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GROWTH ANALYSIS OF INDIGENOUS SOYBEAN LAND RACES

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Abstract

Indigenous land races of soybean has shown promising yield potential, yet limited information are available for leaf area and related parameters. The present study aimed at assessing the leaf area, leaf area index (LAI), specific leaf area (SLA), specific leaf weight (SLW) and crop growth rate (CGR) of three indigenous land races (Kulat brown, Kulat white, Mothi) and two improved varieties (NARC-II, Swat-84) of soybean planted at monthly interval from April to July during 2004 and 2005 growing seasons. The parameters studied were significantly affected by planting dates, varieties and planting dates x varieties. Specific leaf area and crop growth rate at seed filling stage did not respond to the interaction. Maximum leaf area (2735 m^2 $plant^{-1}$), leaf area index (11), and specific leaf area (391.6 cm^2 g^{-1}) was recorded for April planted crop. Gradual decrease in these parameters was observed when planting was delayed from April to July. However specific leaf weight increased from 2.7 to 10.1 mg cm^{-1}, when planting was extended from April to June. Maximum CGR in early vegetative (1.11 mg $g^{-1}day^{-1}$), bloom (22.8 mg $g^{-1}day^{-1}$) and seed fill (6.5 mg $g^{-1}day^{-1}$) stages was recorded for July, May and April planted crops respectively. Maximum leaf area (2165 cm^2), LAI (8.3), and SLA (225 cm^2g^{-1}) was recorded for Kulat brown. Swat-84 demonstrated maximum SLW (7.4 mg cm^{-1}). Land races exhibited greater leaf area (1871 cm^2), LAI (7.1) and SLA (214.7 cm^2 g^{-1}). At early vegetative, bloom and seed fill stages, maximum CGR was recorded for Swat-84 (0.97 mg $g^{-1}day^{-1}$), Mothi (19.9 mg $g^{-1}day^{-1}$) and Kulat brown (5.3 mg $g^{-1}day^{-1}$) respectively. Land races exhibited higher CGR than improved varieties except at early vegetative growth stage. The average CGR at initial vegetative stage, bloom and seed fill stage were 0.81, 17.7 and 4.6 mg $g^{-1}day^{-1}$ respectively. The average CGR for April, May, June and July planted crop was 7.5, 8.9, 7.8 and 6.2 mg $g^{-1}day^{-1}$.

Introduction

In Pakistan domestic edible oil production supplies one third of the total edible oil requirements (Anon., 2007). Efforts are made to improve domestic oil seed production including soybean. Soybean is an important oilseed crop and is grown across a wide range of agro-geographical regions from China to Brazil and from Oceania to Canada (Khan *et al*., 2011). Indigenous land races of soybean from Khyber Pakhun khwa Province has shown prominising yield potential (Asim & Shah, 2003). Grain yield is closely related with plant growth and development. It is therefore essential to explore the growth and development particularly, leaf area and related parameters of land races. The results showed that early date of sowing resulted in a significant increase in vegetative growth and root growth (Muhammad *et al*., 2012). Hunt (1982) believed that growth analysis techniques were useful tools for describing plant response to environment variations, which were successfully used by Yusuf *et al*., (1999) for soybean. Sean *et al*., (2002) reported that grain yield usually attained a straight line with higher leaf area index levels and decreased when leaf area index decreased below 3.5 to 4. Board (2000) and Pedersen & Lauer (2004) reported that seasonal CGR patterns, total dry matter (DM) and leaf area index (LAI) were highly associated with each other. Hatam & Jamro (1991) determined higher leaf area in determinate than in indeterminate soybeans. Kumudini *et al*., (2005) observed that maintenance of leaf area during seed filling period resulted into greater seed yield. Board & Harville (1997) concluded that reduced CGR during the early reproductive period was more detrimental than in the late reproductive period. Abayomi (2008) reported that CGR was higher in late than in early maturity groups. It has been established through research that planting date recommendations for an area shall be monitored through field experiments that have been done periodically with limited multiyear, multilocation with conclusions extrapolated statistically (Shah *et al*., 2012). Planting method is one of a crucial factor for improving crop yield (Bakht *et al*., 2011). It is a concept well defined in various ways of Genotype x Environment interaction when different genotypes are evaluated across diverse environments (Ali *et al*., 2012). The objective of the present study was to determine the relationship between leaf area, leaf area index, specific leaf area, specific leaf weight and crop growth rate of indigenous land races and improved soybean varieties in different planting dates.

Materials and Methods

Plant material and experimental site: Three indigenous land races (Kulat brown, Kulat white, Mothi) and two improved varieties (NARC-II, Swat-84). Research was conducted on assessing the effect of planting date on phasic development of indigenous land races and improved varieties of soybean at New Development Farm, Khyber Pakhtun Khwa Agricultural University, Peshawar during. 2004 and 2005 growing seasons. Indigenous land races Kulat brown and Kulat white were procured from Mingora Swat and Mothi from Mansehra, Hazara division of the province. Improved soybean variety NARC-II was developed and supplied by National Agriculture Research Center, Islamabad. Swat-84, a selection from Williams-82 at Agriculture Research Institute, Mingora, Swat was procured from that institute. Planting dates were April 2, May 2, June 2, and July 2. Planting dates were allotted to main and varieties to sub plots in randomized complete block design with split plot arrangement. Each treatment was replicated four times. A sub plot size of 3m x 3m having six rows, 3m long. 50 cm apart and 50 cm space between plants was used. A basal recommended dose of 25 kg N and 64 kg P_2O_5 ha^{-1} as diammonium phosphate was applied at the time of sowing.

Growth attributes of soybean: At full bloom stage, leaves were collected from five randomly selected plants from each treatment. Area of each individual leaf was determined in cm^2 using leaf area meter (LI-COR, LI-3000 A, PAM 1822, USA). Leaf area of individual leaves $plant^{-1}$ was added up to determine leaf area $plant^{-1}$. Leaves were oven dried (Model DINI 2880-KI, Schutzart, Germany) at 60°C for 24 hours to constant weight for determining leaf dry weight. Leaf area index (LAI), specific leaf area (SLA), specific leaf weight (SLW) and crop growth rate (CGR) (at three crop growth stages, that is 1) early vegetative growth 2) full bloom and 3) seed filling) was calculated from) were determined with the help of the following formulae, adopted by Gardner *et al*., (1985).

$$LAI = \frac{\text{Leaf area plant}^{-1}}{\text{Ground area plant}^{-1}}$$

$$SLA = \frac{\text{Leaf area plant}^{-1}}{\text{Leaf weight plant}^{-1}} = cm^2\ g^{-1}$$

$$SLW = \frac{\text{Leaf weight plant}^{-1}}{\text{Leaf area plant}^{-1}} = mg\ cm^2$$

SLA and SLW determinations were made on dry leaf weight basis:

$$CGR = \frac{W2-W1}{T2-T1} \times \frac{1}{GA} = g.m^{-2.}day^{-1}$$

where
W1 = Initial weight
W2 = Final weight
GA = Ground area

T1 and T2 are the time interval between initial and final dry matter determination.

Results and Discussion

Leaf area $plant^{-1}$: Leaf area measurement is an important tool in assessing crop growth. Leaf area $plant^{-1}$ was significantly affected by planting dates (D), varieties (V) and D x V interaction. Leaf area during the years was almost similar (Table 4). Leaf area in April (2734.5 cm^2) and May (2232.9 cm^2) planting was high but drastically dropped to minimum in June (652.4 cm^2) and July (505 cm^2) planting (Table 2). This pattern was somewhat consistent during both the years. Our findings are supported by Hatam & Jamro (1991) who reported significant reduction in leaf area in all cultivars when planting was delayed beyond mid-June.

Maximum leaf area (2165.2 cm^2) was produced by Kulat brown, followed by Mothi. Swat-84 produced the minimum leaf area (1012.1 cm^2). Land races produced significantly the highest leaf area as compared with improved varieties. On the average the increase in leaf area of land races over improved varieties was more than 83%. Improved varieties did not differ among themselves in leaf area but in land races, Kulat brown and Mothi significantly produced highest leaf area compared with Kulat white (Table 3). Larger leaf area of land races was because of their taller bushy determinate type plants. The same was true with Hatam & Jamro (1991).

The DxV interaction revealed that maximum leaf area for Kulat brown, decreased when planting was delayed from April to July. Similar pattern was observed for Kulat white, Mothi, Swat-84 and NARC-II (Fig. 1). The differences in leaf area between land races and improved varieties during April and May were 50% which dropped to only 16% during June and July. Larger leaf area in April and May planted crop may be attributed to the longer growing period than the late planted crop.

Leaf area index (LAI): Leaf area index (LAI) is expressed as the ratio of leaf area to the ground area occupied. Statistical analysis of the data showed that planting dates (D), varieties (V) and planting dates x varieties interaction significantly affected leaf area index. Leaf area index did not differ between the years. April planting showed maximum leaf area index (11). On the average LAI decreased significantly from 11 in April planted crop to 2 in July planted crop. Planting in June and July exhibited statistically similar LAI. Minimum leaf area index was recorded for July planted crop (Table 2). Hatam & Jamro (1991) reported maximum leaf area in May planted soybeans. Sean *et al*., (2002) observed that LAI below 3.5 to 4 decreased yield and increasing LAI level did not increase seed yield.

Kulat brown gave the highest LAI (8.3) followed by Mothi (7.2). Swat-84 and NARC-II gave minimum LAI of 4 and 4.1 (Table 3). LAI of the land races was significantly greater than improved varieties (Table 4). LAI of the improved varieties did not vary among themselves.

DxV interaction indicated (Fig. 1) that land races and improved varieties exhibited high leaf area index when planted in April. Leaf area index decreased when planting was delayed. Differences in leaf area index narrowed down to negligible level when planting was delayed to July. The greater leaf area with early planting was attributed to the longer growing period as compared with late planting. The differences in LAI between land races and improved varieties were greater in April, which narrowed down to almost negligible value, when planting was delayed to July.

Specific leaf area: Specific leaf area (SLA) is the ratio of leaf area to leaf dry weight and thus a measure of leaf thickness. Specific leaf area was affected significantly by years, planting dates (D), varieties (V) and their interaction. Soybean planted in 2005 showed 6% higher specific leaf area than 2004 planted crop (Table 4). Maximum SLA (391.6 cm^2 g^{-1}) was recorded in April, while minimum SLA (101.8 cm^2 g^{-1}) in July planting. SLA steadily decreased from 391.6 cm^2 g^{-1} in April planted crop to 101.8 cm^2 g^{-1} in July planted crop (Table 2). When SLA of the first two planting dates was compared with SLA of the last two planting dates, SLA declined by 66.2%.

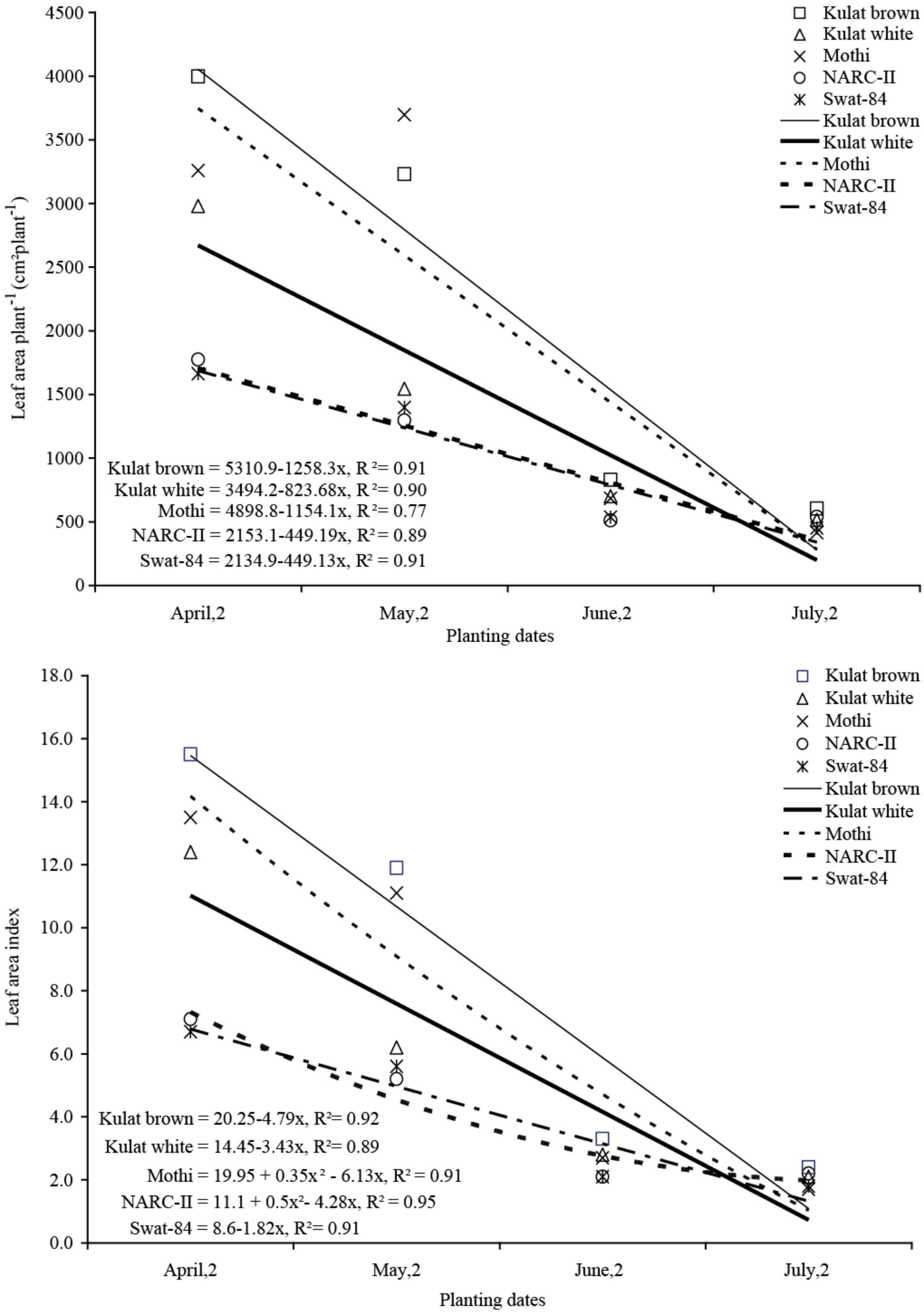


Fig. 1. Leaf area (cm^2 $plant^{-1}$) and leaf area index of soybean varieties as affected by planting dates over two years (2004-2005).

Statistical analysis: The data was analyzed statistically by analysis of variance and differences among the significant treatments were determined by least significant difference (LSD) test. Trend line analyses were performed in MS Excel.

Maximum SLA (225.1 cm^2 g^{-1}) was recorded for Kulat brown, followed by Mothi, while minimum SLA (184.3 cm^2 g^{-1}) was noticed in NARC-II (Table 3). SLA of Swat-84 was not different than SLA of NARC-II. The SLA of land races was significantly higher than improved varieties (Table 4). The overall SLA of land races was greater by 12.9% than improved varieties.

The interaction between D xV showed maximum specific leaf area for land races and improved varieties when soybean was planted in April. In Kulat brown, Kulat white and Mothi specific leaf area decreased when planting was delayed. NARC-II and Swat-84 showed decreased specific leaf area when planting was advanced from April to July (Fig. 2).

The response of SLA to planting dates followed the pattern of LAI. The rate of decline of SLA with delayed planting in land races and improved varieties was quite uniform. In land races SLA declined by 44.5, 74.7 and 75.9 % and in improved varieties by 44.8, 71.4 and 70.7, when planting was delayed from April to May, June and July respectively. It is evident from the data, that there was close association between total leaf area, LAI and SLA. The values for these parameters decreased in a similar fashion with delay in planting and the difference between land races and improved varieties was maintained in the same pattern.

Specific leaf weight: Specific leaf weight (SLW) is expressed as the ratio of leaf weight to leaf area and denoted as mg cm^{-2}. Statistical analysis of the data showed that specific leaf weight (SLW) was significantly affected planting dates (D) and varieties (V) for the two years average (Tables 1&2). Maximum SLW of 10.1and 9.9 mg.cm^{-2} was recorded for June and July planted crops and minimum, SLW of 2.7 and 4.9 mg cm^{-2} for April and May planted crops. SLW steadily increased at each successive planting date (Table 2).

Maximum SLW (7.4 mg cm^{-2}) was observed in Swat-84, followed by NARC-II and Mothi. Minimum SLW was noticed in Kulat brown (6.5 mg cm^{-2}) and Kulat white (6.6 mg cm^{-2}) (Table 3). Differences in SLW means for land races and improved varieties were not significant. Within each planting date, differences in SLW values between land races and improved varieties were very small (Table 4).

The D x V interaction revealed that specific leaf weight (SLW) in all varieties increased when planting was delayed from April to July (Fig. 2). SLW was inversely related to leaf area, LAI and SLA. This shows that leaf dry matter accumulation during late planting was greater than leaf expansion.

Crop growth rate at early vegetative growth stage: CGR is a useful tool in growth analysis of field crops. CGR expresses the gain in total plant dry biomass on unit of land in a unit of time. Statistical analysis of the data for the two years average indicated significant differences in CGR means for planting dates (D), varieties (V) and D x V interaction. CGR was not affected by years. Maximum CGR (1.11 g m^{-2} day^{-1}) was recorded in July planted crop, followed by June planted crop. The CGR average for April (0.75 g m^{-2} day^{-1}) and May (0.43 g m^{-2} day^{-1}) were significantly lower than the means for June and July (Table 2). The reason for greater CGR values for June and July planted crop could be, that the mean minimum temperature ranged from 19 to 25°C in April, May and between 22-26°C in June and July, which was more favorable for plant growth and development (Table 1). Pedersen & Lauer (2004) reported that late planting resulted in more rapid CGR after emergence than early planting, because of warmer temperature. Cho *et al.,* (2004) recorded greater CGR with early planting and during the early growth stage.

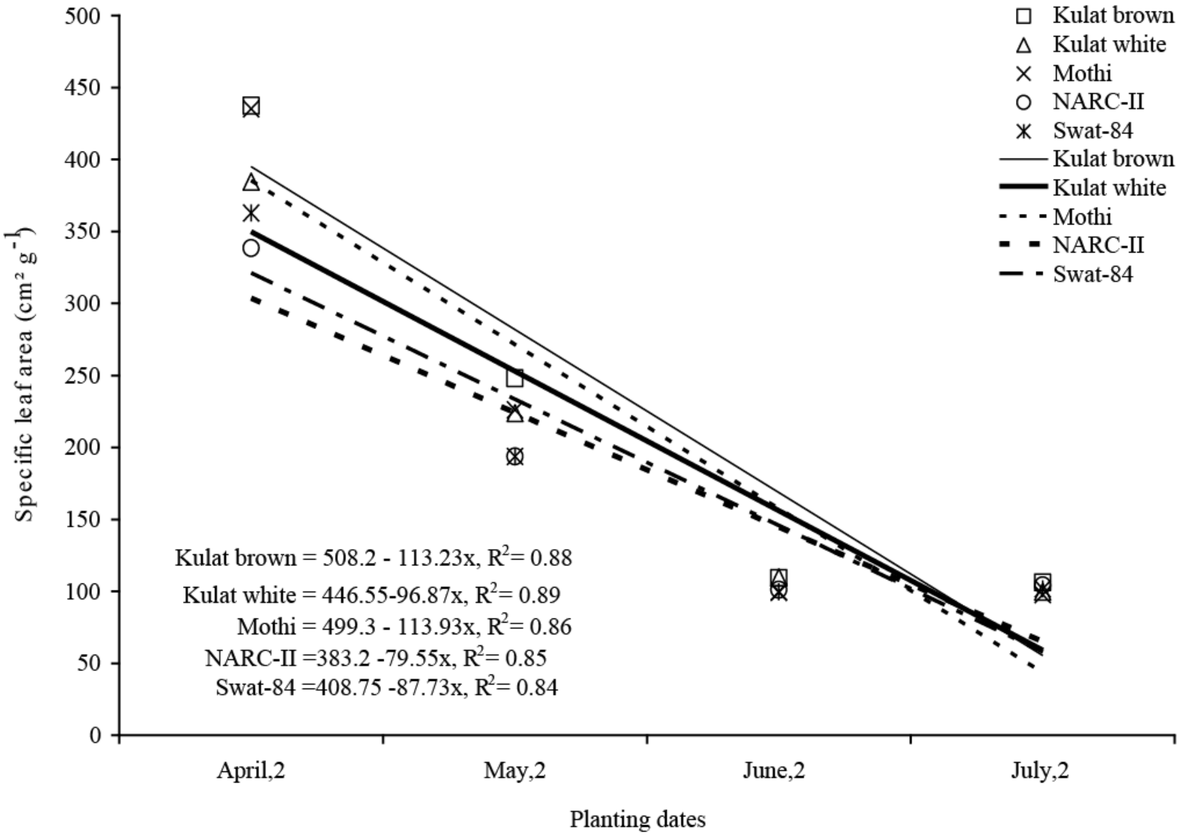
Maximum CGR (0.97 g m^{-2} day^{-1}) was recorded for Swat-84 followed by NARC-II. Minimum CGR (0.67 g m^{-2} day^{-1}) was observed in Kulat brown, which was not different than CGR of Kulat white and Mothi. The CGR of improved varieties was significantly greater by 35% than the land races (Table 3). CGR means on the average within the land races themselves or among the improved varieties were not significantly different. The CGR of improved varieties was greater because bolder seeds were able to produce stronger seedlings and to establish earlier than the land races having very small seeds. The overall low CGR at this stage could be due to the fact that seedlings required some time for establishment and leaf expansion.

DxV interaction indicated that Kulat white, Kulat brown and Mothi exhibited maximum CGR of 1.01, 0.96 and 0.80 g m^{-2} $day^{-1}$when planted in July and minimum CGR of 0.46, 0.43 and 0.39 g m^{-2} day^{-1} respectively when planted in May. NARC-II and Swat-84 planted in July demonstrated maximum CGR of 1.55 and 1.25 g $m^{-2}day^{-1}$and minimum CGR of 0.44 and 0.46 g $m^{-2}day^{-1}$ in May planted crop. The response of CGR in landraces and improved varieties to planting dates was more or less similar.

DxV revealed that in Kulat brown and Kulat white CGR at early vegetative growth stage increased when planting was delayed from April to July. However, in Mothi, NARC-II and Swat-84 CGR decreased when planting was advanced from April to May and then increased when planting was further delayed (Fig. 3).

Crop growth rate at bloom: Soybean crop in 2004 had 27.7% higher CGR than in 2005. Analysis of the data showed that the highest CGR (22.8 g m^{-2} day^{-1}) was recorded for May planted crop followed by June planted crop. CGR for the early planting in April (15.17 g.m^{-2}.day^{-1}) and the late planting in July (13.69 g m^{-2} day^{-1}) exhibited the lowest values, which were statistically similar to each other (Table 2). Arif (2006) also determined CGR values of 6.3, 18.9 and 9.4 g m^{-2} day^{-1} at three continuous intervals, without any specific stages. His middle interval values coincided with our bloom stage.

Maximum CGR of 19.9, 19.17 and 19.01 g m^{-2} day^{-1} was determined in Mothi, Kulat brown and Kulat white respectively. Minimum CGR of 14.92 and 15.32 g m^{-2} day^{-1} was recorded for Swat-84 and NARC-II respectively. CGR of land races was significantly higher by 28% than the improved varieties (Table 3). The differences in CGR within the land races themselves and within the improved varieties were not significant.



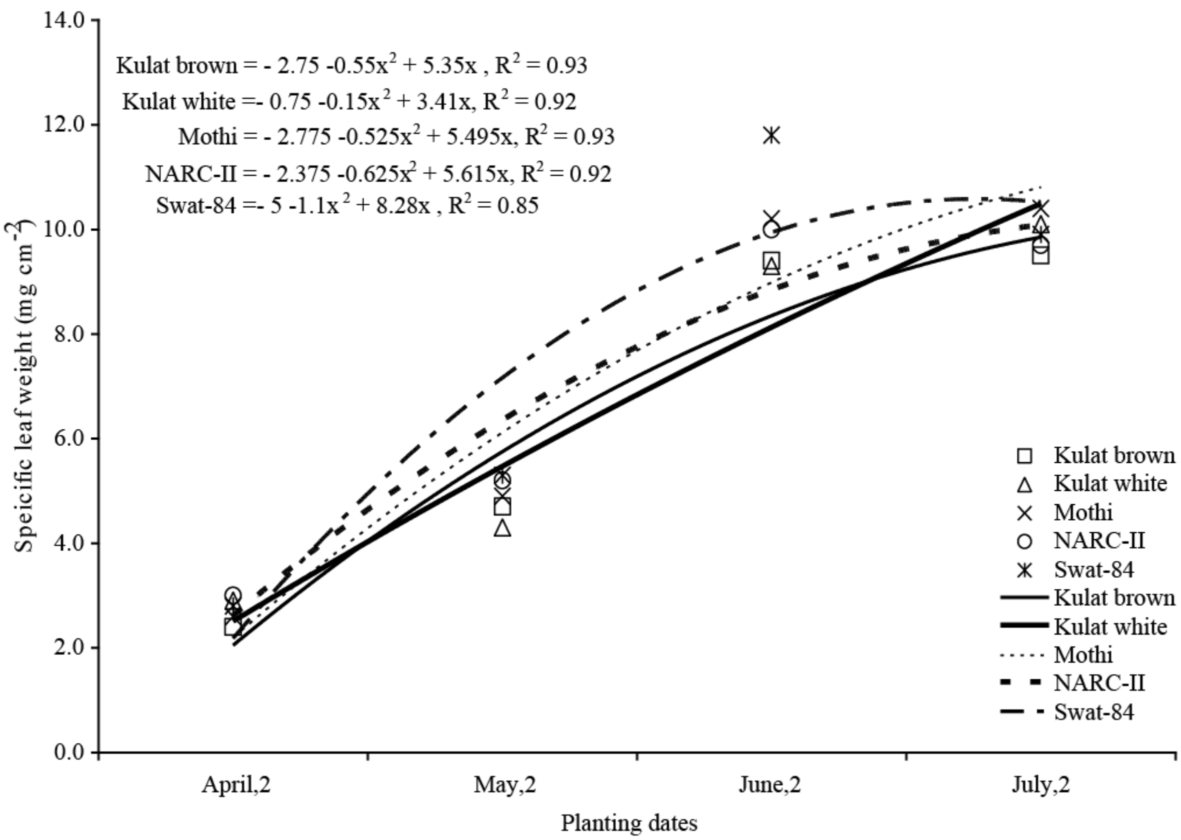


Fig. 2. Specific leaf area (cm^2 g^{-1}) and specific leaf weight (mg cm^2) of soybean varieties as affected by planting dates over two years (2004-2005).

Table 1. Climatic data for the experimental area in two growing seasons (2004 and 2005).

Months	2004				2005			
	Rainfall (mm)	Mean temperature (°C)		Relative humidity (%)	Rainfall (mm)	Mean temperature (°C)		Relative humidity (%)
		Min.	Max.			Min.	Max.	
Jan.	55	18	4	73	25	17	3	85
Feb.	40	23	6	73	97	16	2	82
Mar.	0	28	11	66	109	22	11	79
Apr.	37	33	17	65	9	29	13	81
May	0	37	21	59	22	32	17	78
Jun.	0	38	27	69	0	39	22	79
Jul.	3	37	24	70	6	35	22	75
Aug.	24	35	28	71	20	35	24	77
Sep.	18	34	21	73	4	34	22	78
Oct.	8	28	9	71	0	31	17	81
Nov.	11	25	9	70	0	25	7	82
Dec.	26	21	6	79	0	21	2	82

Table 2. Two years means for leaf area (cm^2 $plant^{-1}$), Leaf area index, specific leaf area (cm^2 g^{-1}), Specific leaf weight (mg cm^{-2}) and crop growth rate (at early vegetative, bloom, seed filling stages) of soybean varieties as affected by planting dates.

Varieties	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (mg cm^{-2})	Crop growth rate		
					Early growth stage	Bloom	Seed filling
April, 2	2734.5 a	11.0 a	391.6 a	2.7 c	0.75 c	15.17 c	6.54 a
May, 2	2232.9 b	8.0 b	217.0 b	4.9 b	0.43 d	22.80 a	5.36 b
June, 2	652.4 c	2.6 c	103.8 c	10.1 a	0.94 b	18.99 b	3.55 c
July, 2	505.0 c	2.0 c	101.8 c	9.9 a	1.11 a	13.69 c	3.67 c
LSD 0.05	507.19	1.34	38.68	0.83	0.16	2.49	1.13

Means of the same category followed by the different letters are significantly different from one another using LSD test ($p \leq 0.05$)

Table 3. Two years means for leaf area (cm^2 $plant^{-1}$)), Leaf area index, specific leaf area (cm^2 g^{-1}), Specific leaf weight (mg cm^{-2}) and crop growth rate (at early vegetative, bloom, seed filling stages) of soybean varieties as affected by Soybean varieties.

Varieties	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (mg cm^{-2})	Crop growth rate		
					Early growth stage	Bloom	Seed filling
Kulat brown	2165.2 a	8.3 a	225.1 a	6.5 b	0.67 b	19.17 a	5.24
Kulat white	1435.0 b	5.9 c	204.4 bc	6.6 b	0.77 b	19.01 a	5.19
Mothi	2013.6 a	7.2 b	214.5 ab	7.0 ab	0.70 b	19.90 a	4.90
NARC-II	1030.1 c	4.1 d	184.3 d	7.0 ab	0.94 a	15.32 b	4.54
Swat-84	1012.1 c	4.0 d	189.4 cd	7.4 a	0.97 a	14.92 b	4.02
LSD 0.05	258.27	0.76	28.43	0.52	0.15	2.38	NS

Means of the same category followed by the different letters are significantly different from one another using LSD test ($p \leq 0.05$)

Table 4. Two years means for Leaf area (cm^2 $plant^{-1}$), leaf area index, Specific leaf area (cm^2 g^{-1}), specific leaf weight (mg cm^{-2}) and crop growth rate (at early vegetative, bloom, seed filling stages) of soybean land races vs improved varieties.

Varieties	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (mg cm^{-2})	Crop growth rate		
					Early growth stage	Bloom	Seed filling
Land races	1871.3a	7.1a	214.7a	6.7b	0.71b	19.36a	5.11a
Improved varieties	1021.1b	4.1b	186.9b	7.2a	0.96a	15.12b	4.28b
Year-I (2004)	1507.5	6.0	197.6	7.1	0.89	19.82	5.35
Year-II (2005)	1554.9	5.8	209.5	6.7	0.73	15.51	4.21

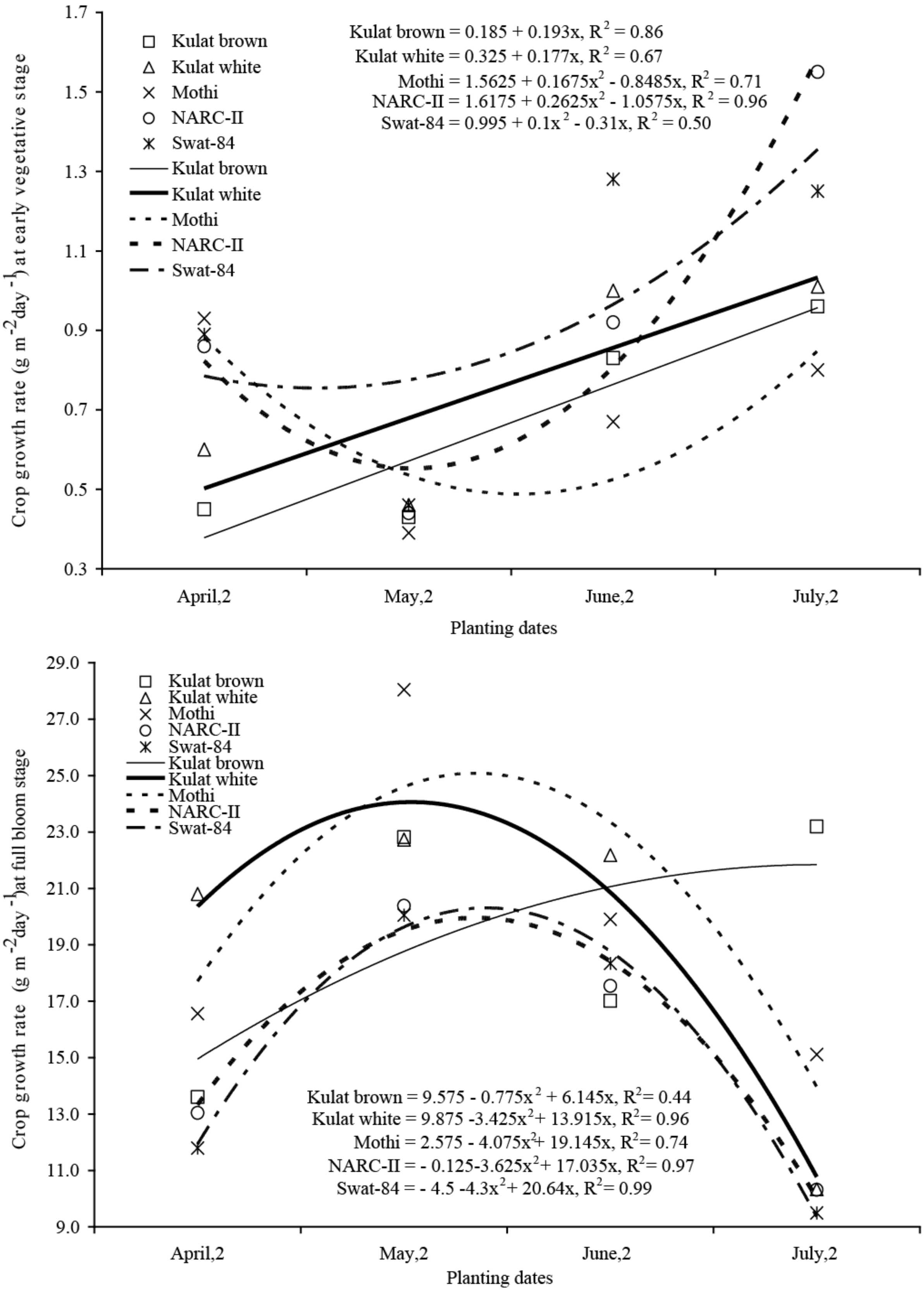


Fig. 3. Crop growth rate (g m^{-2} day^{-1}) at early vegetative and at bloom stage of soybean varieties as affected by planting dates over two years (2004-2005).

DxV interactions revealed that maximum CGR of 28.04, 22.81 and 22.73 g $m^{-2}day^{-1}$ was recorded for Mothi, Kulat brown and Kulat white planted in May and minimum CGR of 15.11 and 10.33 g $m^{-2}day^{-1}$ for Mothi and Kulat white planted in July. Minimum CGR (13.66 g $m^{-2}day^{-1}$) for Kulat brown was noticed in April planted crop. Maximum CGR of 20, 38 and 20.05 g $m^{-2}day^{-1}$ in NARC-II and Swat-84 was recorded in May planted crop and minimum CGR of 10.31 and 9.49 g $m^{-2}day^{-1}$ for the same varieties was recorded in July planted crop Bloom stage was the peak growing period of soybean, therefore the CGR values were higher than the early vegetative stage. At this stage the CGR potential was displayed resulting into significant differences in the treatment means. Arif (2006) also determined CGR values of 6.3, 18.9 and 9.4 g $m^{-2}day^{-1}$at three continuous intervals, without any specific stages. His middle interval values coincided with our bloom stage, but the other two values are slightly higher because of difference in the period of determination.

The interaction between DxV indicated (Fig. 3) that CGR at bloom for Kulat brown increased when planting was advanced from April to July. However, CGR of other varieties increased when planting was advanced from April to May and drastically decreased thereafter. Bloom stage was the peak growing period of soybean, therefore the CGR values were higher than the early vegetative stage. At this stage the CGR potential was displayed resulting into significant differences in the treatment means. Khan (2001) has reported CGR values of 11.3 and 9.1 g m^{-2} day^{-1} for R3 and R6 stages. Scott & Batchelor (1979) supported our findings by reporting that the period of maximum CGR corresponded to late vegetative and early reproductive growth.

Crop growth rate at seed filling: The differences in CGR for years and planting dates (D) were significant for the average of two years. In 2004 CGR means were significantly higher than in 2005 planted crop (Table 4). The averages for the two years revealed that CGR was greater for April (6.54 g m^{-2} day^{-1}) and May (5.36 g m^{-2} day^{-1}) planting than that for June (3.55 g m^{-2} day^{-1}) and July (3.67 g m^{-2} day^{-1}) (Table 2). There was no statistical difference in CGR of the crops planted at the later two dates. Our findings are in conformity with Khan (2001) who reported the highest CGR for May planting, which decreased when planting was delayed further. The relatively low value of CGR for April planting in our case was likely to be due to low temperatures in April (Table 1). CGR means for varieties were not significantly different. CGR of land races was 16.2% higher than the improved varieties (Table 2).

DxV interaction was not significant. CGR means during the seed filling stage indicated that the differences in means among planting dates and varieties narrowed down. The explanation could be that the seed filling stage was the last event of dry matter accumulation and therefore the CGR slowed down to the minimum uniform level as the crop proceeded near maturity. Scott & Batchelor (1979) also concluded that CGR attained peak at early reporductive growth and declined thereafter.

The average CGR at initial vegetative stage, bloom (R2) and seed filling stage (R6) were 0.81, 17.7 and 4.6 g m^{-2} day^{-1} respectively. The explanation could be that at early vegetative stage, a week after emergence the establishing seedlings had very small biomass, while at bloom, the vegetative growth has attained its peak and at seed filling stage, the growth slowed down and the nutrients flow was diverted towards seed filling. The average CGR of the three stages for April, May, June and July planting was 7.5, 8.9, 7.8 and 6.2 g m^{-2} day^{-1} respectively. Our findings are in accordance with the results of Pedersen & Lauer (2004) who reported that CGR for delayed planting was lower than the CGR of early planting determined at R6.

Conclusion

It is concluded that leaf area, leaf area index and specific leaf area declined when planting was delayed from April to July, except specific leaf weight, crop growth at early vegetative growth stage. Varieties significantly affected all parameters except crop growth rate at seed filling stage. Maximum leaf area, leaf area index, specific leaf area and crop growth rate except early vegetative stage were recorded for land races. Improved varieties produced maximum specific leaf weight and crop growth rate at early vegetative stage.

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