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GROWTH AND DRY MATTER PARTITIONING IN SELECTED SOYBEAN (*Glycine max* L.) GENOTYPES

M. S. A. KHAN[1], M. A. KARIM[2], M. M. HAQUE[2]
A. J. M. S. KARIM[3] AND M. A. K. MIAN[4]

Abstract

The experiment was conducted at the experimental site of Agronomy Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during the period from January to June 2011 to evaluate twenty selected soybean genotypes in respect of growth, dry matter production and yield. Genotypic variations in plant height, leaf area index, dry matter and its distribution, crop growth rate and seed yield were observed. The plant height ranged from 40.33 to 63.17 cm, leaf area index varied from 3.01 to 8.13 at 75 days after emergence, total dry matter ranged from 12.25 to 24.71 g per plant at 90 days after emergence (DAE). The seed yield ranged from 1745 to 3640 kg per hectare. The genotypes BGM 02093, BD 2329, BD 2340, BD 2336, Galarsum, BD 2331 and G00015 yielded 3825, 3447, 3573, 3737, 3115, 3542 and 3762 kg per hectare, respectively and gave higher than others contributed by higher crop growth rate with maximum number of filled pods. Seed yield of soybean was positively related to total dry matter at 45 DAE ($Y = 632.19 + 659.31X$, $R^2 = 0.46$) and 60 DAE ($Y = 95.335 + 405.53X$, $R^2 = 0.48$). The filled pods per plant had good relationship with seed yield ($Y = 1397 + 41.85X$, $R^2 = 0.41$) than other components.

Keywords: Growth, dry matter, soybean, seed yield.

Introduction

Soybean (*Glycine max* L.) is one of the most nutritious crops (*Yaklich et al*., 2002) and widely used for both food and feed purpose. Its seed contain 42-45% protein and 22% edible oil (Mondal *et al*., 2001). Moreover, it contains minerals such as Fe, Cu, Mn, Ca, Mg, Zn, Co, P and K. Vitamins B1, B2, B6 and isoflavones are also available in soybean grains (Messina, 1997). Soybean oil is rich in polyunsaturated fatty acids, including the two essential fatty acids (linoleic and linolenic). In Bangladesh, human consumption of soybean is very little. Recently, soybean has become an important crop in Bangladesh for its increasing demand as an ingredient of poultry and fish meal. Therefore, a huge amount of soybean is imported every year. Soybean has become one of the stable and economic kharif crops in greater Noakhali areas of Bangladesh, but the yield is lower. Availability of high yielding and stable genotype of soybean suitable for

[1]Agronomy Division, Bangladesh Agricultural Research Institute (BARI), [2]Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), [3]Department of Soil Science, BSMRAU, [4]Department of Genetics and Plant Breeding, BSMRAU, Bangladesh.

different agro-climatic regions is one of the major constraints of soybean cultivation in Bangladesh. The yield of a crop is related to its various agronomic traits such as growth, development and photo synthetically active leaf area. Differences in dry matter accumulation and their distribution in different plant parts are the important determinants for selecting high yielding genotypes (Hossain and Khan, 2003). The crop growth largely depends on genetical inheritance and prevailing environment. This study was therefore, undertaken with 20 genotypes of soybean to observe the genotypic performance in respect of growth, dry matter partitioning and seed yield.

Materials and Method

The experiment was conducted at the research field of the department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, Bangladesh during the period from January to June, 2011. Twenty soybean genotypes viz. BARI Soybean-5 (check), BARI Soybean-6 (check), G00342, BD 2338, BD 2355, BD 2329, BD 2340, BD 2342, AGS 95, G00056, AGS 129, BD 2336, BGH 02026, BGM 02093, Galarsum, BD 2350, G00084, BD 2331, G00003 and G00015 were tested. These genotypes were selected based on their better performance in agronomic traits as observed in previous study (Khan, 2013). The experiment was laid out in a RCB design with three replications. The unit plot size was 2.4 m x 2.5 m. The soil was silty clay in texture with pH of 6.5. The seeds were sown on 12 January 2011 with 30 cm apart lines maintaining 5 cm plant to plant distances. Fertilizers were applied at the rate of 28-30-60-18 kg/ha of NPKS in the form of urea, TSP, MoP and Gypsum, respectively (FRG, 2005). Half of urea and full doses of other fertilizers were applied at the time of final land preparation. The remaining half of urea was top dressed at flowering stage followed by irrigation. A light irrigation was done on the soil for uniform emergence. Additional three irrigations were given to the crop at trifoliate vegetative (V_3), beginning bloom (R_1) and full pod stage (R_4). Admire 200SL @ 1 ml/liter of water was sprayed at 10 and 25 DAE to control Jassids and white flies. Belt 4g/liter of water and Ripcord 10 EC @ 1 ml/liter of water was sprayed at 45 and 60 DAE, respectively to control leaf roller and pod borer. Five plants were collected from each plot at 15 days interval for different growth parameters like leaf area, total dry matter (TDM) and crop growth rate (CGR). Plants were cut at base and separated into stem, petiole, leaves and reproductive part. Then the leaf area was measured by an automatic leaf area meter (LI 3100 C, LI-COR, USA). The plant samples were oven dried at 70º C to a constant weight to measure dry matter of different plant parts. CGR was calculated using the following equation (Radford, 1967): CGR ($g /m^2 /day^1$) = $(DW_2 – DW_1) / (t_2-t_1)$, where, DW_1 and DW_2 are the dry matter of the crop from unit ground area (g /m^2) collected at different days t_1 and t_2 ($t_2 > t_1$), respectively. The crop was harvested from 3 May to 14 May, 2011. Yield contributing

characters were recorded from linearly collected 5 plants and yield were recorded from an area of one square meter. Data were analyzed and means were compared using Least Significant Difference (LSD).

Results and Discussion

Plant height

Plant height of different soybean genotypes varied appreciably over time (Fig. 1). Plant height increased slowly till 30 DAE and rapidly thereafter. Difference in plant height was apparent across the genotypes at different growth stages. The tallest plant was observed in genotype BD 2336 (63.17 cm) at 90 DAE which was identical with the height of BGM 02093 (61.00 cm) and followed by BD 2355 (58.50 cm) and BGH 02026 (58.33 cm). These genotypes also maintained increasing trend of height up to 90 DAE. The shortest plant was recorded in BARI Soybean-5 (40.33 cm) irrespective of growth stages. Rasaily *et al.,* (1986) and Ghatge and Kadu (1993) reported high variability in plant height of soybean varieties. Aduloju *et al.,* (2009) reported significant influenced in plant height by the genotypes.

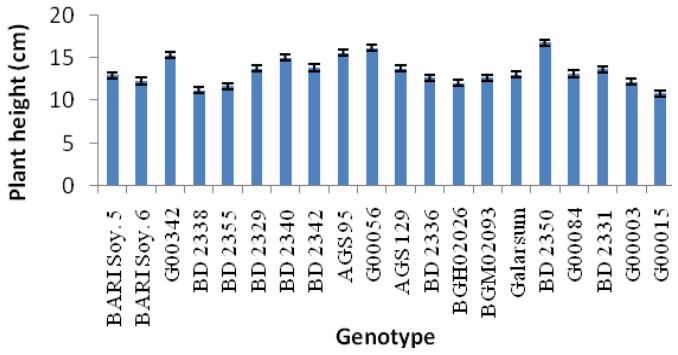

Fig.1a. Plant height of soybean genotypes at 30 DAE.

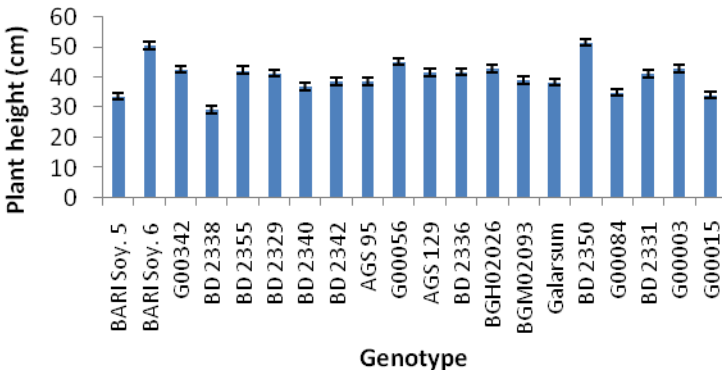

Fig.1b. Plant height of soybean genotypes at 60 DAE

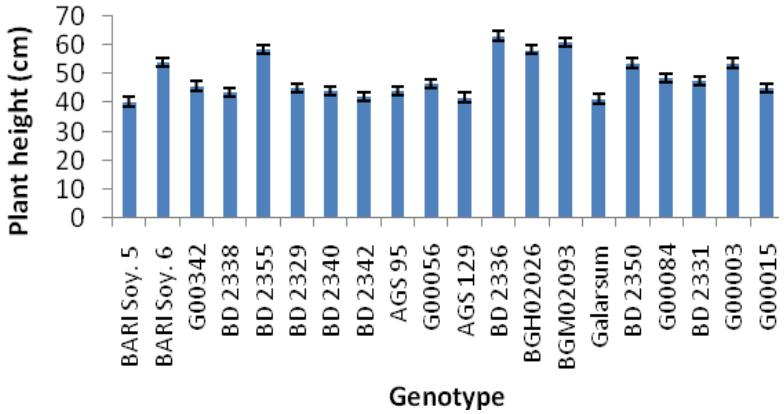

Fig.1c. Plant height of soybean genotypes at 90 DAE.

Leaf area index

Leaf area index (LAI) increased sharply from 30 DAE and reached maximum at 75 DAE and then declined sharply (Table 1). The decrease in leaf area index at later period may be attributed to the onset and senescence of the leaves. Among the genotypes, BGM02093 (4.22) showed maximum leaf area index at 45 DAE (blooming stage) followed by the index of genotypes BARI Soybean-6 (4.12), BD 2355 (3.70), BD 2329 (3.51), BD 2340 (4.21), G00056 (4.19), AGS 129 (3.64), Galarsum (4.21), BD 2331 (3.73) and G00003 (3.51). The increased leaf area index in soybean genotypes might be due to higher number of leaves per plant. The lowest leaf area index was obtained from BD 2342 (3.01) at 45 DAE. Board and Harville (1992) reported that attaining LAI of 3.5 to 4.0 by blooming stage (R_1) is necessary to optimize yield.

Total dry matter

Total dry matter (TDM) production of soybean genotypes increased progressively over time (Table 2). However, the total dry matter accumulation varied depending on genotypes and the stage of growth. The TDM production rate was minimum up to 45 DAE, and then increased sharply. At 90 DAE, the maximum TDM was recorded in G00015 (24.71 g /plant) followed by the TDM of genotypes BARI Soybean-6 (18.43 g/ plant), G00342 (18.28 g/ plant), BD 2338 (18.22 g/ plant), BD 2340 (16.34 g/ plant), BD 2331 (16.12 g/ plant) and G00003 (16.57 g/ plant). The lowest TDM was recorded in Galarsum (12.25 g/ plant) at 90 DAE. Hossain *et al.*, (2004) reported that soybean genotypes were varied in total dry matter production and seed yield. The seed yield was positively correlated with total dry matter production.

Table 1. Leaf area index of soybean genotypes at different days after emergence (DAE).

Genotype	Leaf area index					
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE	90 DAE
BARI Soybean-5	0.08	0.46	1.94	2.34	4.44	2.41
BARI Soybean-6	0.10	0.57	4.12	4.20	4.94	1.86
G00342	0.14	0.77	3.27	3.52	7.12	2.61
BD 2338	0.05	0.53	3.07	3.35	9.29	5.30
BD 2355	0.14	0.71	3.70	4.04	6.77	5.85
BD 2329	0.07	0.67	3.51	3.71	3.96	1.77
BD 2340	0.09	0.80	4.21	4.37	4.25	2.84
BD 2342	0.08	0.65	2.77	2.87	3.01	0.61
AGS 95	0.10	0.81	2.64	2.95	3.43	2.17
G00056	0.14	0.72	4.19	4.52	4.35	0.83
AGS 129	0.09	0.76	3.64	3.89	5.12	2.00
BD 2336	0.09	0.57	3.04	3.31	4.93	2.57
BGH02026	0.08	0.69	3.34	4.62	5.98	1.50
BGM02093	0.09	0.69	4.22	4.76	5.88	1.30
Galarsum	0.10	0.71	4.21	4.60	4.15	2.14
BD 2350	0.13	0.60	3.09	4.83	4.34	4.31
G00084	0.10	0.75	3.55	3.93	3.75	2.47
BD 2331	0.10	0.93	3.73	4.93	5.01	2.21
G00003	0.14	0.48	3.51	5.92	8.13	5.38
G00015	0.12	0.53	3.20	3.56	5.23	5.56
SE (±)	0.01	0.03	0.14	0.19	0.36	0.36
Mean	0.10	0.67	3.40	4.01	5.20	2.78

Total dry matter and their distribution in percent

Total dry matter and their distribution (%) of the plant of the respective soybean genotypes at 90 DAE is presented in Table 3. The genotypes varied according to their dry matter distribution (%) in different plant parts. Though the genotypes BARI Soybean-6, G00342, BD 2338, BD 2340, BD 2331, G00003 and G00015 produced maximum dry matter, BARI Soybean-6 distributed 21.66% in stem, 4.83% in petiole, 9.24% in leaf blade and 64.27% in pods; G00342 distributed 19.04% in stem, 2.86% in petiole, 10.29% in leaf blade and 67.81% in pods; BD 2338 distributed 17.27% in stem, 6.57% in petiole, 22.01% in leaf blade and

54.06% in pods; BD 2334 distributed 15.56% in stem, 5.34% in petiole, 14.75% in leaf blade and 64.35% in pods; BD 2331 distributed 20.915 in stem, 4.14% in petiole, 11.84% in leaf blade and 63.11% in pods; G00003 distributed 21.50% in stem, 6.9% in petiole, 18.75% in leaf blade and 52.85% in pods; G00015 distributed 16.21% in stem, 7.03% in petiole, 21.54% in leaf blade and 55.22% in pods. Among the genotypes, G00056 distributed the highest dry matter in pods (69.50%) with lowest in petiole (1.99%) and leaf blade (5.25%). Varietal differences in dry matter accumulation with their partitioning in mustard are in agreement with Khan *et al.,* (2006).

Table 2. Total dry matter production of soybean genotypes at different days after emergence (DAE).

Genotype	Total dry matter (g/plant)					
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE	90 DAE
BARI Soybean-5	0.10	0.53	2.30	4.66	14.89	15.20
BARI Soybean-6	0.13	0.67	3.56	7.37	18.21	18.43
G00342	0.18	0.86	3.46	6.37	17.87	18.28
BD 2338	0.07	0.58	2.40	6.49	18.14	18.22
BD 2355	0.17	0.79	3.21	6.21	11.58	15.02
BD 2329	0.10	0.61	3.27	6.62	11.86	15.21
BD 2340	0.13	0.89	4.03	7.19	12.27	16.34
BD 2342	0.10	0.72	3.18	6.57	9.38	12.56
AGS 95	0.13	0.66	2.91	5.88	11.41	13.23
G00056	0.18	0.85	4.10	7.95	13.73	14.52
AGS 129	0.13	0.72	3.93	7.61	13.58	13.77
BD 2336	0.12	0.64	4.05	7.75	14.23	14.72
BGH02026	0.10	0.59	4.05	7.81	12.61	13.34
BGM02093	0.11	0.76	4.30	8.48	13.67	14.12
Galarsum	0.12	0.68	3.90	8.31	11.84	12.25
BD 2350	0.17	0.76	3.77	7.16	12.01	13.12
G00084	0.17	1.45	4.01	6.87	12.45	13.69
BD 2331	0.13	0.79	4.06	8.08	14.48	16.12
G00003	0.17	0.53	2.80	6.65	13.64	16.57
G00015	0.16	0.60	4.31	8.88	18.32	24.71
SE (±)	0.01	0.04	0.14	0.23	0.57	0.64
Mean	0.13	0.73	3.58	7.15	13.81	15.47

Table 3. Total dry matter and their distribution in different plant parts at 90 days after emergence of soybean genotypes.

Genotypes	Stem (%)	Petiole (%)	Leaf blade (%)	Pods (%)	TDM (g/plant)
BARI Soybean-5	18.15	4.71	15.98	61.15	15.20
BARI Soybean-6	21.66	4.83	9.24	64.27	18.43
G00342	19.04	2.86	10.29	67.81	18.28
BD 2338	17.27	6.57	22.10	54.06	18.22
BD 2355	20.04	7.72	27.10	45.13	15.02
BD 2329	17.89	3.83	11.15	67.13	15.21
BD 2340	15.56	5.34	14.75	64.35	16.34
BD 2342	24.65	2.65	6.45	66.25	12.56
AGS 95	18.27	4.76	17.34	59.63	13.23
G00056	23.26	1.99	5.25	69.50	14.52
AGS 129	22.71	4.22	14.36	58.71	13.77
BD 2336	22.55	4.84	13.43	59.18	14.72
BGH02026	26.83	3.11	7.81	62.25	13.34
BGM02093	24.70	2.55	6.19	66.56	14.12
Galarsum	23.80	4.42	15.47	56.31	12.25
BD 2350	17.87	4.87	19.88	57.39	13.12
G00084	25.03	6.02	18.75	50.20	13.69
BD 2331	20.91	4.14	11.84	63.11	16.12
G00003	21.50	6.90	18.75	52.85	16.57
G00015	16.21	7.03	21.54	55.22	24.71
SE(±)	0.73	0.36	1.33	1.44	0.64
Mean	20.90	4.67	14.38	60.05	15.47

Crop growth rate (CGR)

Crop growth rate of the soybean genotypes varied appreciably over the time (Fig. 2). At early stages, CGR was very slow till 30 DAE and thereafter increased rapidly and the differences among the soybean genotypes persisted throughout the growth period. Regardless of genotypes, CGR reached peak at 75 DAE and thereafter declined in all genotypes. Maximum utilization of environmental resources reached the plant at maximum CGR at the reproductive phase. After 75 DAE natural senescence of leaves might have tended to decline in CGR. At 45 DAE, CGR was maximum in genotype G00015 (16.51 g/m^2/day) which was at par in BGM02093 (15.74 g/m^2/day) and followed by the growth rate of

genotypes BD 2336 (15.17 g/m^2/day), BD 2326 (15.36 g/m^2/day) and BD 2331(14.57 g/m^2/day). At 75 DAE it reached the highest in genotype BD 2338 (51.78 g/m^2/day) which was at par with genotypes G00342 (51.11 g/m^2/day) and BARI Soybean-6 (48.19 g/m^2/day). At 90 DAE, the maximum CGR was recorded in genotype G00015 (28.40 g/m^2/day) followed by genotypes BD 2340 (18.10 g/m^2/day), BD 2355 (15.27 g/m^2/day), BD 2329 (14.89 g/m^2/day) and BD 2342 (14.13 g/m^2/day) genotypes.

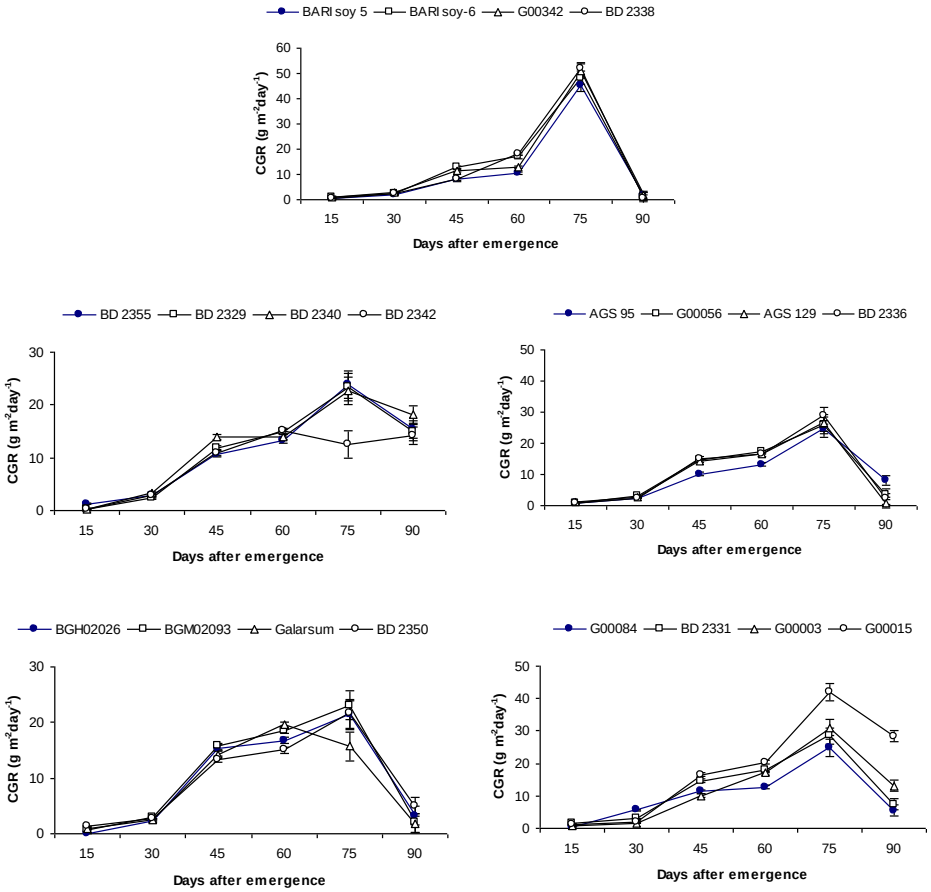

Fig. 2. Crop growth rate (CGR) of soybean genotypes at different growth stages.

Yield and yield attributes

Plant population /m^2, plant height, number of branches per plant, filled pods per plant, unfilled pods per plant, 100-seed weight and seed yield of soybean showed significant variations across the genotypes (Table 4). The maximum plant population was obtained in genotype BD 2329 (67.6 /m^2) and it was statistically

identical with the population of genotypes BARI Soybean-5 (63.6 /m^2), BARI Soybean 6 (64.0 /m^2), G00342 (63.9 /m^2), BD 2355 (66.4 /m^2), BD 2340 (66.4 /m^2), BD 2342 (59.8 /m^2), AGS 95 (67.3 /m^2), G00056 (61.1 /m^2), AGS 129 (66.7 /m^2), BD 2336 (61.3 /m^2), BGH02026 (58.4 /m^2), BGM02093 (62.9 /m^2), Galarsum (60.2 /m^2), BD 2350 (62.5 /m^2), BD 2331 (65.1 /m^2), G00003 (60.1 /m^2) and G00015 (60.4/m^2). The lowest population was recorded in genotype G00084 (50.7 /m^2). The tallest plant was obtained from genotype BD 2336 (63.17 cm) which was statistically identical with genotypes BD 2355 (58.50 cm), BGH02026 (58.33 cm), BGM02093 (61.00 cm). The shortest plant was obtained in BARI Soybean-5 (40.33 cm). Significantly the highest number of branches was recorded in BD 2350 (6.7 /plant) which was at par with genotypes BARI Soybean-6 (4.7 /plant), G00342 (5.0 /plant), BD 2338 (4.7 /plant), BD 2355 (5.7 /plant), BD 2340 (4.7 /plant), BD 2336 (6.0 /plant), BGH02026 (5.0 /plant) and BGM02093 (6.3 /plant). The lowest number of branch recorded in genotype Galarsum (3.0 /plant). Among the genotypes, BD 2336 and BGM 02093 produced the maximum number of filled pods (55.7/ plant) followed by BARI Soybean-6 (45.7/plant), BD 2340 (45.7 /plant) and BGH 02026 (45.7 /plant). Genotype G00056 produced the lowest number of filled pods (23.0 /plant). The highest number of unfilled pods was recorded in BARI Soybean-5 (10.7 /plant) and it was statistically at par with genotype BD 2342 (7.3 /plant). The lowest unfilled pod was recorded in genotypes BD 2329 and G00084. The heavier seed weight (16.52 g) was recorded in genotype G00056 followed by G00015 (14.81 g). The lighter seed weight was recorded in BD 2336 (6.81 g) which was at par with genotypes BGH 02026 (6.86 g) and BGM 02093 (7.12 g). Seed yield was also varied significantly due to genotypic variations. The highest seed yield was obtained from genotype BGM 02093 (3825 kg/ha) and it was statistically identical with genotypes BARI Soybean-6 (3640 kg/ ha), BD 2329 (3447 kg/ ha), BD 2340 (3573 kg/ ha), AGS 129 (3004 kg/ ha), BD 2336 (3737 kg/ ha), BGH 02026 (3267 kg /ha), Galarsum (3115kg/ ha), BD 2350 (2869 kg/ ha), BD 2331(3542 kg/ ha) and G00015 (3762 kg/ ha). The highest seed yield was attributed by the higher number of plant population/ m^2, filled pods/ plant and 100-seed weight. The lowest seed yield was obtained from genotype G00003 (1745 kg/ ha). Malik *et al.*, (2006) also observed high variability for seed yield in soybean genotypes.

Relationship between TDM at different growth stages and seed yield were estimated to find out the stages which one is more representative to seed yield and to predict required TDM of irrespective stages for attaining the optimum seed yield of soybean (Fig. 3). There was negative and weak relationship between TDM and seed yield at 15 DAE ($Y = 3643.6 – 4899.4X$, $R^2 = 0.07$) and 30 DAE ($Y = 3020.1 – 36.90X$, $R^2 = 0.01$). The relations were positive but weak at 75 DAE ($Y = 2315.3 + 49.09X$, $R^2 = 0.04$) and 90 DAE ($Y = 2177.7 + 52.70X$, $R^2 = 0.06$). Seed yield of soybean was more positively related to TDM at 45

DAE (Y = 632.19 + 659.31X, R^2 = 0.46) and 60 DAE (Y= 95.335 + 405.53X, R^2 = 0.48) DAE (Fig. 3). The filled pods /plant had significant relationship with seed yield (Y = 1397 + 41.85X, R^2 = 0.41) than other components (Fig. 4). The strong relationship between filled pods /plant and seed yield revealed that pods /plant had greater contribution to seed yield of soybean. A similar result of highly positive association between seed yield and number of filled pods was also reported by Arshad *et al.,* (2006).

Table 4. Yield contributing characters and yield of soybean genotypes.

Genotypes	Plant popn /m^2 (no.)	Plant height (cm)	Branches /plant (no)	Filled pods /plant (no.)	Unfilled pods /plant (no.)	100 seed weight (g)	Seed yield (kg/ha)
BARI Soybean-5	63.6	40.33	3.7	40.0	10.7	9.95	2222
BARI Soybean-6	64.0	54.00	4.7	45.7	4.7	10.40	3640
G00342	64.0	45.73	5.0	34.0	7.3	12.47	2443
BD 2338	57.6	43.50	4.7	42.0	2.3	8.91	2775
BD 2355	66.4	58.50	5.0	31.7	1.3	10.91	2799
BD 2329	67.6	45.17	4.3	38.0	1.0	10.76	3447
BD 2340	66.4	44.07	4.7	45.7	7.0	10.92	3573
BD 2342	59.8	42.00	3.7	27.3	2.7	9.87	2345
AGS 95	67.3	44.17	4.0	42.3	4.3	9.98	2421
G00056	61.1	46.50	4.0	23.0	3.7	16.52	2639
AGS 129	66.7	41.83	4.3	37.0	3.3	10.11	3004
BD 2336	61.3	63.17	6.0	55.7	2.0	6.81	3737
BGH02026	58.4	58.33	5.0	45.7	3.0	6.86	3267
BGM02093	62.9	61.00	6.3	55.7	3.3	7.12	3825
Galarsum	60.2	41.33	3.0	36.0	6.7	9.93	3115
BD 2350	62.4	53.83	6.7	37.7	2.3	11.13	2869
G00084	50.7	48.50	3.7	24.0	1.0	13.37	2691
BD 2331	65.1	47.50	4.0	38.3	2.3	10.46	3542
G00003	60.9	53.67	3.3	27.7	2.3	11.64	1745
G00015	60.4	45.10	4.0	35.0	2.0	14.81	3762
LSD (0.01)	9.18	8.44	2.3	11.7	3.6	0.68	967
CV (%)	6.65	7.79	23.15	13.69	44.42	2.86	14.59

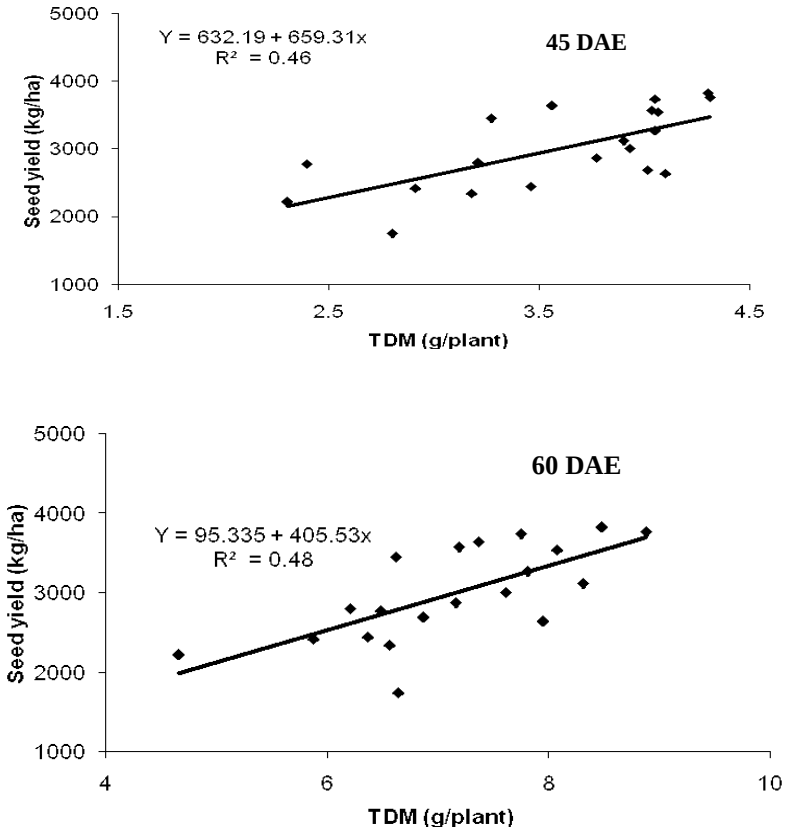

Fig. 3. Relationship between TDM and seed yield at different growth stages (45 and 60 DAE).

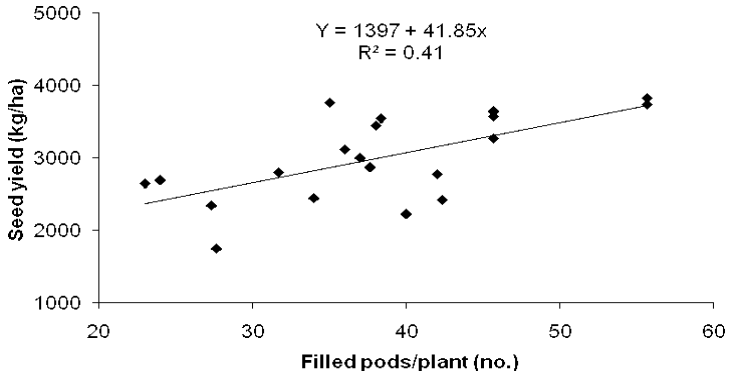

Fig. 4. Relationship between filled pods/plant and seed yield of soybean.

Conclusion

Plant height, leaf area index, dry matter distribution in different parts, crop growth rate and seed yield showed variation among the genotypes. The genotypes BGM 02093, BD 2329, BD 2340, BD 2336, Galarsum, BD 2331 and G00015 performed better in respect of higher accumulation of total dry matter and seed yield. The selected genotypes should further be incorporated in breeding trials to develop high yielding soybean varieties.

References

Aduloju, M.O., J. Mahamood and Y.A. Abayomi. 2009. Evaluation of soybean (*Glycine max* (L) Merrill) genotypes for adaptability to a southern Guinea savanna environment with and without P fertilizer application in north central Nigeria. *Afr. J. Agric. Res.* **4:** 556-563.

Arshad, M., N. Ali and A. Ghafoor. 2006. Character correlation and path coefficient in soybean *Glycine max* (L.) Merrill. *Pak. J. Bot.* **38**(1): 121-130.

FRG, 2005. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215.

Board, J.E., and B.G. Harville. 1992. Explanations for greater light interception in narrow-vs. wide-row soybean. *Crop Sci.* **32:** 198-202.

Ghatge, R.D., and R.N. Kadu. 1993. Genetic variability and heritability studies in soybean. *Advances in Plant Science* **6:** 224-228.

Hossain, M.A., and M.S.A. Khan. 2003. Genotypic variation in root growth, dry matter accumulation, nutrient uptake and yield of *Brassica* species. *Bangladesh J. Agril. Sci.* **30**(1): 143-150.

Hossain, M.A., R.R. Saha and M.S.A. Khan. 2004. Root development, nutrient uptake and yield performance of soybean as influenced by phosphorus fertilization. *Bangladesh J. Agril. Sci.* **31**(2): 161-168.

Khan, M.S.A., M.A. Hossain, M.N. Islam, M.S. Aktar and M.A. Rahman. 2006. Root length density, dry matter accumulation and yield performance of mustard varieties under rainfed condition. *The Agriculturists* **4**(1&2): 141-148.

Khan, M.S.A. 2013. Evaluation of soybean genotypes in relation to yield performance, salinity and drought tolerance. Ph.D. Dissertation. Dept. Agronomy, BSMRAU, Salna, Gazipur.

Malik, M.F.A., A.S. Qureshi, M. Ashraf and A. Ghafoor. 2006. Genetic variability of the main yield related characters in soybean. *Int. J. Agri. Biol.* **8**(6): 815-819.

Messina, M. 1997. Soyfoods: Their role in disease prevention and treatment. In Liu, K. (ed). Soybeans: Chemistry, Technology and Utilization, Chapman and Hall, New York. Pp.442-466.

Mondal, M.R.I., and M.A. Wahhab. 2001. Production Technology of Oilcrops. ORC, BARI, Joydebpur, Gazipur. Pp.57-67

Radford, P.J. 1967. Growth analysis formulae – their use and abuse. *Crop science*. Vol. 7: 171-175.

Rasaily, S.K., N.D. Desai and M.U. Kukadia. 1986. Genetic variability in soybean (*Glycine max* (L) Merrill). *Gujrat Agric*. *University Res. J.* **11:** 57-60.

Yaklich, R.W., B. Vinyard, M. Camp and S. Douglass. 2002. Analysis of seed protein and oil from soybean northern and southern region uniform tests. *Crop Sci*. **42:** 1504-15.