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Characterization and seed quality of some dwarf soybean genotypes

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Abstract

An investigation was carried out at the experimental field of the Department of Agronomy of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during January 2012 through April 2012, to characterize different plant parameters of thirteen dwarf soybean (*Glycine max* L.) genotypes. A wide diversity among the genotypes in their physio-morphological characters including yield was recorded. Genotypes varied from days 36 in G00221 to 40 days in G00197 to initiation of 50% flowering. Genotypes G00042 took the longer time (80.7 days) for maturity, where G00351 took the shortest time (68.67 days). Pods number per plant was the highest (60.67) in G00207, while the lowest (15.04) in G00041. The highest number of seeds per pod (2.087) was obtained from G00046, while G00207 had the least (1.657). Weight of 100-seed was the maximum (16.34 g) in G00041and that was the minimum (10.55 g) in G00166.Among all the genotypes, G00207 produced the highest seed yield (4.23 t/ha). Contrary genotypes G00046 produced the lowest seed yield (1.43t/ha). The germination percentage of the thirteen soybean genotypes varied from 76.00% (G00042) to 86.66% (G00166). The terazolium-test showed that the highest viable seed (91.67%) was in the genotype G00166 and the lowest (85.67%) was in G00042. Electrical conductivity test showed that genotype G00204 had the minimum (18.84mS $cm^{-1}g^{-1}$) conductivity value, where G00343 had the maximum value (29.89mS $cm^{-1}g^{-1}$), which was followed by G00053 and G00221. It was concluded that variation in physio-morphology of the 13 genotypes would be useful in developing short duration high yielding soybean verities through genetic manipulation.

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Introduction

Soybean (*Glycine max* (L.) Merrill) contains high amount of quality protein (>42 per cent) and oil (20 per cent).The soybean is often called "the miracle plant", for its high quality nutrients in grain, which contains 35-55% of easily digestible proteins, 17-27% fats, 30% carbohydrates, calcium, iron, fiber, vitamins, etc., depending on variety and growing conditions. It is one of the important legume crops in the world. Soybean is widely cultivated in the temperate and subtropical regions and also in many parts of the tropics (Purse glove, 1984).

The plant type is short, bushy or climbing. Due to rich and varied chemical composition it is widely used as a food, forage and industrial crop, having a great agro technological importance as well (Aliyev and Akperov, 1995; Ososki and Kennelly, 2003; Pimentel and Patzek, 2008; Sakai and Kogiso, 2008). The soybean has also the ability to assimilate air nitrogen (Burris and Roberts, 1993) and, therefore, requires minimal costs for nitrogen fertilizers, which is often considered the single major energy contributor to agriculture. World soybean production was about 210.9 million metric tons in 2009 (Soystats, 2010).

The consumption of soy-based products increases worldwide due its enormous health related beneficial effects, which include reduction of cholesterol level, prevention of cancer, diabetes and obesity, protection against intestinal and kidney diseases (Friedman and Brandon, 2001).

Soybean has been cultivating in Bangladesh as minor crop. So far, little attention has been paid for the improvement of its yield potential as well as development of crop management options.

Consequently, the yield level of soybean in Bangladesh remains low compared to other countries of the world. In Bangladesh, about 5000 hectares of land was under soybean cultivation and annual production was approximately 4000 metric tons with an average yield of 1.5-2.3 t/ha in the year 2009-2010. Recently the crop has gained popularity in the poultry industry and its cultivation area is gradually increasing that covers about 51778 ha only in Noakhali and Laxmipur Districts (Chowdhury, 2012).

There was an effort to establish soybean in Bangladesh during 1980s. However, the attempt was not successful mainly due to lack of good variety, marketing channel and availability of quality seed.

The problem with lack of good variety and seed quality, however, remains unresolved. Seed quality is essential to obtain a successful field emergence of soybean crop (Arango *et al*., 2006) and the seed quality is mostly influenced by the temperature and moisture fluctuations (Harrington, 1972) which regularly occur in Bangladesh during the soybean harvest. There is a bright prospect for local soybean production and its possible to meet 40 percent of local demand of soybean oil by bringing 0.7-0.8 million hectares of lands in char areas under cultivation with an expected production 1.7-1.8 million metric tons of soybean (Mollah, 2009).

The dwarf genotypes can easily be intercropped with other popular crops, e.g. maize. Moreover, due to their short duration, they can be fitted well in the existing cropping patterns in Bangladesh. However, precise information on the performance as well as plant characters of the dwarf soybean genotypes is necessary before they are used at the field level by the farmers. The present investigation was, therefore, undertaken to characterization, yield performance and analysis of seed quality of exotic 13 dwarf genotypes of soybean.

Materials and methods

The experiment was carried out at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during January to April 2012. The experimental site is located (24°09 N and 90°26'E) at the center of Madhupur Tract (Brammer, 1971) of Agro ecological Zone (AEZ) 28. Thirteen dwarf soybean genotypes collected from AVRDC, Taiwan which was available at the Dept. of Agronomy of Bangabandhu Sheikh Mujibur Rahman Agricultural University, were included in the present investigation. The genotypes were G0041, G00197, G00166, G00207, G00343, G00204, G00154, G00046, G00221, G00351, G00138, G00053, and G00042.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks, representing three replications. Each block was further subdivided into 13 unit plots. The thirteen different genotypes of dwarf soybean represented as treatments of the experiment and were allotted to the 13 unit plots per block. The unit plot size was 1.2 m x 1.0 m accommodating 40 plants in each plot having row and plant spacing of 30 cm and 10 cm, respectively. Fertilizers were applied as urea, triple super phosphate, muriate of potash, gypsum and boric acid as source of N, P,K,S and B @ 50, 150, 120, 80 and 10 kg ha^{-1}, respectively. All intercultural operations were done as soybean production technology. At physiological maturity, dry pods were harvested at different days after sowing (DAS) for different genotypes. The harvesting was started from 90 DAS and continued up to 110 DAS for different genotypes. The crop was harvested upon maturity and pods were sun dried at 9% moisture. Different physio-morphological parameters data were recorded, viz. days to emergence, days to first unifoliate leaf, days to first trifoliate leaf, days to first flowering, days of 50% flowering, branch no. $plant^{-1}$,stem diameter, days to maturity and plant height.

Measurement of SPAD value

The data were recorded from the fully expanded leaf by using SPAD (Soil Plant Analyses Development) meter (MINOLTA SPAD 502) at three days interval from first flowering to physiological maturity. Ten randomly selected plants per genotype were used for measurement SPAD value. The following data were recorded: pod length, pod breadth, number of pods $plant^{-1}$, number of $seedspod^{-1}$, seed color, seed diameter, 100-seed weight, no. of $seedsplant^{-1}$

Quality attributes of harvested soybean seed

A total of thirty-nine seed samples were collected from the harvested soybean seeds and quality attributes of the harvested soybean seeds (moisture content, germination%, 100-seed weight, seed viability, and seed vigor) were also determined according to ISTA rules.

Germination percentage

For germination test, one hundred seeds from each genotype were used and replicated four times. Seeds were placed in 21 cm X 15.5 cm plastic trays containing filter paper soaked with distilled water. Then the plastic trays with seeds were placed in an incubator at 30ºC till the completion of germination. The germinators were opened every 24 h interval to count germinated seeds and to add water if necessary. Germination was considered to have occurred where a radical length of approximately 2 mm had been reached (Ramin, 1997). Final germination count was made according ISTA, (2006). Data on hard, fresh, rotten and germinated seed were recorded as percentage basis. Germination percentage was calculated by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Nuber of seeds germinated}}{\text{Number of seeds tested}} \times 100$$

Seed vigor (electrical conductivity) test

For electrical conductivity test, 10g seeds of each sample were taken in a conical flask containing 100 ml de-ionized water and incubated at 20ºC for 20 hours. After 20 hours, water of the beaker containing seeds was decanted in order to separate the seeds. The electrical conductivity meter was used. Three replications of measurements were made for each sample of seed and expressed on a $\mu S\ cm^{-1}g^{-1}$with a conductivity meter (Model-CM-30ET).

Seed viability (Tetrazolium) test

The tetrazolium test was used in the determination of seed viability. Soybean seeds were immersed in alcohol for 30 minutes, rinsed with water, immersed in water at 30ºC for 24 hours and had the testa removed. After the preparation procedure, the seed was immersed in tetrazolium solution (0.75%) at 30ºC for 5 hours.

Moisture content

Moisture content of seeds was determined by high constant temperature oven method. After fine grinding an amount of 5g of two independently drawn working samples were dried at a temperature of 130-133ºc for a period of one hour.

Percentage of moisture content was recorded to one decimal place (ISTA, 2006) by means of the following formula:

$$\% \text{ Moisture content} = (M_2 - M_3) \times \frac{M_2 - M_1}{100}$$

Where,

M_1 is the weight in grams of the container and its cover,

M_2 is the weight in grams of the container, its cover and its contents before drying,

M_3 is the weight in grams of the container, cover and contents after drying.

Statistical Analysis

The data obtained from the experiments on different parameters were analyzed statistically following analysis of variance (ANOVA) technique with the help of computer package, MSTAT. Means were separated using Duncan's multiple range test at a significance level of 0.05 (Gomez and Gomez, 1984).

Results and discussion

Mean performance of growth characters of thirteen soybean genotypes

Days to emergence

Genotypic differences were observed in case of days to emergence (Table 1). The genotype G00046 took minimum days (9.33) to emergence followed in increasing order by G00197 (9.73), G00041 (10.40) and G00166 (10.42).

The maximum days (11.47) required for emergence of the genotype G00343, which was followed by G00154 (11.40) and G00221 (11.13).

Days to first unifoliate leaf (DAE)

Marked differences among the genotypes were observed in respect to days required to attain first unifoliate leaf (Table 1).

The genotype G00343 took minimum days (4.47) to attain first unifoliate leaf stage, whereas G00221 (5.60) took the maximum days. Six genotypes under study took 4.00 to 5.00 days and the seven took > 5.00 days to attain first unifoliate leaf stage.

Days to first trifoliate leaf (DAE)

Marked differences among the genotypes were observed in respect to days required to attain first trifoliate leaf (Table 1).

The genotype G00221 took minimum days (10.33) to attain first trifoliate leaf stage, whereas G00046 (12.07) took the maximum days. Seven genotypes under study took 10.00 to 11.00 days and the rest six took >11.00 days to attain first trifoliate leaf stage.

Table 1. Mean performance of growth characters of thirteen soybean genotypes.

Genotypes	Days to emergence	Days to first unifoliate leaf	Days to first trifoliate leaf	Days to first flowering	Branch plant^{-1}	Stem Diameter (mm)	Days to maturity
G00041	10.40 de	4.53 cd	11.27 abc	32.00 ef	2.33 bc	4.33 e	78.67 ab
G00197	9.73 ef	4.73 bcd	11.80 a	35.27 a	1.80 c	4.44 cde	78.67 ab
G00166	10.42 de	5.00 abcd	10.80 bcd	34.27 b	2.33 bc	4.22 e	79.00 ab
G00207	10.73 bcd	4.93 abcd	11.28 abc	33.07 cd	3.20 a	4.80 b	75.67 abcd
G00343	11.47 a	4.47 d	10.74 bcd	33.73 bc	2.73 ab	4.84 b	76.33 abc
G00204	11.00 abcd	5.20 abc	11.34 abc	31.20 fgh	2.27 bc	4.70 bcd	69.33 cd
G00154	11.40 ab	4.73 bcd	10.54 cd	32.20 de	2.33 bc	4.71 bc	72.00 bcd
G00046	9.33 f	5.00 abcd	12.07 a	29.13 i	1.80 c	4.23 e	75.33 abcd
G00221	11.13 abc	5.60 a	10.33 d	30.60 h	2.20 bc	4.40 de	75.00 abcd
G00351	10.47 cd	4.73 bcd	10.87 bcd	31.67 efg	2.20 bc	4.82 b	68.67 d
G00138	10.80 abcd	5.40 ab	10.40 d	32.00 ef	2.13 bc	4.32 e	77.33 ab
G00053	10.93 abcd	5.13 abcd	10.41 d	31.00 gh	2.26 bc	4.45 cde	73.33 abcd
G00042	10.87 abcd	5.20 abc	11.40 ab	30.73 gh	2.40 bc	5.30 a	80.67 a
LSD(0.05)	0.685	0.690	0.843	0.946	0.646	0.310	7.46
CV (%)	3.81	8.23	4.54	1.75	16.61	4.02	5.87

Days to first flowering (DAE)

Genotypic differences were observed in case of days to first flowering (Table 1). The genotype G00046 took minimum days (29.13) to first flowering followed in increasing order by G00221 (30.60), G00042 (30.73) and G00053 (31.00). The maximum days (35.27) required for the genotype G00197, which was followed by G00166 (34.27) and G00343 (33.73). It was also apparent that around 59% of the total genotypes flowered within 32.00 to 33.73 days after emergence. Moran and Barrales (1990) reported that the flowering of (*Glycine max* L.) genotypes occurred from 22 to 57 days after emergence. Masaya *et al.* (1986) defined flowering behavior as the time and position of the first flower and considered it to be an important trait of soybean cultivars.

Days to 50% flowering (DAE)

Marked genotypic differences were observed for days to 50% flowering among. The genotypes under investigation (Fig.1). The genotype G00197 took maximum days (39.86) to 50% flowering, which was closely followed by G00166 (39.60). The genotype G00221 took minimum days (36.06) to 50% flowering.

The seven genotypes, viz. G00041 (36.67), G00204 (36.73), G00221 (36.06), G00053 (36.80), G00046 (37.86), G00138 (37.73) and G00351 (37.86) were flowered within short duration (less than 38 days after emergence).

About 50% of the total genotypes under trial flowered within 32.00 to 34.00days from emergence. In a vary *et al* trial, Joshi *et al.* (1987) reported that the varieties required 31-36 days to 50% flowering which was in consonance with majority of the varieties under investigation. The differences in days to 50% flowering might be due to the genetical factors of the genotype concerned.

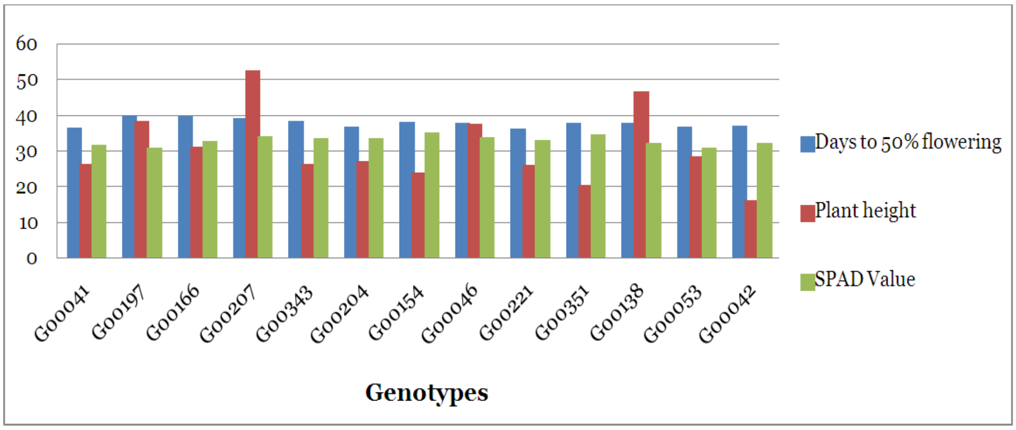

Fig. 1. Days to 50% flowering, Plant height and SPAD Value of 13 soybean genotypes.

Number of branchplant-1

The number of branches per plant varied among the soybean genotypes (Table 1). The mean number of branches per plant was 2.30. Significantly higher number (3.20) of branches was recorded in G00207, while the lowest (1.80) was in G00046 and G00197.

Steam diameter

The stem diameter varied among the soybean genotypes (Table 1). The mean number of stem diameter plant was (4.58 mm). Significantly highest (5.30mm) stem diameter was recorded in G00042 and the lowest (4.22mm) was in G00166.

Days to maturity

The difference of days to maturity among the genotypes was significant in different varieties (Table 1). The highest duration (80.76 days) to maturity was found in the genotype G00042 which was followed by genotype G00166 (79), G00041 and G00197. The shortest duration (68.67) was found in the genotype G00351 followed by G00204.

Plant height

The genotypes varied enormously in plant height (Fig. 1). The tallest (52.37 cm) plant was in G00207 and the shortest (16.14 cm) in G00042.

The variation observed in plant height among the genotypes might be due to difference in genetical constituents as well as environmental effects.

Measurement of SPAD value

The genotypes varied enormously in SPAD value (Fig. 1). The highest value (35.00) of plant was in G00154and the lowest (30.71) in G00197. The variation observed in SPAD value among the genotypes might be due to difference in genetical constituents as well as environmental effects.

Yield and yield contributing characters of thirteen soybean genotypes

Seed diameter

Seed diameter varied among the soybean genotypes (Table 2). The mean number of seed diameter was (5.13 mm). Significantly larger (5.73 mm) seed diameter was recorded in G00042 and the lowest (4.44 mm) was in G00207.

Pod length

Pod length was remarkably affected by genotypes and varied from 3.49 cm to 4.26 cm (Table 2). The longest pod (4.26 cm) was recorded in G00046 followed by G00042 (4.19cm), G00204 (4.12cm) and G00166 (4.05cm), while the shortest one was in G00207 (3.49cm). In respect of pod length, 70% of the genotypes under study varied from 3.49cm to 3.99cm. The rest genotypes, 30% of the total, ranged from 4.04cm to 4.26cm in pod length. Wide variation (4.9cm to 6.7cm) in pod length among some genotypes of soybean was reported by Gupta *et al.,* (1983).

Table 2. Yield and yield contributing characters of 13 soybean Genotypes.

Genotypes	Seed diameter (mm)	Pod Length (cm)	Pod Breadth (cm)	Pods Plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Seed yield (t ha^{-1})
G00041	5.40 abcd	4.04 cd	1.16 a	15.04 f	1.94 ab	16.34 a	1.46 d
G00197	5.23 bcd	3.90 ef	0.84 f	32.27 b	1.92 ab	11.68 e	2.35 b
G00166	4.50 f	4.05 cd	0.88 ef	31.43 bc	1.93 ab	10.55 f	2.26 b
G00207	4.44 f	3.49 g	0.87 ef	60.67 a	1.66 c	12.13 de	4.23 a
G00343	4.77 ef	3.91 ef	0.92 def	35.73 b	1.97 ab	11.67 e	2.40 b
G00204	5.43 abcd	4.12 bc	1.05 bc	19.27 def	1.93 ab	14.49 b	1.77 cd
G00154	5.28 bcd	3.80 f	1.02 bc	19.73 def	1.92 ab	13.94 bc	1.62 cd
G00046	5.09 de	4.26 a	0.96 cde	18.73 ef	2.087 a	12.88 d	1.43 d
G00221	4.64 f	3.85 f	1.02 bc	21.47 def	1.963 ab	13.06 cd	1.76 cd
G00351	5.15 cd	3.81 f	1.03 bc	24.73 de	1.827 bc	14.65 b	1.94 bc
G00138	5.53 ab	3.99 de	0.99 bcd	25.28 cde	2.047 a	14.45 b	2.35 b
G00053	5.52 abc	3.88 ef	1.07 abc	25.67 cd	2.060 a	14.33 b	2.38 b
G00042	5.73 a	4.19 ab	1.08 ab	17.04 f	1.787 bc	15.92 a	1.48 cd
LSD(0.05)	0.377	0.119	0.106	6.564	0.219	0.984	0.477
CV (%)	4.36	1.76	5.96	14.59	6.76	4.31	13.39

Pod breadth

There had an appreciable variation (1.16cm to 0.84cm) in pod breadth among the genotypes (Table 2). The genotype G00041 attained the maximum pod breadth (1.16cm), which was closely followed by genotypes G00042 (1.08cm), G00053 (1.07cm), G00204 (1.05cm) and G00351 (1.03cm). Breadth of pod was found to be the minimum in G00197 (0.84cm), followed in increasing order by G00207 (0.87cm), G00166 (0.88cm), G00343 (0.92cm) and G00046 (0.96cm). Gupta *et al.,* (1983) recorded a significant variation in respect of pod diameter among thirty erect types of soybean genotypes. They found 0.6 cm pod diameter, the lowest and 1.2mm, the highest with a mean value of 1.0 cm with variance 1.03.

Pods plant^{-1}

Marked variation regarding number of pods per plant among the genotypes was observed that varied from 15.04 to 60.67 (Table 2). The highest number of pods per plant (60.67) was produced by G00207.Considering the number of pods per plant three genotypes namely, G00204 (19.27), G00154 (19.73) and G00046 (18.73) were closeted, appeared to be intermediate (Table 2).

The genotype G00041 (15.04) produced the lowest number of pods per plant which was followed by G00042 (17.04).

The highest number of pods per plant was obtained from the genotype G00207 (60. 67) More than fifty percent of the total genotypes under study (seven genotypes) had pods/plant that varied from 21.47 to 35.73. Three genotypes G00351, G00138 and G00053 had the pods 24.73, 25.28 and 25.67 respectively. The difference in number of pods per plant among the genotypes under trial was remarkable from practical standpoint.

The number of pods per plant varied from 22 to 36 as reported by Singh *et al.* (1992) from their experiment at the Mariana. Dwivedi *et al.* (1995) recorded 22.35 pods per plant in 'Rajmah' to 34.24 in 'Arka Komal'. Therefore, variation of pod number among soybean genotypes is a common plant character.

Seeds pod^{-1}

Seeds per pod were significantly affected by genotypes (Table 2). The highest number of seeds per pod was obtained from the genotype G00046 (2.087) which was closely followed by G00053 (2.060) and G00138 (2.047). The genotypes G00207 produced the lowest (1.66) number of seeds per pod. Fifty percent of the total genotypes (seven genotypes) under study varied from 1.92 to 1.97 in terms of seeds per pod.

100-seed weight

A great genotypic variation in 100-seed weight was observed. The 100-seed weight varied from 10.55 to 16.34g (Table 2). The highest 100-seed weight was recorded in G00041 (16.34 g), which was closely followed by G00042 (15.92g). The minimum 100-seed weight was obtained from the genotype G00166 (10.55g), which was closely followed by G00197 (11.68g), G00207 (12.13), and G00046 (12.88g). Seven genotypes (around 50%) produced seeds within the range of 13.00 to 15.00g in 100-seed weight. Guzman *et al.* (1997) reported that 100-seed weight was the highest in 'Bayo Victoria' (46.6g) and the lowest in lines 'BAT 477' and 'L 3-1-1-1 M' (22.8g) among 16 genotypes of common bean. Dwivedi *et al.* (1995) recorded 100-seed weight ranged from 46.08g in 'Rajmah' to 63.63g in cv. Contender.

Seed yield

The number of pods retained per plant for seed production had a significant effect on the yield of seed per hectare. The highest (4.23 tha^{-1}) seed yield was found in the genotype G00207,which is significantly higher as compared to the other genotypes andthe lowest (1.43 t ha^{-1}) yield was recorded in the genotype G00046 (Table 2). A positive linear relationship was observed between seed yieldha^{-1} and pods no. plant^{-1}. It indicated that seed yieldha^{-1} increased with the increase of pods no.plant^{-1} (Fig. 2).

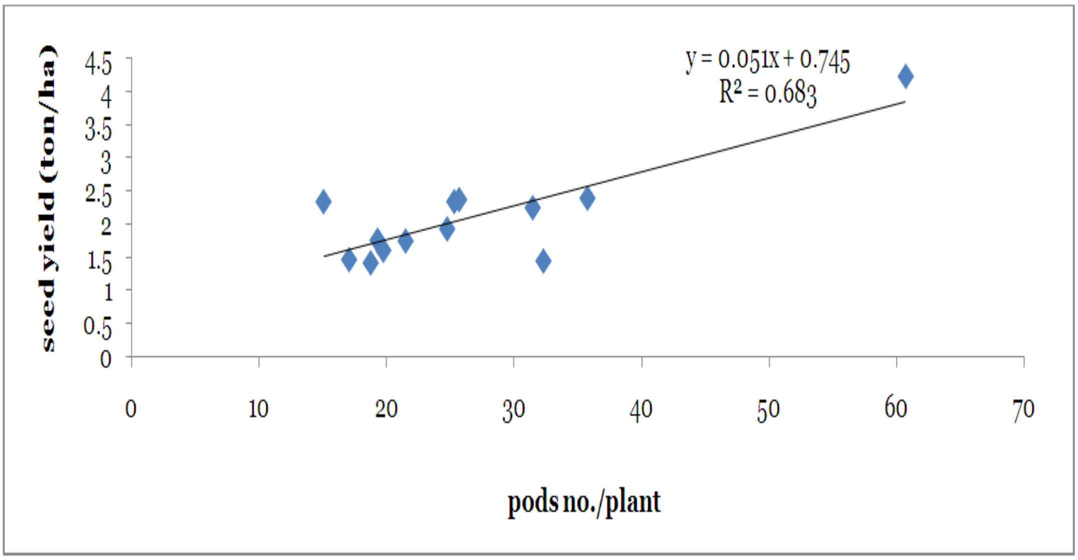

Fig. 2. Functional relationship between pods no/plant and seed yield (ton ha^{-1}).

Evaluation of quality of harvested 13 soybean genotypes seeds

Germination (%)

The percentage of seed germination varied significant among the different genotypes (Table 3.)

The maximum percentage of germination (86.66%) was found in the genotype G00166 which was followed by the genotype G00207 (Table 3).

The minimum percentage of seed germination (76.00%) was found in the genotype G00042 which was followed by the genotype G00041. Probably, genotypes with low germination% lost their viability faster than the genotypes with higher germination (Fig. 3).

Moisture content

The moisture content of soybean seed showed significantly difference among the different genotypes (Table 3). The highest moisture content (11.52 %) was found in G00351, which was followed by G00042 (11.49 %). The lowest moisture content (9.89 %) was found in the G00166. A negative linear relationship was observed between germination percentage and moisture content. It indicated that germination percentage increased with the decrease of moisture content (Fig. 3). The higher percentage of moisture content indicated the lower quality of seed. Also a negative linear relationship was observed between % viability and moisture content. It indicated that viability percentage increased with the decrease of moisture content (Fig. 4).

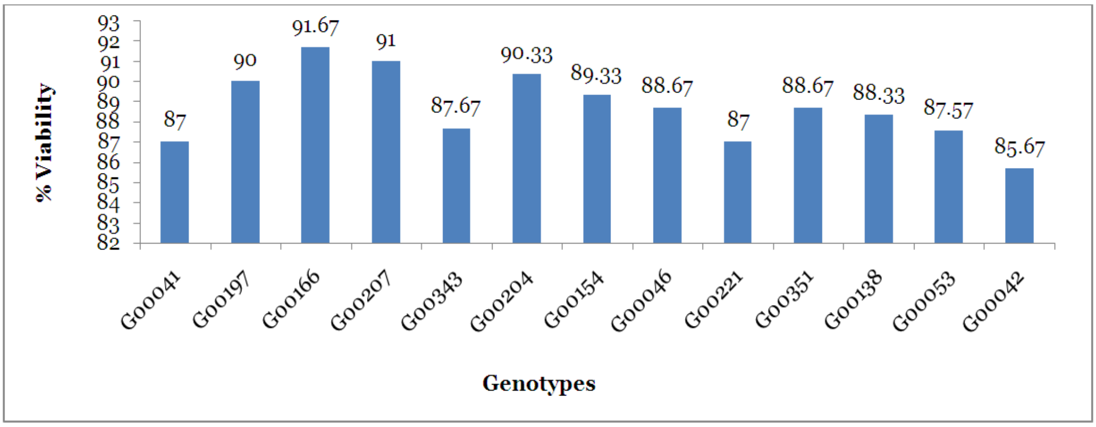

Fig. 3. Graphical presentation of % viability of 13 soybean genotypes.

Table 3. Germination (%), moisture content (%) and electrical conductivity of 13 soybean genotypes.

Genotypes	Germination%	Moisture content (%)	Electrical conductivity (mS $cm^{-1}g^{-1}$)
G00041	76.67 ef	10.85 abc	24.95 ab
G00197	80.00 cdef	10.56 abc	22.49 bc
G00166	86.66 a	9.89 c	22.64 bc
G00207	85.67 ab	10.13 bc	24.68 abc
G00343	81.33 bcde	10.96 ab	29.89 a
G00204	84.67 abc	10.98 ab	18.84 c
G00154	83.00 abcd	11.29 a	22.56 bc
G00046	82.67 abcd	10.68 abc	24.20 abc
G00221	78.67 def	10.83 abc	29.08 a
G00351	82.00 abcd	11.52 a	24.60 abc
G00138	82.00 abcd	10.81 abc	25.35 ab
G00053	81.33 bcde	11.20 a	28.69 a
G00042	76.00 f	11.49 a	27.49 ab
LSD(0.05)	5.11	1.054	5.90
CV (%)	3.72	5.76	13.99

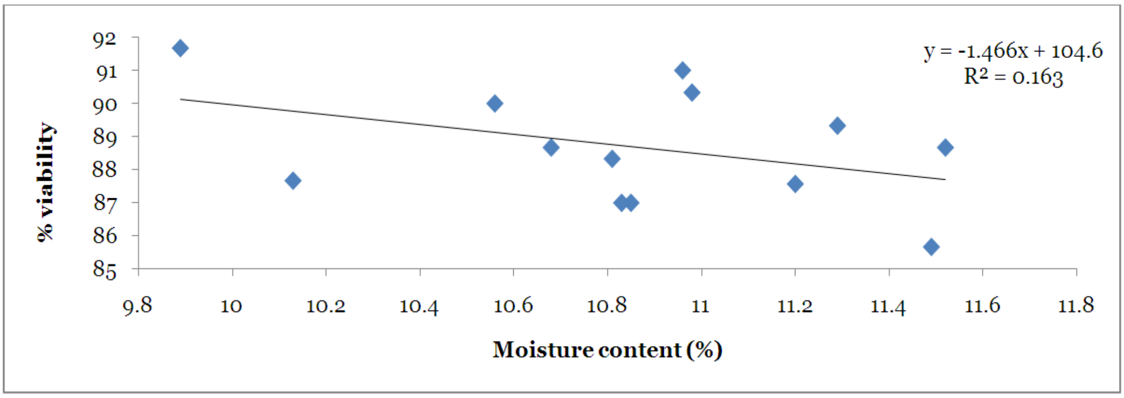

Fig. 4. Functional relationship between moisture content and % viability.

Seed viability (%)

Different soybean genotypes showed different viability (Fig. 3). The highest (91.67%) viable seed was found in the genotype G00166 and the lowest (85.67%) was found in the genotype G00042.Seed viability and germination percentage also showed positive linear relationship. Germination percentage increased with the increase of (%) viability (Fig 5).

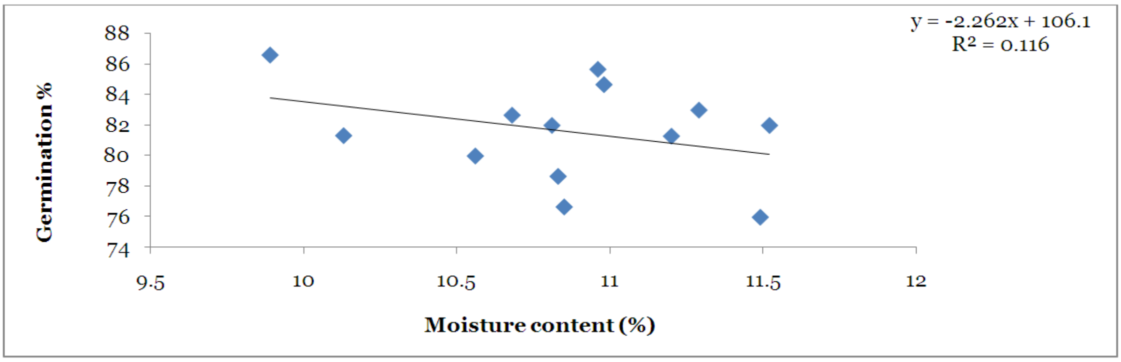

Fig. 5. Functional relationship between moisture content and germination percentage.

Electrical conductivity

In this observation the lowest electrical conductivity (18.84mS cm^{-1}) was found in the genotype G00204 (Table 3). Which was statistically similar to the genotype G00154 (22.56mS cm^{-1}). The genotype G00343 showed the highest electrical conductivity (29.89mS cm^{-1}), which was followed by the genotype G00221, G00053, G00042, G00041, and G00351 (Table 3).

Germination %was negatively correlated with the electrical conductivity (Fig.6). Seed with the low electrical conductivity showed higher germination percentage. Also a negative correlation was evident between electrical conductivity and (%) viability (Fig.7).Seed with the low electrical conductivity showed higher viability percentage.

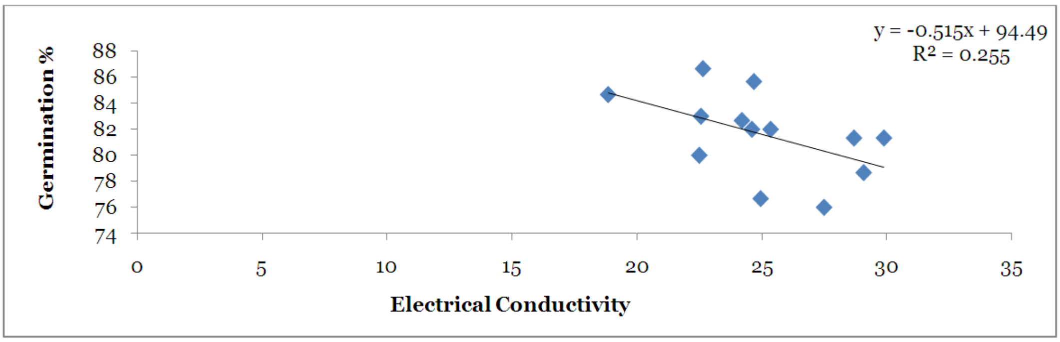

Fig. 6. Functional relationship between electrical conductivity and germination percentage.

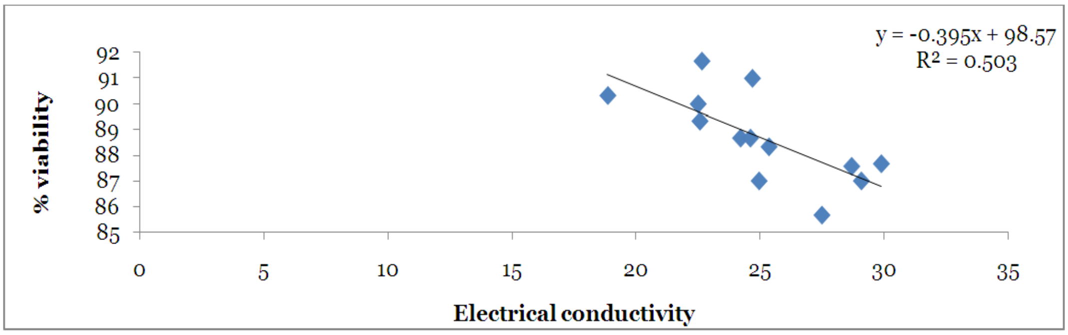

Fig. 7. Functional relationship between % viability and electrical conductivity.

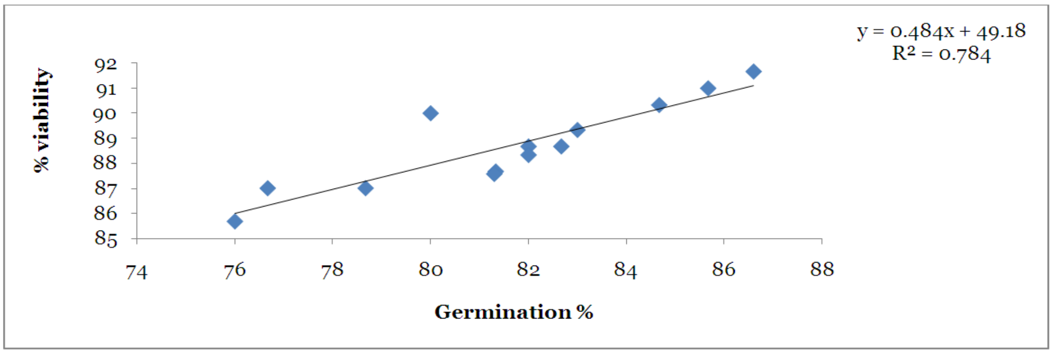

Fig. 8. Functional relationship between % viability and germination percentage.

Conclusion

Among 13 dwarfs soybean genotypes G00207 produced the maximum grain yield (t ha^{-1}), followed by G00343, G00053, G00138 and G00197due to the highest pods number per plant. Variations were also significant among the genotypes in relation to seed morphological characters, germination behavior and electrical conductivity value. The highest (86.66%) germination was found in G00166. Similarly, the viability was the maximum (91.67%) in G00166.Seed viability had positive relationship with germination, while negative relationship with electrical conductivity value and seed moisture content.

Recommendation

Among the thirteen genotypes G00207 was the best in relation to seed production, followed by G00343, G00053, G00138 and G00197. Therefore, G00207 is recommended for further evaluation to reconfirm the result.

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