pods plant^{-1} depends on varietal characteristics. Islam observed that fertile pods plant^{-1} differed significantly between two soybean genotypes.

Effect of Plant Density: There was a significant effect of plant density on the number of fertile pods plant^{-1} (Table 3). The highest number of fertile pods plant^{-1} (16.91) was obtained from crop sown at 20 plants m^{-2}, which was statistically identical to that at 40 plants m^{-2}. The lowest (12.88) number of fertile pods plant^{-1} was found with 120 plants m^{-2}. The number of fertile pods plant^{-1} decreased with increasing plant density. Similar result was obtained by Shafshak et al., [31].

Interaction Effect of Variety and Plant Density: The interaction effect of variety and plant density on the number of fertile pods plant^{-1} was non-significant (Table 4). However, numerically the highest number of fertile pods plant^{-1} (20.86) was obtained from variety PB-1 at a density of 20 plants m^{-2}. The lowest number of fertile pods plant^{-1} (10.23) was found in variety G-2 sown at 120 plants m^{2}.

Number of Non-Fertile Pods Plant^{-1}

Effect of Variety: Variety had significantly influence on number of non-fertile pods plant^{-1} (Table 3). Variety PB-1 produced higher number of non-fertile pods plant^{-1} (1.50) than variety G-2 (0.76). The result revealed that the production of non-fertile pods plant^{-1} was more in PB-1 compared with G-2.

Effect of Plant Density: There was a significant effect of plant density on number of non-fertile pods plant^{-1} (Table 3). The highest number of non-fertile pods plant^{-1} (2.06) was obtained from 20 plants m^{-2}. The lowest number of non-fertile pods plant^{-1} (0.63) was

found from the crop at 120 plants m^{-2}. It was clear that the number of non-fertile pods $plant^{-1}$ increased with decreasing plant density.

Interaction Effect of Variety and Plant Density: The interaction effect of variety and plant density was significant for number of non-fertile pods $plant^{-1}$ (Table 4). Variety PB-1 sown at 20 plants m^{-2} resulted the highest (2.10) non-fertile pods $plant^{-1}$ which was statistically similar to that at same plant density in variety G-2. The lowest number of non-fertile pods $plant^{-1}$ (0.30) was produced with variety G-2 sown at 120 plants m^{-2}.

Number of Seeds $Plant^{-1}$

Effect of Variety: Variety had a significant influence on number of seeds $plant^{-1}$. The higher number of seeds $plant^{-1}$ (37.14) was found in variety PB-1 than that (23.00) in variety G-2 (Table 3).

Effect of plant density: Plant density had a significant effect on number of seeds $plant^{-1}$ (Table 3). The highest number of seeds $plant^{-1}$ (35.79) was found from 20 plants m^{-2}. The lowest number of seeds $plant^{-1}$ (24.83) was found from 120 plants m^{-2}. It is clear that number of seeds $plant^{-1}$ increased with decreasing plant density. Similar result was obtained by Akhtaruzzaman [32].

Interaction Effect of Variety and Plant Density: Interaction effect of variety and plant density was significant for number of seeds $plant^{-1}$. The highest number of seeds $plant^{-1}$ (45.00) was produced in variety PB-1 sown at 20 plants m-2 and the lowest (19.80) was found from variety G-2 sown at 120 plants m^{-2} (Table 4).

Number of Seeds Pod^{-1}

Effect of variety: The number of seeds pod^{-1} did not vary significantly due to variety (Table 3). But numerically the number of seeds pod^{-1} (2.03) was higher in variety PB-1 than in variety G-2 (1.96).

Effect of Plant Density: Plant density had a non-significant influence on number of seeds pod^{-1} (Table 3). The lowest number of seeds pod^{-1} (1.88) was found at 100 $plantsm^{-2}$ and the highest number of seeds pod^{-1} (2.10) was found at 20 $plantsm^{-2}$.

Interaction Effect of Variety and Plant Density: There had no-significant influence of interaction of variety and plant density on number of seeds pod^{-1} (Table 4). However, the lowest number of seeds pod^{-1} (1.87) was found in variety G-2 at 100 plants m^{-2} and the highest (2.15) was obtained from variety PB-1 at 20 plants m^{-2}.

Seed Yield $Plant^{-1}$

Effect of Variety: Variety had significant effect on seed yield $plant^{-1}$ (Table 3). Higher seed yield $plant^{-1}$ (3.27 g) was found in variety PB-1 than variety G-2 (1.13 g). Islam found higher seed yield $plant^{-1}$ in variety G-2 than variety PB-1. This character probably related to the growing season.

Effect of Plant Density: Seed yield $plant^{-1}$ significantly varied due to plant density (Table 3). The highest seed yield $plant^{-1}$ (2.51g) was obtained from 20 $plantsm^{-2}$, which was statistically identical with 40 plants m^{-2}. The lowest seed yield $plant^{-1}$ (1.77g) was found from 120 plants m^{-2}. Zeyada et al., reported that seed yield $plant^{-1}$ decreased with increasing plant density [33].

Interaction Effect of Variety and Plant Density: Seed yield $plant^{-1}$ was significantly influenced by interaction of variety and plant density. The highest seed yield $plant^{-1}$ (3.79g) was found in the variety PB-1 at 20 plants m^{-2}. The lowest seed yield $plant^{-1}$ (0.86g) was obtained from the variety G-2 at 120 plants m^{-2} (Table 4). Nenadic and Slovic found that seed yield was highest at lower density [34].

Weight of 100-Seed

Effect of Variety: Variety had a significant influence on 100-seed weight (Table 3). Higher 100-seed weight (9.93g) was found in variety PB-1 than variety G-2 (5.33g). Mojumdar observed that 100-seed weight differed significantly between two soybean cultivars PB-1 and G-2 [35].

Effect of Plant Density: Plant density had significant effect on 100-seed weight (Table 3). The highest 100-seed weight (7.90g) was found at 20 plants m^{-2} which was statistically identical with 40, 60 and 80 plants m^{-2}. The lowest 100-seed weight (7.30g) was obtained at 120 plants m^{-2}.

Interaction Effect of Variety and Plant Density: The interaction effect of variety and plant density on 100-seed weight was significant (Table 4). Variety PB-1 produced the highest 100-seed weight (10.38g) at 40 plants m^{-2} which was statistically identical with that produced with variety PB-1 at 20 plants m^{-2}. The lowest 100-seed weight (5.05g) was found at 120 plants m^{-2} in variety G-2.

Seed Yield

Effect of Variety: Seed yield varied significantly between the two varieties (Table 3). The higher seed yield (1.14 t ha^{-1}) was found in variety PB-1 than variety G-2 (0.50 t ha^{-1}). Higher seed yield in variety PB-1 was attributed to higher number of pods $plant^{-1}$, fertile pods $plant^{-1}$, number of seeds pod^{-1} and seeds $plant^{-1}$ than variety G-2.

Effect of Plant Density: Seed yield was influenced significantly by plant density (Table 3). The highest seed yield was (1.02 t ha^{-1}) obtained with 100 plants m^{-2}, which was statistically identical to 80 plants m^{-2}. The lowest seed yield (0.54 t ha^{-1}) was obtained from the crop grown at 20 plants m^{-2}. Zaimoglu et al., reported that plant density of 12.8 plants m^{-2} gave the highest seed yield and they also reported that seed yield increased with increasing plant density [36]. Grain yield increased with increasing plant density up to 50 plants m^{-2} among the plant density at 30, 40, 50 and 60 plants m-2 [37].

Interaction Effect of Variety and Plant Density: Interaction effect of variety and plant density on seed yield t ha^{-1} was significant (Table 4). The highest seed yield (1.5 t ha^{-1}) was produced from thevariety PB-1 at 100 plants m^{-2} followed by 120 plants m^{-2}. The lowest seed yield (0.34 t ha^{-1}) was found at 40 plants m^{-2} in variety G-2 which was statistically similar with variety G-2 at 20 plants m-2. Ethredge et al., observed that seed yield was significantly higher at plant density of 26.0 and 39.0 plants m-2 [38].

Stover Yield

Effect of Variety: There was a significant variation in stover yield between the two varieties (Table 3). The higher stover yield (0.97 t ha^{-1}) was produced in variety PB-1 than in variety G-2 (0.71 t ha^{-1}).

Effect of Plant Density: Plant density had a significant influenced on stover yield (Table 3). The highest stover yield (1.15 t ha^{-1}) was obtained from the 100 plants m^{-2} which was statistically similar with

that obtained at 120 plants m^{-2}. The lowest stover yield (0.51 t ha^{-1}) was observed at 20 plants m^{-2}. The stover yield m^{-2} was increased significantly with increase in plant population. Abbas et al., showed that stover yield was highest at the highest plant density among the plant density at 40, 60 and 80 plants m-2 [39].

Interaction Effect of Variety and Plant Density: There was a significant effect of variety and plant density on stover yield (Table 4). The highest stover yield was found in the variety PB-1 (1.44 t ha^{-1}) at 100 plants m^{-2}, which was statistically similar with the same variety at 120 plants m^{-2}. The lowest stover yield (0.49 t ha^{-1}) was produced from the variety G-2 at 20 plants m^{-2}.

Harvest Index

Effect of Variety: Variety had a significant effect on harvest index (Table 3). Higher harvest index (54.90%) was found in variety PB-1 than variety G-2 (41.51%).

Effect of Plant Density: Plant density had significant effect on harvest index (Table 3). The highest harvest index (52.56%) was found at 60 plants m^{-2} and the lowest harvest index (43.45%) was observed at 120 plants m^{-2}, which was statistically similar to that at 100 plants m^{-2}. Jahan stated that increased plant density generally tended to decrease harvest index (%) [40].

Interaction Effect of Variety and Plant Density: The interaction effect of variety and plant density had a significant influence on harvest index (Table 4). The highest harvest index (59.52%) was found in the variety PB-1 at 40 plants m^{-2} which was statistically identical to that at 20 plants m^{-2} with the same variety. The lowest harvest index (36.22%) was also found with the variety G-2 at 120 plants m^{-2}, which was also statistically identical within the variety at 100 plants m^{-2}. This is because number of plant population low, so canopy or number of branching increases ultimately seed yield and also biological yield high [41-43].

Table 1: Effect of Plant Density and Variety on Plant Characters of Soybean in Kharif – II Season of 2012

Treatments	Plant height(cm)	Nodes plant^{-1} (no.)	Branches plant^{-1} (no.)	Total dry matter m^{-2}(g)
Plant density(plants m^{-2})20				
	26.02e	10.81d	1.08a	105.18e
40	27.40d	11.73bc	0.95b	112.88d
60	28.44d	12.01ab	0.83c	152.76c
80	31.02c	12.13ab	0.82c	202.15b
100	36.35a	12.35a	0.80c	217.29a
120	34.66b	11.51c	0.60d	208.58b
CV (%)	2.89	3.24	5.84	3.82
S x	0.36	0.16	0.02	2.59
Level of significance	***	***	***	***
Variety				
G-2	27.75b	11.12b	0.68b	116.42b
PB-1	33.54a	12.40a	1.02a	211.60a
CV (%)	3.20	1.11	13.96	0.40
S x	0.23	0.03	0.03	0.16
Level of significance	**	**	*	***

In a column, the figures having common letter (s) do not differ significantly (as per DMRT) at 5% level of probability.

* = Significant at 5% level of probability.
** = Significant at 1% level of probability.
*** = Significant at 0.1% level of probability.

Table 2: Interaction Effect of Plant Density and Variety on Plant Characters of Soybean in *Kharif* – II Season of 2012

Plant density (plants m^{-2}) x Variety	Plant height (cm)	Nodes $plant^{-1}$ (no.)	Branches $plant^{-1}$ (no.)	Total dry matter m^{-2}(g)
20 x G-2	24.82h	10.63d	0.83c	83.86h
40 x G-2	25.88gh	11.00cd	0.60ef	83.75h
60 x G-2	27.41efg	11.36bc	0.73d	103.93g
80 x G-2	29.66d	11.56bc	0.66de	184.06d
100 x G-2	30.12d	11.80b	0.60ef	139.75e
120 x G-2	28.61def	10.36d	0.63ef	132.71ef
20 x PB-1	27.22fg	11.00cd	1.33a	126.50f
40 x PB-1	28.91de	12.46a	1.30a	142.01e
60 x PB-1	29.47d	12.66a	0.93b	201.58c
80 x PB-1	32.38c	12.70a	0.97b	220.23b
100 x PB-1	42.58a	12.90a	1.0b	294.83a
120 x PB-1	40.70b	12.66a	0.57f	284.45a
CV (%)	2.89	3.24	5.84	3.82
S $\bar{x}$	0.51	0.22	0.03	3.67
Level of significance	***	*	***	***

In a column, the figures having common letter (s) do not differ significantly (as per DMRT) at 5% level of probability.

* = Significant at 5% level of probability.
*** = Significant at 0.1% level of probability.

Table 3: Effect of Plant Density and Variety on Yield and Yield Attributing Characters of Soybean in *Kharif* – II Season of 2012

Treatments	Fertile $podsplant^{-1}$ (no.)	Non fertile $podsplant^{-1}$ (no.)	$Seedsplant^{-1}$ (no.)	$Seeds\ pod^{-1}$ (no.)	Seed $yieldplant^{-1}$ (g)	100-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Plant density (plants m^{-2})20									
	16.91a	2.06a	35.79a	2.10	2.51a	7.90a	0.54e	0.51d	49.41b
40	16.10ab	1.20b	32.72b	2.02	2.37a	7.74ab	0.59d	0.54d	49.79b
60	15.35bc	1.12b	30.80bc	2.00	2.32ab	7.63ab	0.82c	0.70c	52.56a
80	14.90bc	0.93c	29.53c	1.98	2.15b	7.63ab	1.01ab	1.01b	49.48b
100	14.28c	0.87c	26.78d	1.88	2.11b	7.60b	1.02a	1.15a	44.55c
120	12.88d	0.63d	24.83d	1.92	1.77c	7.30c	0.97b	1.12a	43.45c
CV (%)	7.20	7.27	6.37	7.24	7.71	2.86	4.75	4.84	3.34
S $\bar{x}$	0.44	0.03	0.87	0.05	0.06	0.09	1.60	1.66	0.66
Level of significance	***	***	***	NS	***	**	***	***	***
Variety									
G-2	**11.76b**	**0.76b**	**23.00b**	**1.96**	**1.13b**	**5.33b**	**0.50b**	**0.71b**	**41.51b**
PB-1	18.38a	1.50a	37.14a	2.03	3.27a	9.93a	1.14a	0.97a	54.90a
CV (%)	2.29	9.64	5.37	8.20	13.06	4.18	1.10	0.38	1.09
S $\bar{x}$	0.081	0.025	0.38	0.04	0.06	0.07	0.21	0.07	0.12
Level of significance	***	**	**	NS	**	***	***	***	***

In a column, the figures having common letter (s) do not differ significantly (as per DMRT) at 5% level of probability.

** = Significant at 1% level of probability.
*** = Significant at 0.1% level of probability.
NS = Not significant.

Table 4: Interaction Effect of Plant Density and Variety on Yield and Yield Attributing Characters of Soybean in *Kharif* – II Season of 2012

Plant density (plants m^{-2})x Variety	Fertile pod-$splant^{-1}$(no.)	Non fertile $podsplant^{-1}$ (no.)	Seed-$splant^{-1}$ (no.)	Seeds pod $^{-1}$(no.)	Seed yield-$plant^{-1}$(g)	100-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
20 x G-2	12.96	2.03a	26.59e	2.05	1.24e	5.61d	0.35g	0.49e	41.31e
40 x G-2	12.66	0.73e	24.60ef	1.95	1.27e	5.10ef	0.34g	0.50de	40.06ef
60 x G-2	12.06	0.63e	23.67efg	1.97	1.20e	5.39def	0.50f	0.54de	48.20c
80 x G-2	11.46	0.47f	22.57fgh	1.96	1.08ef	5.49de	0.84d	1.00b	45.41d
100 x G-2	11.16	0.43fg	20.83gh	1.87	1.15ef	5.37def	0.53f	0.87c	37.87fg
120 x G-2	10.23	0.30g	19.80h	1.93	0.86f	5.05f	0.49f	0.85c	36.22g
20 x PB-1	20.86	2.10a	45.00a	2.15	3.79a	10.19ab	0.73e	0.54de	57.52a
40 x PB-1	19.53	1.67b	40.83b	2.09	3.47ab	10.38a	0.85d	0.57d	59.52a
60 x PB-1	18.63	1.60b	37.93bc	2.03	3.45ab	9.88bc	1.15c	0.87c	56.93a
80 x PB-1	18.33	1.40c	36.50c	1.99	3.21bc	9.76c	1.18c	1.02b	53.55b
100 x PB-1	17.40	1.30c	32.73d	1.89	3.07c	9.83bc	1.51a	1.44a	51.23b
120 x PB-1	15.53	0.97d	29.87d	1.92	2.67d	9.56c	1.44b	1.40a	50.67bc
CV (%)	7.20	7.27	6.37	7.24	7.71	2.86	4.75	4.84	3.34
S $\bar{x}$	0.63	0.05	1.11	0.08	0.09	0.13	2.26	2.35	0.93
Level of significance	NS	***	*	NS	*	*	***	***	***

In a column, the figures having common letter (s) do not differ significantly (as per DMRT) at 5% level of probability.

* = Significant at 5% level of probability.
*** = Significant at 0.1% level of probability.
NS = Not significant.

Conclusion

Variety PB-1 exhibited higher plantheight (cm), number of nodes $plant^{-1}$, branches $plant^{-1}$, total dry matter, number of fertile pods $plant^{-1}$, non-fertile pods $plant^{-1}$, number ofseeds $plant^{-1}$, seed yield $plant^{-1}$, seed yield, 100-seed weight, stover yield and harvest index than variety G-2. Plant height (cm), number of nodes $plant^{-1}$, total dry matter, seed yield and stover yield increased with increasing plant density up to 100 plant m^{-2} and then decreased with increased in plant density. Again number of branches $plant^{-1}$, number of fertile pods $plant^{-1}$, non-fertile pods $plant^{-1}$, number of seeds $plant^{-1}$, seed yield $plant^{-1}$ and 100-seed weight linearly decreased with increasing plant density. Variety PB-1 gave the highest seed yield (1.51 t ha^{-1}) and stover yield (1.44 t ha^{-1}) at 100 $plantsm^{-2}$, while the highest seed yield (0.84 t ha^{-1}) and stover yield (1.00 t ha^{-1}) in variety G-2 at 80 plants m^{-2}. It may be concluded that variety PB-1 gave more yield at higher plant density than variety G-2 (Bangladesh soybean-4).

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