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RESEARCH PAPER

Morpho-physiological characterisation of quadra and pentafoliate soybean [*Glycine max* (L.) Merrill] genotypes for yield potential

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ABSTRACT: A field experiment was carried out during *Kharif* 2019 at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad to study Morpho-physiological characterisation of quadra and pentafoliate soybean genotypes for yield potential. The experiment was laid out in Randomized block design with eight genotypes (DSb 31, DSb 21, DSb 23, DSb 32, DSb 36, JS 335, JS 93-05 and DSM considering each these genotypes as individual treatments and laid out in four replications. The study revealed that, genotypes DSb 31 and DSb 36 were with quadra/pentafoliate leaves and the presence of wide genotypic variation with respect to bio-physical and yield characters. Among the genotypes, DSb-21 followed by genotypes DSb 23, JS 335 and DSb 31 (quadra/pentafoliate leaves) exhibited superiority over rest of the genotypes in yield while giving a better response to most of the yield contributing characters such as higher leaf area, higher dry matter accumulation and higher photosynthetic rate. It is inferred from the present investigation that, genotype DSb 31 (quadra/pentafoliate leaves) is having the advantage of a greater number of leaflets per plant, of short duration, of good height and bears a greater number of four seeded pods as compared to some high yielding soybean genotypes like DSb 21, JS 335 and DSb 23.

Key words: Bio-physical, Genotype, Pentafoliate, Soybean

Introduction

Soybean [*Glycine max* (L.) Merrill] belongs to family fabaceae and sub family papilionaceae, is one among the most important crops cultivated worldwide for its high protein, oil content and the numerous health benefits for bioactive factors (Desroches *et al.,* 2004). Soybean is thought to be originated from East Asia (parts of China) but it is well adapted to tropical, subtropical and temperate regions of the world. United States, Brazil, Argentina, China, India, Paraguay and Canada are the major soybean producing countries in world (Krishnan, 2008). Soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh, Nagaland and Gujarat. In India, area, production and productivity of soybean during the year 2019 was 113.98 lakh ha, 135.05 lakh mt and with average of 1185 kg per ha, respectively. Among soybean producing Indian states Madhya Pradesh is one of the major states with a cultivated area of 52.09 lakh ha producing 59.17 lakh mt and having productivity of 1294 kg per ha during 2019. In Karnataka, soybean was cultivated around 3.31 lakh ha with production of around 2.90 lakh mt and having productivity of around 911 kg per ha in the year 2019 (Anon., 2019). In karnataka, major soybean growing districts in Karnataka are Dharwad, Bidar, Belgaum and some parts of Haveri and Bagalkot.

Soybean seed contains 18-20 per cent oil, 40 per cent protein, 30 per cent carbohydrates, 4 per cent saponins and 5 per cent fiber. Soybean protein is rich in valuable amino acid lysine (5 %) as compared to most of the cereals. It also contains 60 per cent polyunsaturated fatty acids (52.8 % linolenic acid and 7.2 % linoleic acid) and has high caloric value releasing 432 calories from 100 g edible protein as compared to 350 calories from cereals of same quantity. Soybean seed is also known to contain the vitamins (A and C), elements like calcium, iron and zinc and smaller amount of dietary fiber, fat and sugar (Ali *et al.*, 2013). However, there is a great scope in improving the productivity potential of soybean by using some suitable measures, and in particular, the use of good genotypes. However, the genotypic improvement programme in soybean is approaching a threshold limit and hence, to increase potential yield new approaches like crop biomass, leaf area, photosynthetic efficiency, etc., are to be given interest and this clearly indicates that there is need for genetic manipulation of photosynthetic characters (Long *et al*., 2006).

Generally, soybean leaves are trifoliate, but now some newly developed genotypes were observed with quadra/pentafoliate leaves (DSb-31, DSb-36). These genotypes generally follow the same growth pattern and ontogeny as that of other soybean genotypes. Further, they start showing the emergence of quadra and penta foliate leaves after 25 to 30 days of plant emergence. In these genotypes after 25 to 30 days of sowing, the emerging new leaf have equal chances of getting either trifoliate or tetra and pentafoliates. As per the morphology of these genotypes, the lower 6 to 8 leaves are trifoliate and after 30 DAS the emergence of quadra and pentafoliate leaves starts. The upper canopy of these genotypes showed all the types (tri, quadra and pentafoliated) of leaves indicating that these genotypes have mixture of all tri, quadra, and pentafoliate leaves. These genotype at fully matured stage had 12 to 15 quadra and pentafoliate leaves but each foliate area is less in these genotypes compared to other soybean varieties. Hence, present experiment was conducted to study the morphology and ontogeny of quadra/pentafoliate genotypes and dry matter production and leaf area of quadra/pentafoliate genotypes and their relation with yield.

Material and methods

A field experiment was carried out in Randomized block design with 8 soybean genotypes and 4 replications in black clay soil during *kharif*-2019 at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Located in Northern Transition Zone (Zone-8) of Karnataka which lies at 15^0 26' N latitude, 75^0 07' E longitudes and on an altitude of 678 m above mean sea level to study "Morpho-physiological characterisation of quadra and pentafoliate soybean genotypes for yield potential".

The good quality seeds of soybean genotypes DSb 31, DSb 21, DSb 23, DSb 32, DSb 36, JS 335, JS 93-05 and DSM were sown at a depth of 5 cm with a spacing of 30 cm × 10 cm. The leaf area per plant was worked out by disc method on dry weight basis (Vivekanandan *et al*., 1972). Total dry matter production and its partition to various parts *viz*., stems, leaves and pods at various growth stages were estimated after shade drying and keeping the sample in oven at 80°C for 48 hours. The index leaf (third leaf from top) was selected to measure net photosynthetic rate, by using IRGA (Infrared gas analyzer) of LICOR 6400-40 XT portable photosynthesis system as described by Aminifar *et al.* (2012). For computing yield and yield attributes, total filled pods present in plants were counted. Number of seeds in pod was counted and recorded as number of seeds per pod and 100 seeds from these samples were counted weighed and were recorded as test weights. For calculating harvest index the ratio of economic product (seed) to the total biomass at harvest was taken as described by Donald, (1962). The data were analysed statistically using the 'F' test and critical difference (C.D) was calculated (Panse and Sukhatme, 1967)

Results and discussion

Leaf area (dm^2) per plant

The data on leaf area per plant shown significant differences among genotypes in all growth stages (Table 1). At 5th node emergence stage, genotype DSb 23 (25.16 dm^2) was observed with significantly higher value for leaf area over other genotypes. Significantly lower value of leaf area was recorded in DSM (20.82 dm^2). When genotypes were at flower initiation stage, genotype DSb 21 (36.12 dm^2) shown highest value of leaf area. Genotype DSM (28.33 dm^2) had lowest value for leaf area and genotypes DSM and JS 93-05 (29.62 dm^2) were significantly lower for leaf area over other genotypes. At the stage of seed initiation, for leaf area, DSb 21 (54.50 dm^2) was significantly superior over all other genotypes. Significantly lower value for leaf area was observed in genotype DSM (43.93 dm^2) over all other genotypes except JS 93-05 (46.50 dm^2) which was on par with DSM. When genotypes began to mature, genotype DSb 21 (62.57 dm^2) showed highest value for leaf area and it was significantly superior over all other genotypes. Genotype DSM (48.92 dm^2) showed significantly lower value for leaf area over all other genotypes.

Leaf size and leaf area are considered to be the major requisites for good light interception by the plant (Yoshida, 2002). Martre and Dambreville (2018) opined that the development of leaf area is crucial for better capture of light, carbon, nitrogen and water by plants which is a pre-requisite for better yielding efficiency. In present study, it was observed that high yielding genotypes like DSb-21, DSb 23, JS-335 and DSb 31 had grater leaf area per plant and these genotypes also showed good yield levels and these results were confirmed with the studies of Martre and Dambreville (2018). Though genotypes DSb 31 and DSb 36 were with quadra/pentafoliate leaves, the leaves were lanceolate in shape and not had good width causing them to have leaf area lesser than other trifoliate genotypes. Good leaf area in plants permits them for higher surface area available for the process of photosynthesis and process of photosynthesis is found to be positively corelated with yield levels (Turner, 2012).

Total dry matter production (g / plant)

Data presented in Table 2 represents dry matter accumulation per plant and it indicates significant differences between the genotypes at all the growth stages. At the stage when 5th node started to emerge in genotypes, genotype JS 335 (2.11 g / plant) recorded highest value for leaf dry matter accumulation and it was significantly superior over other genotypes. Genotype DSM (1.28 g / plant) recorded significantly lower value for leaf dry matter at this stage. At this stage, highest dry matter accumulation in stem was recorded in genotype DSb 21 (3.97 g / plant) and it was significantly superior over all other genotypes, DSM (2.53 g per plant) exhibited lowest value for stem dry matter. In total dry matter accumulation per plant at this stage, the highest value was observed in genotype DSb 21 (6.09 g / plant) and it was significantly superior over all the other genotypes, followed by JS 335 (5.35 g / plant), DSb 23 (5.17 g /plant), and DSb 31 (quadra/pentafoliate leaves) (5.18 g / plant) and these 3 genotypes had no significant difference with each other. The lowest value for dry matter accumulation was seen in genotype DSM (3.81 g/ plant).

Table 1. Genotypic variations in leaf area (dm^2) per plant at different phenological phases in various stage of soybean genotypes

Genotypes	Leaf area (dm^2) per plant			
	V5 Stage	R1 Stage	R5 Stage	R7 Stage
DSb 31	22.82^{bc}	32.37^{b}	48.60^{bc}	53.48^{c}
DSb 21	23.91^{b}	36.12^{a}	54.50^{a}	62.57^{a}
DSb 23	25.16^{a}	34.27^{ab}	51.31^{b}	58.69^{b}
DSb 32	20.72^{d}	28.81^{c}	45.39^{d}	50.29^{de}
DSb 36	20.67^{d}	28.88^{c}	45.57^{d}	50.00^{de}
JS 335	22.64^{bc}	33.20^{b}	49.59^{b}	58.44^{b}
JS 93-05	21.43^{cd}	29.62^{c}	46.50^{cd}	52.77^{cd}
DSM	20.82^{d}	28.33^{c}	43.93^{d}	48.92^{e}
Mean	22.38	31.51	48.18	54.40
S.Em (±)	0.61	0.72	0.92	1.06
L.S.D @ 5%	1.80	2.11	2.71	3.12

Note : V5-Emergence of 5th node R1-Flower initiation stage
R5-Initition of seed development
R7-Initiation of maturity

Values in the column followed by the same letter do not differ significantly (NS)

Table 2. Genotypic variations in dry matter accumulation (g / plant) at different phenophases in various stage of soybean genotypes

Genotypes	V5 Stage			R1 stage			R5 Stage				R7 Stage			
	Leaf dry weight (g /plant)	Stem dry weight (g /plant)	Total dry weight (g/plant)	Leaf dry weight (g /plant)	Stem dry weight (g/ plant)	Total dry weight (g/ plant)	Leaf dry weight (g/ plant)	Stem dry weight (g/ plant)	Pods dry weight (g/ plant)	Total dry weight (g/ plant)	Leaf dry weight (g/ plant)	Stem dry weight (g /plant)	Pods dry weight (g/ plant)	Total dry weight (g/ plant)
DSb 31	1.77^{c}	3.39^{bc}	5.18^{b}	3.21^{b}	5.29^{b}	8.50^{b}	6.28^{b}	10.24^{b}	5.18^{b}	21.69^{b}	5.91^{b}	11.22^{b}	11.85^{b}	28.97^{b}
DSb 21	1.93^{b}	3.97^{a}	6.09^{a}	3.72^{a}	6.01^{a}	9.72^{a}	7.15^{a}	11.03^{ab}	5.64^{ab}	24.37^{a}	6.72^{a}	12.26^{a}	13.32^{a}	32.28^{a}
DSb 23	1.82^{bc}	3.34^{bc}	5.17^{b}	3.34^{b}	5.37^{b}	8.70^{b}	6.36^{b}	10.31^{b}	5.84^{a}	22.01^{b}	5.78^{b}	11.40^{b}	12.18^{b}	29.35^{b}
DSb 32	1.57^{d}	3.13^{bcd}	4.68^{c}	2.90^{c}	4.66^{c}	7.56^{c}	5.81^{c}	9.33^{c}	4.44^{c}	19.58^{c}	5.23^{c}	10.54^{c}	10.73^{c}	26.49^{c}
DSb 36	1.55^{d}	3.07^{cd}	4.52^{c}	2.84^{c}	4.49^{c}	7.32^{c}	5.63^{cd}	9.26^{c}	4.53^{c}	19.42^{c}	5.18^{c}	10.46^{c}	10.69^{c}	26.32^{c}
JS 335	2.11^{a}	3.45^{b}	5.35^{b}	3.24^{b}	5.51^{ab}	8.54^{b}	6.44^{b}	11.11^{a}	5.24^{b}	22.03^{b}	5.92^{b}	11.30^{b}	11.97^{b}	29.18^{b}
JS 93-05	1.48^{d}	2.98^{d}	4.46^{c}	2.85^{c}	4.54^{c}	7.39^{cd}	5.72^{cd}	9.34^{c}	4.37^{c}	19.43^{c}	5.20^{c}	10.61^{c}	10.58^{c}	26.38^{c}
DSM	1.28^{e}	2.53^{e}	3.81^{d}	2.55^{d}	3.85^{d}	6.82^{d}	5.34^{d}	8.54^{d}	3.82^{d}	17.61^{d}	4.69^{d}	9.73^{d}	9.45^{d}	23.86^{d}
Mean	1.68	3.23	4.91	3.08	4.94	8.02	6.08	9.83	4.86	20.78	5.58	10.94	11.34	27.86
S.Em(±)	0.04	0.12	0.16	0.06	0.19	0.25	0.14	0.23	0.14	0.51	0.16	0.20	0.37	0.73
L.S.D @ 5%	0.12	0.36	0.46	0.12	0.56	0.75	0.41	0.69	0.43	1.51	0.48	0.60	1.11	2.16

Note : V5-Emergence of 5th node R1-Flower initiation stage R5-Initition of seed development R7-Initiation of maturity

Values in the column followed by the same letter do not differ significantly (NS)

When genotypes began to flower, genotype DSb 21 exhibited significantly higher values for both leaf (3.72 g per plant), stem (6.01 g per plant) as well as for total (9.72 g per plant) dry matter accumulation per plant. At this stage, significantly lower values for stem and leaf dry matter accumulation was observed in genotype DSM (leaves dry weight of 2.55 g per plant and 3.85 g of stem dry weight per plant). At this stage lowest value for total dry matter accumulation pert plant was observed in genotypes DSM (6.82 g per plant) and JS 93-05 (7.39 g per plant). At the stage of seed initiation, highest significant values for leaf, stem and pods dry matter accumulation per plant was seen in genotypes DSb 21 (7.15 g / plant) for leaf, JS 335 (11.11 g / plant) and DSb 21 (11.03 g / plant) for stem, DSb 23 (5.84 g /plant) DSb 21(5.64 g / plant) for pods dry weights respectively. At this stage, genotype DSb 21 (24.37 g / plant) unveiled significantly higher value for total dry matter production followed by genotypes, JS 335 (22.03 g / plant), DSb 23 (22.01 g / plant) and DSb 31 (21.69 g/ plant). Significantly lower value for total dry matter accumulation was recorded in genotype DSM (17.61 g /plant) at seed initiation stage.

When genotypes began to mature, significantly higher value for leaf, stem, pods and total dry matter accumulation was observed in genotype DSb 21 (6.72 g of leaves dry weight per plant, 12.26 g of stem dry weight per plant, 13.32 g of pods dry weight per plant and 32.28 g of total dry matter). At this stage, genotype DSM displayed significantly lower values for leaf, stem, pods as well as for total dry matter accumulation per plant (4.69 g of leaves dry weight per plant, 9.73 g of stem dry weight per plant, 9.45 g of pods dry weight per plant and 23.86 g of total dry matter).

The decline in dry matter accumulation in leaf and stem in all genotypes at the later reproductive stages may be due to the processes of translocation of stored photosynthates from stem and leaves to towards newly developing pods-the reproductive organs. Genotype DSb 21 showed maximum dry matter accumulation for stem, leaf and as well as for reproductive parts followed by DSb 23, JS 335 and DSb 31. Though genotypes DSb 31 and DSb 36 were with quadra/ pentafoliate leaves and higher number of foliates, the leaves were lanceolate in shape and with less width causing them to have leaf area lesser than other trifoliate genotypes and leaf area was found to be directly correlated with dry matter production. The genotypes which showed higher total dry matter accumulation were also showing higher yield levels. There was a positive correlation between leaf dry weight, stem dry weight at vegetative stage and seed yield in soybean and this is in conformity with the findings of Reddy *et al.* (1998) and Anil *et al.* (2014). It was further observed, the total dry weight indicated that it increased substantially from initial crop growth stage to the stage of maturity a steady increase was found. The increase in total dry matter accumulation is may be due to higher rate photosynthesis during the crop growth period. Genotypes differed significantly for total dry matter accumulation between themselves. Board and Modali (2005) observed that total dry matter accumulation at the reproductive growth phases were closely linked to yield levels in soybean. Further, Bruin and

Pedersen (2009) also revealed the similar results about the association between total dry matter and yield levels of soybean. In the present study, the genotypes which produced higher dry matter, produced higher yields.

Photosynthetic rate (µ mol of CO_2 $m^{-2}s^{-1}$)

The data on photosynthetic rate shown significant differences among genotypes in all growth stages (Table 3). At 5th node emergence stage, genotypes DSb 21 (22.90 µ mol of CO_2 $m^{-2}s^{-1}$), JS 335 (22.29 µ mol of CO_2 $m^{-2}s^{-1}$) were observed with significantly higher values for photosynthetic rate over other genotypes followed by DSb 31 (quadra/pentafoliate leaves) (22.19 µ mol of CO_2 $m^{-2}s^{-1}$). Significantly lower values for photosynthetic rate were recorded in genotypes JS 93-05 (18.63 µ mol of CO_2 $m^{-2}s^{-1}$), DSM (19.08 µ mol of CO_2 $m^{-2}s^{-1}$). When genotypes were at flowering initiation stage, genotypes JS 335 (25.96 µ mol of CO_2 $m^{-2}s^{-1}$), DSb 21 (24.82 µ mol of CO_2 $m^{-2}s^{-1}$) shown significantly higher values for photosynthetic rate Genotype DSM (19.22 µ mol of CO_2 $m^{-2}s^{-1}$) was observed with significantly lower value for photosynthetic rate. At the stage of seed initiation, genotypes DSb 21 (27.65 µ mol of CO_2 $m^{-2}s^{-1}$), JS 335 (26.96 µ mol of CO_2 $m^{-2}s^{-1}$) were significantly superior over all other genotypes for photosynthetic rate. Significantly lower value for photosynthetic rate at seed initiation stage was observed in genotype DSM (21.19 µ mol of CO_2 $m^{-2}s^{-1}$). When genotypes began to mature, genotype DSb 21 (21.22 µ mol of CO_2 $m^{-2}s^{-1}$) showed highest value for photosynthetic rate and it was significantly superior over all other genotypes. Genotype DSM (22.19 µ mol of CO_2 $m^{-2}s^{-1}$) was recorded with significantly lower value for photosynthetic rate.

It is not only the rate of photosynthesis which is important for plant productivity but also the duration of prolonged supply and synthesis of photosynthates. In this present study, it was observed that genotypes DSb 21, DSb 23, DSb 31 and JS 335 which were observed with high yield also were recorded higher rate of photosynthesis and genotypes DSM and JS 93-05 recorded lower yield levels also had lower rate for photosynthesis. Similar results were observed with the works of Qu *et al.* (2017). Tomeo and Rosenthal (2017) suggested that the overall yield and crop growth in soybean is mainly dependent on crop photosynthetic efficiency and which is linked again to plant stomatal conductance, mesophyll conductance and the rate of carbon dioxide diffusion from substomatal cavities to the sites of carboxylation. So, the genotypes which had higher rate of photosynthesis (DSb 21, DSb 23, DSb 31 and JS 335) also had higher values for dry matter accumulation, growth rates and specific leaf weight. Higher rate of photosynthesis resulted in higher photosynthates accumulation there by resulting in higher yield levels. Rate of photosynthesis is not corelated to the plant leaf shape and leaflet numbers and it varied genetically. In the present case too genotypes with quadra/pentafoliate leaves their leaf shape and leaf number did not correlated to photosynthetic rate. Similar results were observed by Novas (2017).

Table 3. Genotypic variations in Photosynthetic rate (µ mol of CO_2 $m^{-2}s^{-1}$) at different phenological phases in various stage of soybean genotypes

Genotypes	Photosynthetic rate (µ mol of CO_2 $m^{-2}s^{-1}$)			
	V5	R1	R5	R7
DSb 31	22.19^{b}	23.21^{b}	25.63^{b}	20.09^{b}
DSb 21	22.90^{a}	24.82^{ab}	27.65^{a}	21.22^{a}
DSb 23	23.71^{a}	23.43^{b}	25.95^{b}	20.31^{b}
DSb 32	19.89^{c}	21.18^{c}	23.62^{c}	18.93^{c}
DSb 36	19.86^{c}	21.32^{c}	23.35^{c}	19.21^{c}
JS 335	22.29^{ab}	25.96^{a}	26.96^{ab}	20.55^{b}
JS 93-05	18.63^{d}	20.94^{c}	23.08^{c}	18.55^{c}
DSM	19.08^{cd}	19.22^{d}	21.19^{d}	17.88^{d}
Mean	21.20	22.35	24.55	19.24
S.Em (±)	0.28	0.48	0.61	0.18
L.S.D @ 5%	0.84	1.42	1.80	0.54

Note : V5-Emergence of 5th node R1-Flower initiation stage
R5-Initition of seed development
R7-Initiation of maturity

Values in the column followed by the same letter do not differ significantly (NS)

Yield and yield attributes

The data presented in Table 4 on number of seeds per pod shown significant differences among the genotypes. For number of seeds per pod, genotype DSb 31 (3.29 seeds per pod) showed significantly superior value over all genotypes and DSb 36 (3.09 seeds per pod) was on par with DSb 31(3.2) (quadra/ pentafoliate leaves) and followed by genotype DSb 32 (2.99 seeds /pod). Significantly lower value for number of seeds per plant was recorded in genotype DSM (2.20 seeds / pod) and genotype JS 93-05 (2.30 seeds per pod) was on par with DSM. Data on number of pods per plant shows significant difference among the genotypes. Genotype DSb 21 (53.75 pods / plant) showed significantly higher value for number of pods per plants over all the genotype except JS 335 (52.55 pods / plant) which was on par with DSb 21. Significantly lower values for number of pods per plant were seen in genotypes DSb 36 (35.14 pods / plant) and DSb 32 (33.65 pods / plant). Data on seed yield per plant shows significant difference amid the genotypes. Genotype DSb 21 (13.23 g $plant^{-1}$) showed significantly higher value for seed yield per plant over all the genotypes except genotypes JS 335 (13.01 g $plant^{-1}$) and DSb 23 (12.90 g /plant) which were on par with DSb 21 followed by DSb 31 (quadra/pentafoliate leaves) (12.72 g /plant). Genotype DSM (10.95 g $plant^{-1}$) showed significantly lower value for seed yield per plant. The result data with respect to 100 seed weight per plant showed significant differences between genotypes. Genotype DSM (14.11 g) showed significantly higher value for hundred seed weight over all other genotypes followed by genotypes DSb 31 (13.14 g) and DSb (13.05 g). Significantly lower value for hundred seed weight was recorded in genotype JS 93-05 (12.32 g). Data on harvest index shows significant difference among the genotypes. Genotype DSb 21 (0.444) showed significantly higher value for harvest index over all the genotypes except genotype JS 335 (0.437) which was on par with DSb 21 followed by DSb 23 (0.434) and DSb 31 (0.431). Genotype DSM (0.393) showed significantly lower value for harvest index.

Table 4. Genotypic variations in yield parameters in various soybean genotypes

Genotypes	Number of pods plant^{-1})	Number of seeds pod^{-1})	Seed yield (g plant^{-1})	100 Seed weight (g)	Harvest index	Seed yield (q ha^{-1})
DSb 31	39.2^{d}	3.2^{a}	12.72^{b}	13.14^{b}	0.431^{bcd}	31.31^{bc}
DSb 21	53.8^{a}	2.6^{c}	13.23^{a}	12.84^{de}	0.444^{a}	36.02^{a}
DSb 23	51.1^{b}	2.4^{cde}	12.90^{ab}	12.66^{e}	0.434^{bc}	32.92^{b}
DSb 32	35.1^{e}	2.9^{b}	11.91^{cd}	13.05^{bc}	0.426^{cde}	28.83^{de}
DSb 36	33.6^{e}	3.0^{ab}	12.24^{c}	12.94^{cd}	0.424^{de}	29.55^{cd}
JS 335	52.5^{ab}	2.5^{cd}	13.01^{ab}	12.75^{e}	0.437^{ab}	33.33^{b}
JS 93-05	46.8^{c}	2.3^{de}	11.58^{d}	12.32^{f}	0.417^{e}	27.08^{e}
DSM	48.1^{c}	2.2^{e}	10.95^{e}	14.11^{a}	0.393^{f}	25.11^{f}
Mean	45.4	2.6	12.31	12.97	0.425	29.65
S.Em.($\pm$)	0.8	0.1	0.14	0.06	0.003	0.65
L.S.D @ 5%	2.4	0.3	0.56	0.19	0.010	1.91

Note: Values in the column followed by the same letter do not differ significantly (NS)

Data on seed yield per hectare and this data shows significant difference between the genotypes. Genotype DSb 21 (36.02 q ha^{-1}) showed significantly higher value for seed yield per hectare over all the genotypes followed by genotypes JS 335 (33.33 q ha^{-1}), DSb 23 (32.92 q ha^{-1}), DSb 31 (quadra/ pentafoliate leaves) (31.31 q ha^{-1}). Genotype DSM (25.11 q ha^{-1}) showed significantly lower value for seed yield per hectare. Humphries (2009) opined that, yield is result of final manifestation of physiological, morphological, growth parameters and biochemical processes and yield is also considered to as the result from conversion of solar energy efficiently. Further they also reported that, improvement of yield can be done in two ways, one by tapping at the available best genotypes for cultivation and other way is by better cultivation practices. In present investigation, it was found that seed yield and its components such as number of seeds per pod, number of pods per plant, seed yield per plant, harvest index,100 seed weight and yield in quintals per hectare differed significantly among the genotypes chosen for study.

Ranjan *et al.* (2010) opined that, total seed yield in plant is the product of number of pods per plant with number of seeds per pod observed in plant. In present study, genotype DSb 31 was observed with highest number of seeds per pod (DSb 31 was observed with a greater number of four seeded pods). Though DSb 31 had highest value for number of seeds per pod, highest seed yield was observed in genotype DSb 21 since number of pods per plant were low in DSb 31 as compared to DSb 21. Even though, genotype DSM is having highest 100 seed weight and a greater number of pods in comparison with genotypes DSb 31, DSb 32, DSb 36 and JS 93-05, seed yield was observed to be lowest because number of seeds per pod were low as it was having greater number of two seeded pods. The higher values for seed yield in genotypes DSb 21, DSb 23, JS 335 and DSb 31 was not just attributed by higher number of pods per plant and seed weight per plant but also higher values of leaf area, growth parameters, specific leaf weight, SPAD values, total dry matter production, stomatal conductance and photosynthetic rate. It was further being observed that, in low yielding genotypes like DSM and JS 93-05 the performance of leaf area, growth parameters, specific leaf weight, SPAD values, total dry matter production, stomatal conductance and photosynthetic rate were poor. Similar results were observed with the works of Khan and khalil (2010) and Jin *et al.* (2010). In present study, harvest index which indicates the partitioning efficiency, was found to be significant among genotypes. Our present investigation results were in conformity with the works of Malik *et al.* (2007) who opined that, difference among harvest index can be seen among genotypes.

Conclusion

Genotype Dsb - 31 having quadra and pentafoliate leaves showed higher aleaf area, photosynthetic rate and seed yield per hectare.

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