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Performance of Soybean Genotypes as Affected by Spacing and Nitrogen Management in Madhupur Tract, Bangladesh

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Abstract: The experiment was conducted at the Field Research Site of Bangabandhu Sheikh Mujibur Rahman Agricultural University Gazipur from February to May 2013 to evaluate the performance of soybean genotypes as affected by spacing and nitrogen management. The experiment was laid out in a three factor Split-Plot design with three replications. Two levels of nitrogen (2/3 basal application along with foliar application of 1% urea at flowering stage and 2/3 basal application with top dress of 1/3 urea at flowering stage at the rate of 60 kg ha^{-1}) and two spacing (30cm × 5cm and 40cm × 5cm) were considered as treatment for the experiment. Four genotypes G1 =BARI Soybean 6, G2 = Bangladesh soybean 2329, G3 = Bangladesh soybean 2331, G4 = Bangladesh soybean 2340) were used in this experiment. Significant effect on plant height, branches per plant, number of pods per plant, number of seed per pods, days to first flowering and Phosphorus uptake were obtained higher productivity of soybean, the treatment having a minimum row spacing of 30cm × 5cm along with 2/3 basal application of N at a rate of 60 kg ha^{-1} and a foliar application of 1% urea at flowering stage was found to be the most appropriate combination of treatments for the soybean genotype var. Bangladesh Soybean 2329.

Keywords: Soybean; Genotypes; Nitrogen management; Spacing; Seed yield.

INTRODUCTION

Soybean (*Glycine max* L. Merril) ranks first as an oilseed crop of the world. It has a tremendous value in agriculture as a good source of high-quality plant protein and vegetable oils in one hand and nitrogen fixing ability on the other. It belongs to the family Leguminosae, sub family Papilionaceae. Soybean has now established itself as one of the world's most important oilseed crops, accounting for more than half of all oilseed produced and 30% of total vegetable oil supply (US Soybean Export Council 2008). Major producers are the US (33% of world production), followed closely by Brazil (28%) and Argentina (21%). The remaining producers are China, India, and a few other countries. Currently, soybean is grown on about 90.5 million hectares throughout the world, with a total production of nearly 220 million metric tons (US Soybean Export Council 2008). Soybean, also known as the "miracle bean," has proven its worth as an industrially important and viable oilseed crop.

Scenarios of soybean farming in Bangladesh is bright as it can successfully be grown under a wide range of climatic and edaphic conditions and cultivated throughout the year (Rahman, 1982). Soybean helps to improve the soil by fixing the atmospheric nitrogen through *Rhizobium* bacteria. Steward (1966) reported that the soybean plants could fix 94 kg nitrogen ha-1 in soil in a season. In Bangladesh the area under soybean cultivation is about 5000 ha with a production of 4000 ton & the yield ranges from 1.50 to 2.30 tha-1 (BARI, 2005). The lower yield of soybean at farmer's level is mainly attributed to the lack of improved agronomic management practices of which judicious fertilizer application is an important determinant for better yield of soybean. Among the nutrients, nitrogen is a major essential plant nutrient element. It has the quickest and most pronounced effect on plant growth and yield of crops. It tends primarily to encourage above ground vegetative growth and to impart deep green color to the leaves. In all plants, nitrogen governs a considerable degree of utilization of potassium, phosphorus and other nutrients.

Plants receiving insufficient nitrogen are stunted in growth with restricted root systems. The leaves turn yellow or yellowish green and tend to drop-off. For its optimum yield realization, it is necessary to optimize the nutrient inputs. Plant population is another important factor for higher yield realization through light penetration in crop canopy. If plant density is above the optimum, the plant growth may be poor due to competition for nutrients, light and space. On the other hand, if it is below optimum then the nutrients, space and light will not be utilized to their full extent, thus resulting in poor yield. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. To get the best results from this crop, keep the row to row spacing consistent with the plant population. Improved plant nutrition, particularly nitrogen (N) uptake, has contributed to increased soybean yield. Adequate N supply throughout the growing season is important for high yields (Salvagiotti *et al*. 2009). Nitrogen uptake is highest during early seed fill (Gutierrez-Boem *et al*. 2004). Nitrogen that is supplied from fixation is commonly not sufficient to maximize yield (Ray *et al*., 2005).

Under scientific management conditions, soybean cultivation yields the highest productivity, and builds up soil fertility as well. Being a member of the legume family, soybean forms a nitrogen- fixing symbiosis with *Bradyrhizobium japonicum* and *Sinorhizobium* species it is capable of meeting its nitrogen requirements from atmospheric nitrogen through root nodules bacteria thus building up the soil fertility. The present study was, therefore, undertaken to find out the suitable soybean variety, optimum spacing, to determine the external nitrogen application method, and finally to find out the nutrient uptake status of the soybean variety.

MATERIALS AND METHODS

Study area

The experiment was conducted at the Field Research Site of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from February to May 2013. The location of site is at 24º05'N latitude and 90º25'E longitude having an elevation of 8.2 m from sea level (Anonymous 1989) (Figure 1). The soil is loamy in texture and slightly acidic in reaction with P^H value of 6.5 and contains very low amount of nitrogen and phosphorus (AEZ 28). The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall during *Rabi* season (October-March) associated with moderately low temperature. The average temperature ranges between 21^0C to 35^0C during the experimentation. The experiment was laid out in a three factor Split- Plot design having three replications. Each replication had 16-unit plots to which the treatment combinations were assigned randomly. The unit plot size was 2.88 m^2 (2.4m ×1.2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively.

Treatments

There were three factors in the experiment namely genotype, row spacing (i.e., line to line distance) and nitrogen application methods as:

Genotype: 4	A. Nitrogen management: 2	B. Spacing: 2
G1 =BARI Soybean 6, G2 = Bangladesh soybean 2329, G3 = Bangladesh soybean 2331, G4 = Bangladesh soybean 2340) Spacing (S1 = 40 cm, S2 = 30 cm)	a. N1 = 2/3 basal application of 60 kg N ha-1 at land preparation + Top dress application of 1/3 urea at flowering stage, b. N2 = 2/3 basal application of 60 kg N ha-1 at land preparation + Foliar application of 1% urea at flowering stage	S1 = 40cm × 5cm, S2 = 30cm × 5cm Treatment Combinations T1 = N1 S1 G1, T2 = N1 S1 G2, T3 = N1 S1 G3, T4 = N1 S1 G4, T5 = N2 S1 G1, T6 = N2 S1 G2, T7 = N2 S1 G3, T8 = N2 S1 G4, T9 = N1 S2 G1, T10=N1 S2G2, T11 = N1 S2 G3, T12= N1S2G4, T13 = N2 S2 G1, T14 =N2 S2 G2, T15 = N2 S2 G3, T16 = N2 S2 G4

Set up of experiment

The land was prepared by ploughing and cross ploughing with power tiller and country plough followed by laddering. The fertilizers were applied as basal dose at final land preparation where urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP), gypsum and Boron were applied @ 60 kg ha^{-1}, 175 kg ha^{-1}, 120 kg ha^{-1}, 115 kg ha^{-1} and 10 kg ha^{-1} respectively according to the fertilizer recommendation guide of Bangladesh Agriculture Research Institute (BARI) in all plots. 2/3 urea as basal and all other fertilizers were applied by broadcasting and mixed thoroughly with soil. Urea was used as 1/3 top dressed and 1% with foliar spray in 30 days after emergence (DAE). Seeds were sown with a spacing of 30cm X 5cm and 40 cm X 5cm in the line and about 3.0 cm was seeding depth on February 05, 2013 and the seeds were covered with the pulverized soil just after sowing and gently pressed with hands. The field was irrigated after sowing to supply sufficient moisture needed for quick germination. Proper intercultural operation such as weed control, thinning at 20 days after sowing (DAS), maintain plant to plant spacing 5 cm, insect and pest control and irrigation and drainage was done when it was necessary. At the time when 80% of the pods turned brown color, the crop was considered to attain maturity. The crop was harvested at 90 DAS from prefixed 1.0 m^2 areas. Before harvesting ten plants were selected

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randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the Agronomy laboratory for collecting data. Pods were separated from the plants by hand. After collecting pods were sun dried properly and seeds were separated from the plants by beating the pods with bamboo sticks and dried in the sun until moisture percentage reach 9%. The dried seeds and straw were cleaned and weighed.

Laboratory analysis of plant samples

Total Nitrogen analysis: Plant sample was digested in Kjeldahl digestion flask with salicylic sulfuric acid and digestion catalyst. After digestion, color of the solution was developed with reagents by the help of titration.

Total Phosphorus analysis: Total P was determined by nitric-perchloric acid digestion. The absorbance was measured at 440 nm with Double Beam Spectrophotometer.

Potassium analysis: During K analysis dry plant sample was digested with nitric-perchloric acid solution. After digestion the sample was diluted with distilled water. Then the absorbance of that respective ion was measured with atomic absorption spectrophotometer.

Data analysis

The collected data (Plant height (cm), Measurement of SPAD value, Number of leaves per plant, Dry weight of leaves per plant, Dry weight of stem per plant, Number of pods per plant, Number of seeds per pod, 100-seed weight, Seed yield (t ha-1) were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT and the mean differences were adjusted by Least Significance Difference (LSD) test at a significance level of 0.05.

RESULTS AND DISCUSSIONS

Effect of Nitrogen

The days to first flowering, Plant height, Measurement of Soil Plant Analysis Development (SPAD) value, Branches per plant, Leaf number per plant, Dry weight of stem, Leaf, Petiole per plant of soybean were significantly influenced by nitrogen application method, row spacing and genotypes, which ranged from 34.0 to 39.67 days for first flowering. The treatment T_4 took minimum days (34.0) to first flowering followed by T_5 and T_8 treatment. The treatment T_{14} took maximum days (39.67) to first flowering. The days to maturity of soybean were not significantly influenced by nitrogen application method, row spacing and genotypes, which ranged from 85.33 to 89.0 days to maturity (Table 1).

Table 1. Days to 1st flowering and Days to maturity of four selected soybean genotypes as influenced by spacing and nitrogen management.

Treatment	Days to 1st flowering	Days to maturity
T_1	38.00	87.00
T_2	37.67	89.00
T_3	36.00	87.00
T_4	34.00	86.00
T_5	34.00	86.00
T_6	36.33	87.00
T_7	35.00	85.00
T_8	34.00	86.00
T_9	35.00	87.00
T_{10}	38.33	89.33
T_{11}	36.67	87.33
T_{12}	36.00	87.33
T_{13}	37.00	88.00
T_{14}	39.67	89.33
T_{15}	39.00	89.00
T_{16}	35.67	85.33
$LSD_{(0.05)}$	4.225	5.881
CV (%)	6.94	4.03

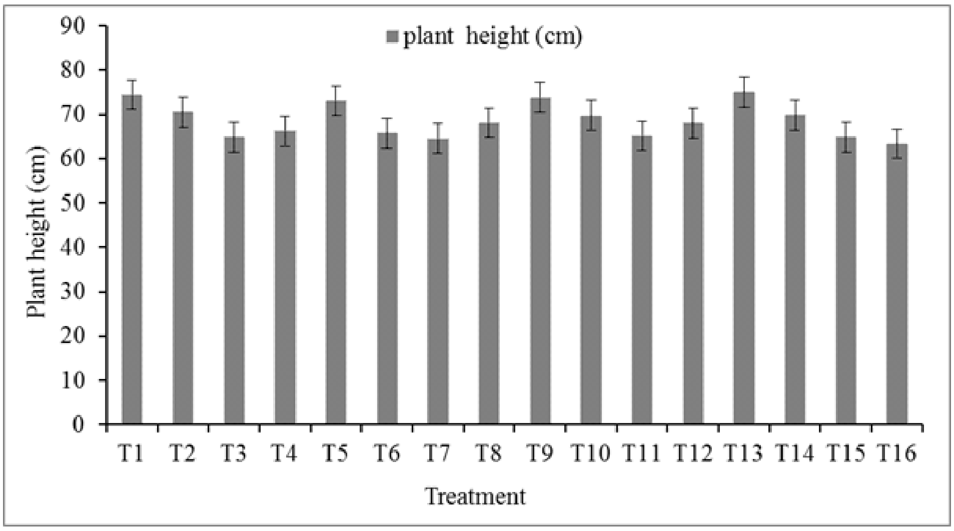

Figure 1. Plant height of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates $LSD_{(0.05)}$ = 6.701.

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The effect of nitrogen application method, row spacing and genotypes on plant height of soybean was significant which ranged from 63.37 to 75.03 cm. However, in general, most of the genotype except T_3, T_7, T_{15} and T_{16} showed relatively higher plant height. The treatment T_{13} produced the tallest plants (75.03cm) followed by the treatment T_1 (74.41 cm) and shortest plants (63.37cm) were obtained from the treatment T_{16} (Figure 1). The SPAD value of soybean was varied enormously by the different genotype, spacing and nitrogen application method. In 25 Days after emergence (DAE) the highest value (36.65) plant was in T_{11} treatment and the lowest (32.29) in T_3 treatment. In 29 Days after emergence (DAE) the highest value (39.19) plant was in T_2 treatment and the lowest (36.63) in T_{13} treatment. In 33 Days after emergence (DAE) the highest value (40.49) plant was in T_2 treatment. In 37 Days after emergence (DAE) the highest value (42.04) plant was in T_2 treatment and the lowest (37.47) in T_1 treatment. In 41 Days after emergence (DAE), the highest value (38.12) plant was in T_2 treatment and the lowest (34.46) in T_6 treatment. In 45 Days after emergence (DAE), the highest value (39.2) plant was in T_7 treatment and the lowest (35.43) in T_{16} treatment. In 49 Days after emergence (DAE) the highest value (39.27) plant was in T_1 treatment and the lowest (32.55) in T_2 treatment (Table 2). The number of branches per plant varied among the soybean genotype which was influenced by row spacing and nitrogen application method.

Table 2. SPAD value of four selected soybean genotypes as influenced by spacing and nitrogen management.

Treatment	**SPAD value**						
	25 DAE	29 DAE	33 DAE	37 DAE	41 DAE	45 DAE	49 DAE
T_1	33.07	36.98	39.71	37.47	35.16	38.37	39.27
T_2	33.8	39.19	40.49	42.04	38.12	39.07	32.55
T_3	32.29	37.12	39.49	40.43	37.58	38.5	34.64
T_4	34.56	39.14	39.81	39	36.83	36.9	37.26
T_5	33.31	36.86	38.32	38.57	35.21	36.65	35.26
T_6	33.2	37.94	39.51	39.83	34.46	38.33	36.94
T_7	33.94	37.26	38.56	38.86	36.5	39.2	34.54
T_8	34.28	37.74	38.91	38.84	36.28	37.66	36.16
T_9	34.55	37.83	40.2	38.44	37.28	38.11	36.1
T_{10}	34.38	38.46	38.82	39.22	35.86	38.67	36.2
T_{11}	36.65	38.62	39.31	39.6	34.92	37.11	35.77
T_{12}	34.37	38.33	38.69	38.39	36.72	38.92	37.86
T_{13}	35.35	36.63	38.58	37.8	37.01	39.11	36.27
T_{14}	35.42	36.98	39.25	39.88	36.65	37.76	37.68
T_{15}	35.23	38.11	39.16	40.16	37.52	37.45	36.5
T_{16}	34.75	37.29	38.55	38.78	37.35	35.43	36.92
LSD $_{(0.05)}$	5.57	8.26	8.07	5.15	7.39	6.98	6.44
CV (%)	3.197	0.896	0.981	3.374	4.507	4.432	3.901

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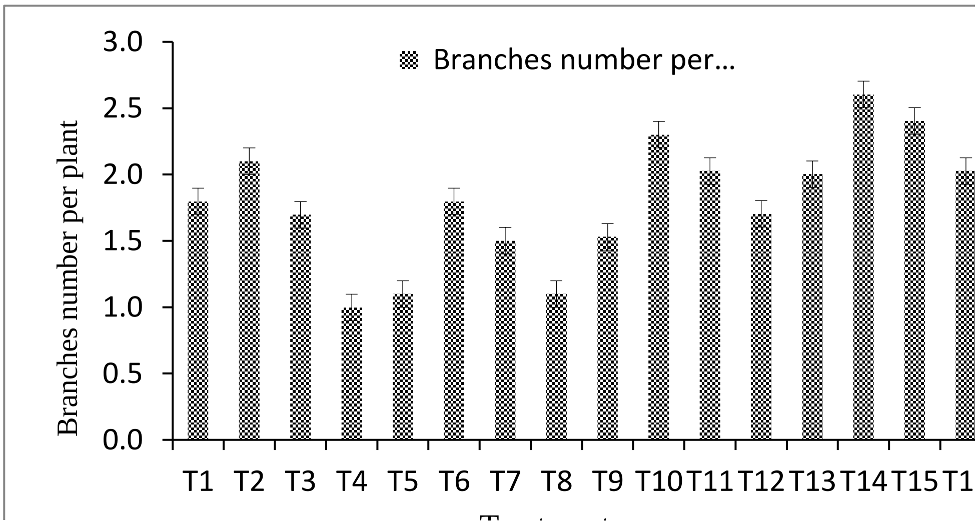

Figure 2. Branches per plant of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates LSD $_{(0.05)}$ = 0.2181.

All the treatment except T_4, T_5 and T_8 in general showed higher number of branches per plant. The mean number of branches per soybean plant was 1.80. The highest number of branches per plant 2.6 was recorded in the treatment T_{14}, while the lowest (1.0) was recorded in the treatment T_4 (Figure 2). The number of leaves per plant counted was significantly influenced by spacing and nitrogen application method. In general, the number of leaves per plant was higher in all treatment except T_4. The treatment T_{14} produced maximum (16.8) number of leaves followed by the treatment T_{15} (16.7). On the other hand, treatment T_4 produced minimum (12.47) number of leaves per plant (Figure 3). The different soybean genotypes showed relative values stem dry mass under different row spacing and nitrogen application method. Irrespective of stem dry weight all treatment except T_4, T_7 and T_8 had more stem dry weight plant^{-1}. The treatment T_{13} showed highest (6.30 g plant^{-1}) stem dry weight plant^{-1} and the lowest 3.53g stem dry weight plant^{-1} in the treatment T_7 (Figure 4).

Table 3. Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Boron (B) content of four selected soybean genotypes as influenced by spacing and nitrogen management.

Treatment	N content (%)	P content (%)	K content (%)	S content	B content (ppm)
T_1	4.33	0.11	1.40	(%)	11.30
T_2	4.71	0.11	1.44	0.09	12.26
T_3	3.88	0.08	1.39	0.11	10.61
T_4	3.37	0.14	1.30	0.08	9.74
T_5	3.58	0.10	1.32	0.04	10.08
T_6	4.29	0.12	1.40	0.06	11.07
T_7	3.75	0.13	1.38	0.09	10.52
T_8	3.46	0.15	1.34	0.07	9.87
T_9	3.74	0.11	1.38	0.05	10.49
T_{10}	4.73	0.14	1.45	0.07	13.06
T_{11}	4.60	0.11	1.42	0.11	12.09
T_{12}	3.98	0.08	1.39	0.10	10.67
T_{13}	4.60	0.14	1.42	0.08	12.12
T_{14}	5.34	0.12	1.48	0.10	16.58
T_{15}	5.21	0.12	1.47	0.17	13.47
T_{16}	4.56	0.09	1.41	0.13	11.79
LSD $_{(0.05)}$	0.547	0.053	0.175	0.10	1.633
CV (%)	7.68	8.31	7.48	0.017	8.41

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Table 4. Seed yield per plant and yield of four selected soybean genotypes as influenced by spacing and nitrogen management.

Treatment	pod number plant-1	Seed number pod-1	100-seed weight (g)	Seed Yield plant-1 (g)	Yield (t/ha)
T_1	32.83	2.33	6.64	5.11	2.04
T_2	38.27	2.50	5.87	5.59	2.24
T_3	38.53	2.30	5.73	5.05	2.02
T_4	30.57	2.13	5.65	3.66	1.46
T_5	28.73	2.10	6.08	3.68	1.47
T_6	36.86	2.33	5.94	2.04	2.04
T_7	34.53	2.40	5.77	4.80	1.92
T_8	32.10	2.13	5.48	3.74	1.50
T_9	36.54	2.30	5.78	4.92	1.97
T_{10}	41.77	2.53	5.72	6.06	2.46
T_{11}	37.03	2.40	6.11	5.41	2.17
T_{12}	36.03	2.30	5.96	4.91	1.97
T_{13}	35.70	2.40	6.37	5.46	2.18
T_{14}	47.77	2.67	6.08	7.72	3.11
T_{15}	46.59	2.57	5.99	7.18	2.87
T_{16}	37.23	2.40	5.94	5.28	2.11
LSD $_{(0.05)}$	4.936	0.2848	0.7863	0.5315	0.2305
CV (%)	7.99	7.26	7.91	6.31	6.66

The leaf dry weight per plant of all treatment was much higher than that of T_3 and T_7 treatment. The treatment T_{13} maintained the highest (5.5 g plant^{-1}) absolute value followed by the treatment T_{14}. On the other hand, treatment T_3 produced only 2.6 g plant^{-1} dry leaf weight followed by the treatment T_7 (Figure 5). The treatment T_{13} maintained the highest (2.43 g plant^{-1}) petiole dry weight per plant. The lowest (1.37g plant^{-1}) petiole dry weight was produced by the treatment T_7 (Figure 6).

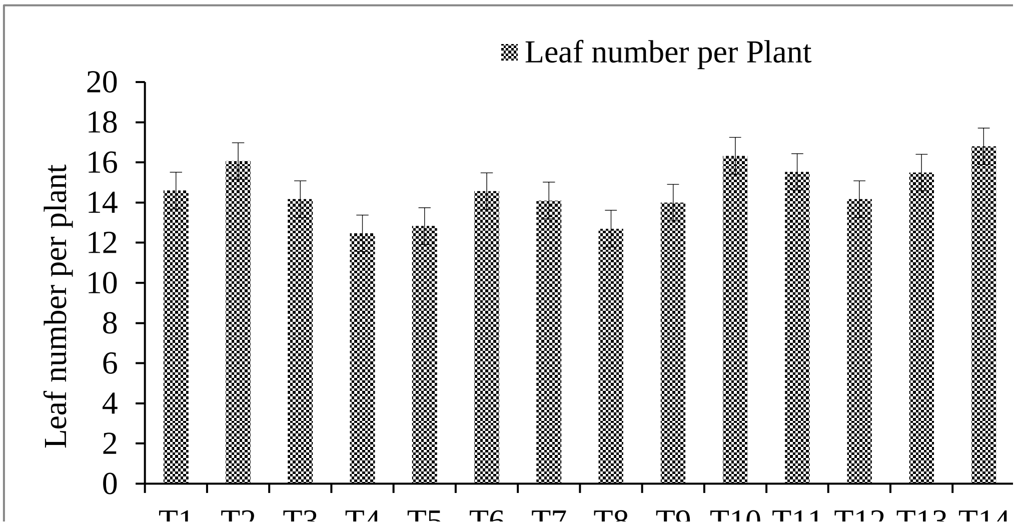

Figure 3. Leaf number per plant of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates LSD $_{(0.05)}$ = 1.825.

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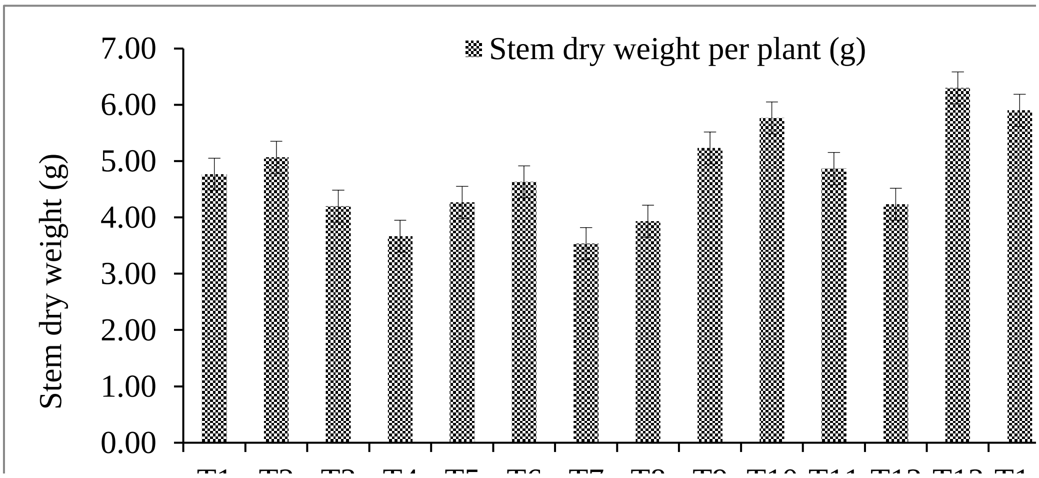

Figure 4. Stem dry weight per plant of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates LSD $_{(0.05)}$ = 0.5696.

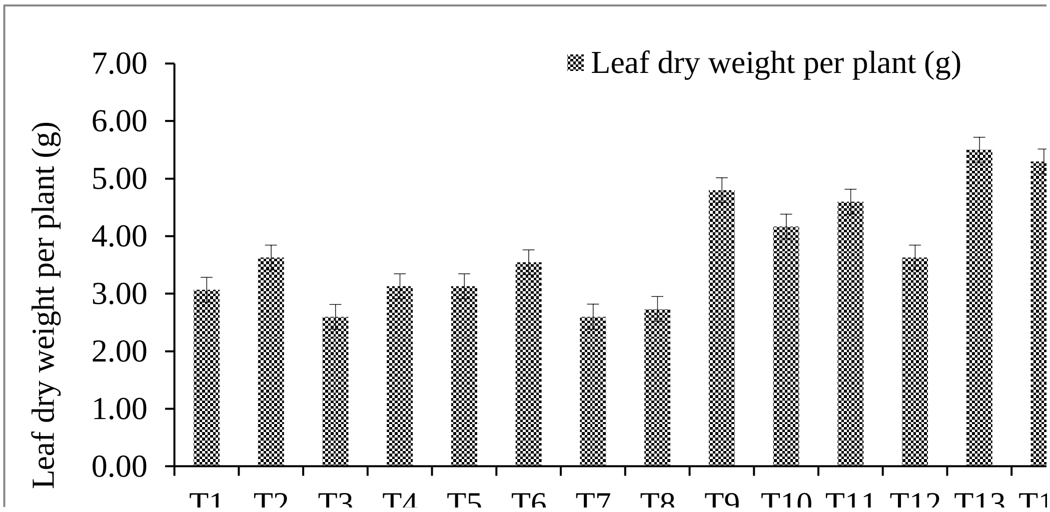

Figure 5. Leaf dry weight per plant of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates LSD $_{(0.05)}$ = 0.4329.

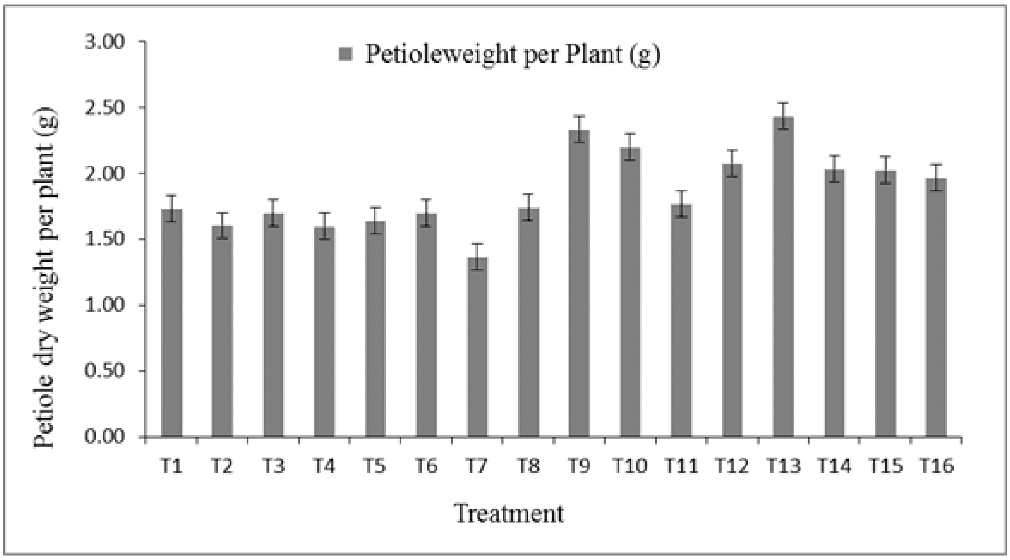

Figure 6. Petiole dry weight per plant of four selected soybean genotypes as influenced by spacing and nitrogen management. Bar indicates LSD $_{(0.05)}$ = 0.1587.

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CONCLUSION

Crop management techniques such as selection of variety, row spacing, and nitrogen fertilization might affect crop stand height and soil coverage. However, soybean grain yield remained elevated across a wide range of row spacings and with nitrogen fertilization as well. Soybean is noticeably adaptable to changing conditions through compensation or competition processes during yield component formation. Consequently, from an agronomic point of view, cultivation with a variety var. Bangladesh Soybean 2329, a lower row spacing (30 cm) and nitrogen fertilization (2/3 of 60 kg N ha-1 at land preparation + 1% urea applied as foliar at flowering stage) can be recommended.

REFERENCES

Azarpour E., Danesh, R.K., Mohammadi, S., Bozorgi, H.R. and Moraditochaee, M. 2011. Effects of nitrogen fertilizer under foliar spraying of humic acid on yield and yield components of cowpea (*Vigna unguiculata*). World Applied Sciences Journal**,** 13: 1445-1449.

Babik, I. and Elkner, K. 2002. The effect of nitrogen fertilization and irrigation on yield and quality of broccoli. In: Proc. Eco. Fertil. Veg. Acta Hort., 571: 33–43.

BARI. (Bangladesh Agricultural Research Institute) 2005. Handbook on Agro-technology. 2 nd Edition, BARI, Gazipur. p. 155.Bhuiyan, A.J., and Huq, M.A. 1979. Effect of split application of nitrogen and potash on the growth and yield of onion. Bangladesh. Hort., **7** (1 & 2): 36-39.

Board, J.E., Harville, B.J. and Saxton. A.M. 1990. Branch Dry Weight in Relation to Yield Increases in Narrow-Row Soybean. Agron. J., 82**:** 540-544.

Choudhary G.L. and Yadav L.R. 2011. Effect of fertility levels and foliar nutrition on cowpea productivity. Journal of Food Legumes, 24(1): 67-68.

Council US. 2008. How the global oilseed and grain trade works. Soyatech, LLC, Southwest Harbor, Maine, US.

Dixit, P.M. and Elamathi. S. 2007. Effect of foliar application of DAP, micronutrients and NAA on growth and yield of green gram (*Vigna radiata* L.). Legume Research, 30: 305-307.

Duraisami, V. P. and Mani, A. K. 2001. Residual effect of inorganic nitrogen, composted coirpith and biofertilizer on yield and uptake of soybean in an Inceptisol. Madras Agric J., 88(4/6): 277-280.

Geetha P and Velayutham A. 2009. Refinement of nutrient management techniques for growth, yield and nutrient uptake of rice fallow black gram. Madras Agricultural Journal, 96: 163-166.

Ghildiyal, M.C. 1992. Effect of urea on photosynthesis and yield in mung bean. J. Agron. CropSci. 168 (2): 91-94.

Gutierrez-Boem, F.H., J.D. Schiener, H.R. Korsakov, and R.S. Lavado. 2004. Late Season Nitrogen Fertilization of Soybeans: Effects on Leaf Senescence, Yield and Environment. Nutr. Cycl. Agroecosys. 68: 109-115.

Hamid, A. 1991. Foliar application of nitrogen in mungbean. I. Influence of rate and frequency of application. Ann. Bang. Agric., 1: 33-39.

Ibrahim, S.A. and Hala. 2007. Growth, Yield and Chemical Constituents of Soybean *(Glycin max L.)* Plants as Affect by Plant Spacing under Different Irrigation Intervals. Journal of Agriculture and Biological Sciences, 3(6): 657-663.

Jain, R.C. and Tiwari, R.J. 1997. Lentil response to kimberlite in combination with chemical fertilizers and phosphate solubilizing bacteria in India. Lens Newsletter Ind., 24(1-2): 37-38.

Kalita, P., Dey, S.C., Chandra, K. and Upadhyaya, L.P. 1994. Effect of foliar application of nitrogen on morpho-physiological traits of pea (*Pisum sativum*). Indian J. Agric. Sci. 64: 850-52.

Khan P., Memon, M.Y., Imtiaz, M. and Aslam, M. 2009. Response of wheat to foliar and soil application of urea at different growth stages. Pak. J. Bot. 41(3): 1197-1204.

Khan, E.A., Aslam, M., Ahmad, H.K., Ayaz, M. and Hussain, A. 2010. Effect of row spacing and seeding rates on growth yield and yield components of chickpea. Sarhad J. Agric. 26(2): 201-211.

Khan, S., Shah, S., Akbar, H. and Khan, S. 2001. Effect of planting geometry on yield and yield components in mungbean. Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan. Sarhad J. Agric. 17(4): 519-524.

Kumar GS, Muthukrishnan P, Ramasamy, S. and Chandaragiri, KK. 2008. Effect of organic and inorganic foliar spray on growth and yield of blackgram (*Vigna mungo* L.). Madras Agricultural Journal, 95: 57-60.

Kumar, M., Chattopadhyay, T. K., Das, D. K. and Munsi, P. S. 1998. Effect of zinc and sulphur application on the yield and post-harvest quality of onion (Allium cepa L.) under different methods of storage. Indian. J. Interacademicia, 2 (3): 158-163.

Kumawat, S. M., Dhakar, L. L. and Maliwal, P. L. 2000. Effect of irrigation regimes and nitrogen on yield, oil content and nutrient uptake of soybean (*Glycine max*). Indian J Agron. 45(2): 361-366.

Rashid, A. R. M. H. 1998. Effects of NPKS on growth and yield of onion at different plant spacing. MS thesis, Dept. Hort., Bangladesh Agril. Univ., Mymensingh. p. 72.

Rahman, L. 1982. Cultivation of Soybean and Its Uses. City press. Dhaka. pp. 5-7.

Ray, J.D., L.G. Heatherly, and F.B. Fritschi. 2005. Influence of Large Amounts of Nitrogen on Non irrigated and Irrigated Soybean. Crop Sci. 46: 52-60.

Saharia, P. and Thakuria, K. 1988. Response of dwarf pea varieties to different sowing dates and row spacing. Indian J. Agron. 34 (4): 405-408.

Salvagiotti, F., Specht, J.E., Cassman, K.G., Walters, D.T. Weiss, A. and Dobermann, A. 2009. Growth and Nitrogen Fixation in High-Yielding Soybean: Impact of Nitrogen Fertilization. Agron. J., 101: 958-970.

DOI: https://doi.org/10.55706/jae1403

Smith, K. and Huyser, W. 1987. World distribution and significance of soybean. In J. R. Wilcox (Ed) Soybean: improvement, production and uses. Third edition Agronomy Monographs 16 ASA, CSSA and SSSA, Madison. pp 1-22.

Subramanian, A. and Palaniappan, S.P. 1981. Effect of methods of planting, plant density and fertilization on yield of blackgram in irrigated system. Madras Agric. J. 68: 96-99.

Svoboda, P. and Haberle, J. 2006. The effect of nitrogen fertilization on root distribution of winter wheat. Plant Soil Environ., 52: 308–313.

Syverud, T. D., Walsh, L.M., Oplinger, E.S. and Kelling, K.A. 1980. Foliar fertilization of soybean (*Glycine max* L.). Communications in Soil Science and Plant Analysis 11: 637–651.

Villeneuve S., Coulombe J., Belec C. and Tremblay, N. 2002. A comparison of sap nitrate test and chlorophyll meter for nitrogen status diagnosis in broccoli (*Brassica oleracea* L. var. *italica*). In: Proc. Workshop Eco. Fertil. Veg. Acta Hort., 571: 171–177.

Westerveld, S.M., McKeown, A.W., McDonald, A.W. and Scott-Dupree, C.D. 2003. Chlorophyll and nitrate meters as nitrogen monitoring tools for selected vegetables in southern Ontario. In: Proc. XXVI. IHC-Fertil. Strateg. Field Veg. Prod. Acta Hort., 627: 259–266.

Yadav, J.K., Singh, H.L. and Kumar, R. 2003. Determining selection components in chickpea (Cicer arietinum L. Wilczek). Plant Archives, 3: 125-128.

Zahran, F.A. and Abdoh, A.E. 1998. Nitrogen fertilization of onion in sandy soils. Egypt. J. Agr. Res., 76: 903–911.

Zeidan, M.S. 2003. Effect of sowing dates and urea foliar application on growth and seed yield of determinate faba bean (*Vicia faba* L.) under Egyptian conditions. Egypt. J. Agron., 24: 93–102.

DOI: https://doi.org/10.55706/jae1403