

Evaluation of effect of growth parameters, leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR) on seed yield of soybean during kharif season

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ABSTRACT

The field experiment entitled "Evaluation of effect of growth parameters, Leaf area index (LAI), Leaf area duration (LAD), Crop growth rate (CGR) on Seed yield of soybean during *kharif* season. was conducted at the Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri with a view to study is evaluate the effect of various growth parameters on the seed yield of soybean cultivars. The experiment was laid out in randomized block design (RBD) with 3 replications including eight soybean varieties namely JS- 335, MACS-58, MACS-124, DS-186, PK-472, PK-1029, Arati and Pooja. The observations were recorded during two years (2000 and 2003). In the present studies the pooled data regarding Leaf area index (LAI), Leaf area duration (LAD), Crop growth rate (CGR), showed that, there were significant differences among all varieties at 30-60 DAS, 60-90 DAS and 90 DAS to harvest of crop. The significantly highest pooled mean LAI at 30 DAS was noted of variety MACS-124 and Pooja (2.16), it was at par with variety MACS-58 (2.10). At 60 DAS, the significantly highest pooled mean LAI was seen of variety Pooja (9.03). While the lowest pooled mean LAI was seen of variety JS-335 (3.39). However at 90 DAS, the significantly highest pooled mean LAI was observed in variety Pooja (7.12), while the lowest pooled mean LAI was observed in variety DS-186 (0.33). At 30-60 days significantly highest mean pooled LAD was noticed in variety Pooja (167.90 days), while the lowest pooled mean LAD was noted variety JS-335(70.90 days). At 60-90 DAS The significantly highest pooled mean LAD was seen of variety Pooja(242.40 days). While the lowest pooled mean LAD was observed of variety JS-335(61.10 days). However at 90 DAS to harvest of crop the significantly highest pooled mean LAD was observed of variety Pooja (99.79 days) while the lowest pooled mean LAD was observed of variety DS-186(1.16 days). At 30-60 DAS, significantly highest mean pooled CGR was recorded of variety Pooja(23.41 g/m²/day). At 60-90 DAS, the significantly highest CGR was noticed in variety JS-335 (36.13 g/m²/day) and lowest was noticed in variety PK-1029 (13.41 g/m²/day). However at 90 DAS to harvest of crop the significantly highest CGR was recorded in variety Pooja (27.61 g/m²/day) and the lowest in variety PK-1029 (1.04 g/m²/day). There was significantly positive correlation of LAI at 30, 60 and 90 DAS with seed yield. There was significant positive correlation of LAD 30-60, 60-90 DAS and 90 DAS to harvest of crop with seed yield. There was significantly positive correlation of CGR (30-60 DAS and 90 DAS to harvest) with seed yield. The pooled data of both the years showed that significantly highest seed yield was recorded in variety Pooja (24.045q/ha) lowest seed yield was noted in variety DS-186 (12.518).

Key words : Soybean, LIA, LAD, C.G.R.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is an important pulse as well as oilseed crop. It has become wonder crop of the twentieth century and is often designated as 'Golden bean'. It is legume crop belonging to family leguminasae and sub family papillionaceae (Jodhavar, 1992; Liu, 1997).

At present soybean has become major oilseed crop covering an area of about 7.3 million hectares with 7.6 million tonnes annual production in India. Maharashtra has become second soybean growing state contributing about 25 % area (18.26 lakh hectares) of the country next to Madhya Pradesh. The area production and productivity of Maharashtra reported during 1991-92 was area (2.74,000 ha) production (1,95,000 MT) and productivity 712 kg/ha. During the year 2002-03 area (12,56,000 ha), production (15,76,000 MT) and productivity (1255 kg/ha) was recorded (Anonymous, 2004). The reason of low productivity of soybean may be due top physiological aspects and hence the study of evaluation of various growth parameters viz. LAI, LAD, CGR was undertaken.

MATERIALS AND METHODS

The present investigations entitled "Evaluation of effect of 'growth parameters, Leaf area index (LAI), Leaf area duration (LAD), Crop growth rate (CGR) on Seed yield of soybean during *kharif* season. were carried out during *kharif* seasons of the year 2000 and 2003. The details of material used and methods followed are presented in this chapter.

The experiment was laid out in randomized block design (RBD) with three replications including eight soybean varieties namely V1) JS- 335 ,V2) MACS-58, V3) MACS-124, V4) DS-186, V5) PK-472, V6) PK-1029, V7) Arati and V8) Pooja. The observations were recorded during two years (2000 and 2003). The recommended dose of fertilizers was given. The various growth observations were recorded at interval of 30 DAS to harvest. The statistical analysis was carried out by the method suggested by Panse and Sukhatme (1985).

Growth parameters :

Three soybean plants were uprooted at 30, 60, 90 DAS and at harvest the observations were recorded timely and on the basis of collected data various growth functions were

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calculated.

1. Leaf area index (LAI)

The leaf area index was calculated from the data of leaf area per plant at 30, 60 and 90 days. According to the formula given by Watson (1947), the LAI was calculated.

$$\text{LAI} = \frac{\text{Leaf area per plant}}{\text{Land area per plant (expressed in same units)}}$$

2. Leaf area duration (LAD) (days)

The leaf area duration was calculated by the formula given by Watson (1947).

$$\text{LAD} = \frac{L_1 + L_2}{2} \times (t_2 - t_1)$$

Where L_1 and L_2 are leaf area index at the time t_1 and t_2 , respectively.

3. Crop growth rate ($\text{g m}^{-2} \text{ day}^{-1}$)

CGR was calculated by using following formula given by Duncan *et al.* (1978)

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{\text{Spacing}}$$

Where W_2 and W_1 represents total dry matter production (g) at the times t_2 and t_1 , respectively.

RESULTS AND DISCUSSION

Growth parameters :

The data required for calculation of various growth parameters on eight soybean varieties was recorded timely during the year 2000 and 2003. Various growth functions were calculated were LAI, LAD and CGR and pooled data of above growth functions of different growth stages i.e. 30-60, 60-90 and 90 DAS to harvest of crop is given in Table 1 and 2. The result discussed are as under.

Statistically significant differences were observed among all varieties studied (Table 1). for pooled mean. of growth parameters LAI at 30, 60 and 90 DAS and LAD, CGR at 30-60 DAS, 60-90 DAS and 90 DAS to harvest of crop

1. Mean leaf area index (LAI):

- At 30 DAS, the highest pooled mean was seen of variety MACS-124 and Pooja (2.16), while the lowest pooled mean LAI was observed in variety JS-335 (1.39)
- At 60 DAS the significantly highest pooled mean LAI was seen of variety Pooja (8.37), while the lowest pooled mean LAI was noticed of variety JS-335 (3.39).
- At 90 DAS, the significantly highest pooled mean LAI was observed of variety Pooja (7.12), while the lowest pooled mean LAI was observed of variety DS-186 (0.33).

Correlation of Mean LAI with seed yield:

At 30 DAS the mean LAI had significant positive correlation with seed yield during the year 2000 (0.659), 2003 (0.883) and pooled data of both the years (0.707), 60 DAS the mean LAI had significant positive correlation with seed yield during the year 2000 (0.849), 2003 (0.877) and pooled data of both the years (0.864). However at 90 DAS the mean LAI had significant positive correlation with seed yield during the year 2000 (0.919), 2003 (0.812) and pooled data of both the years (0.888).

2. Mean leaf area duration (LAD) (days):

- At 30 DAS, the significantly highest pooled mean LAD (167.90 days) was recorded in variety Pooja followed by variety MACS-124 (157.97 day), while the lowest pooled mean LAD was noticed of variety JS-335 (70.90 days).
- At 60 DAS, the significantly highest pooled mean LAD was observed in variety Pooja (242.40 days). While the lowest pooled mean LAD was noticed in variety JS-335 (61.10 days).
- At 90 DAS, the significantly highest pooled mean LAD was observed of variety Pooja (99.79 days), while the lowest pooled mean LAD was observed of variety DS-186 (1.16 days).

Correlation of LAD with seed yield:

At 30-60 DAS the mean LAD had significant positive association with seed yield during the year 2000 (0.876), 2003 (0.872) and pooled data of both the years (0.861), 60-90 DAS the mean LAD had significant positive correlation with seed yield during the year 2000 (0.918), 2003 (0.843) and pooled data of both the years (0.862). However at 90 DAS to harvest the mean LAD had significant positive correlation with seed yield during the year 2000 (0.843), 2003 (0.809) and pooled data of both the years (0.841).

Mean crop growth rate (CGR) ($\text{g/m}^2/\text{day}^{-1}$):

- At 30-60 DAS, the significantly highest mean pooled CGR at 30-60 DAS was recorded of variety Pooja (23.41 $\text{g/m}^2/\text{day}$), while the lowest mean CGR was recorded in variety JS-335 (6.71 $\text{g/m}^2/\text{day}$).
- At 60-90 DAS, the pooled data showed that the significantly the highest CGR was noticed in variety JS-335 (36.13 $\text{g/m}^2/\text{day}$) and lowest was noticed in variety PK-1029 (13.41 $\text{g/m}^2/\text{day}$).
- At 90 DAS, the pooled data showed that significantly the highest CGR was recorded in variety Pooja (27.61 $\text{g/m}^2/\text{day}$) and the lowest in variety PK-1029 (1.04 $\text{g/m}^2/\text{day}$).

Correlation of CGR with seed yield:

At 30-60 DAS the mean CGR had significant positive association with seed yield during the year 2000 (0.781), 2003 (0.779) and pooled data of both the years (0.756), 60-90 DAS. However at 90 DAS to harvest the mean CGR had significant positive correlation with seed yield during the year 2000 (0.393), 2003 (0.481) and pooled data of both the years (0.420).

Mean Seed yield (q/ha) :

It is observed from seed yield (q/ha) data during *kharif* 2000 that significantly highest seed yield was recorded in variety Pooja (24.373) followed by varieties MACS-58 (24.157), MACS-124 (23.933) and Arati (23.277) were statistically at par with variety Pooja. The lowest seed yield was noted in variety DS-186 (13.177 q/ha). However, seed yield during *kharif* 2003 showed that significantly highest seed yield was recorded in variety Pooja (23.717) and lowest was recorded in variety DS-186 (11.860 q/ha).

The pooled data of both the years showed that significantly highest seed yield was recorded in variety Pooja (24.045q/ha) lowest seed yield was noted in variety DS-186 (12.518)

The trend of pooled data of mean seed yield (q/ha) was given as below

$$V_8 > V_2 > V_3 > V_7 > V_5 > V_6 > V_1 > V_4$$

In the present studies the pooled data regarding Leaf area index (LAI), Leaf area duration (LAD), Crop growth rate (CGR) recorded in Table 1, showed that, there were significant differences among all varieties at 30-60 DAS, 60-90 DAS and 90 DAS to harvest of crop. The pooled data regarding leaf area index (LAI) Table 1 showed that there were significant differences among all varieties at 30, 60 and 90 DAS. This result is an agreement with conclusions of Sharma and Sharma (1993).

The pooled data showed that, there was significantly highest LAI in high yielding varieties Pooja (9.03) and MACS-124 (8.37) at 60 DAS. However, at 90 DAS the significantly the highest LAI was recorded in variety Pooja (7.12) over rest of all varieties. The high yielding varieties had higher LAI at 30, 60 and 90 DAS and low yielded variety

had lowest LAI at 30, 60 and 90 DAS. These results are confirmatory with results of Nirmalakumari and Balsubramanian (1990). The present results indicated that, the variations in seed yield were due to variations in LAI. This conclusion is confirmatory with results of Martin *et al.* (1995) who stated that, variations in seed yield were related to LAI.

The mean LAI pooled data revealed that, there was decrease in LAI at 90 DAS and highest LAI observed at 60 DAS. This decrease in LAI was due to senescence of leaves. Bhardwaj and Bagsari (1989) observed that, there was increase in photomass as LAI increases which resulted in higher yield, present investigations results are similar to this. Bisht and Chandel (1989) reported that, the highest LAI reaches at 45 DAS and lowest LAI possibly due to slow initial growth rate result in non significant differences in LAI of soybean varieties.

The pooled data, revealed that, LAI increased as crop growth increases up to 60 DAS. Thereafter at ripening stage the LAI decreased these results are confirmatory with conclusions of Jain *et al.* (1996) who noticed that, LAI increased as crop growth increased and decreased at maturity of crop. However, Pushpakumari *et al.* (1993) revealed that, LAI values gradually increased up to 90 DAS in all varieties.

The mean pooled data of LAD showed that high yielding varieties had highest LAD throughout the crop growth period. The mean pooled data of LAD showed that high yielding varieties had highest LAD at 30-60 DAS and pooled data of both the years showed that at 30-60 DAS the significantly highest LAD observed in high yielding varieties MACS-124 (157-94 days) and Pooja (167.90 days). From this it is concluded that seed yield was positively associated with higher LAD at 30 DAS.

Table 1 : Pooled data mean of Leaf area index (LAI), Leaf area duration (days) LAD, Crop growth rate CGR g. m⁻² day⁻¹ and Seed yield of the year 2000 and 2003

S. No.	Treatment	Mean leaf area index (LAI)			Mean leaf area duration (days) LAD			Mean crop growth rate CGR			Seed yield (q/ha)
		30 DAS-60 DAS	60 DAS-90 DAS	90 DAS-Harvest	30 DAS-60 DAS	60 DAS-90 DAS	90 DAS-Harvest	30 DAS-60 DAS	60 DAS-90 DAS	90 DAS-Harvest	
1	V ₁ -JS-335	1.39	3.33	0.74	70.90	61.10	2.96	6.71	36.13*	9.00	14.600
2	V ₂ -MACS-58	2.10*	8.15	5.43	153.67	203.67	61.27	22.21*	28.86	8.36	22.618
3	V ₃ -MACS-124	2.16*	8.37*	6.25	157.97*	219.32	71.87	21.60*	31.25	7.42	21.847
4	V ₄ -DS-186	1.41	3.81	0.33	78.20	62.02	1.16	10.68	35.07*	11.23	12.518
5	V ₅ -PK-472	1.73	6.74	4.40	127.02	167.02	32.32	15.63	27.37	8.46	19.213
6	V ₆ -PK-1029	1.88*	5.62	3.92	112.72	143.20	53.43	16.08	13.41	1.04	15.810
7	V ₇ - Arati	1.84	6.17	5.49	120.17	174.92	61.88	17.32	23.83	20.96*	20.203
8	V ₈ - Pooja	2.16*	9.03*	7.12*	167.90*	242.40*	99.79*	23.41*	23.75	27.61*	24.045*
	Mean	1.83	6.40	4.21	123.56	159.20	48.08	16.70	27.46	11.76	18.857
	S. E. ±	0.10	0.25	0.24	4.88	7.00	2.84	1.00	1.60	2.45	0.422
	C. D. at 5 %	0.30	0.76	0.71	14.02	21.00	8.24	2.90	4.61	7.12	1.223

* Significant over rest all varieties

The pooled data showed that at 60-90 DAS Pooja variety had significantly highest LAD (242.40 days) over rest of all varieties. However, low yielding varieties had lower LAD values.

However, at 90 DAS to harvest of crop pooled data showed that, the high yielding variety Pooja had significantly highest LAD (99.79 days) over rest of all varieties and low yielding variety DS-186 had lowest LAD (1.16 days) as all leaves were defoliated.

Pooled data showed that high yielding variety Pooja (24.045 q/ha) had significantly the highest LAD throughout crop growth period and low yielding variety DS-186 had lowest LAD.

The pooled data showed that, there was increase in LAD at 60-90 DAS. However, Nirmalakumari and Balsubramanian (1990), who observed that, there was increase in LAD during 40-60 DAS and thereafter it was stable. However, Mcblain and Hume (1980) reported that, the differences in LAD were non significant.

The correlation of the year 2000, 2003 and pooled data Table 2 showed positive association between LAD and seed yield at 30-60, 60-90 and 90 DAS to harvest of crop. From study of the pooled data it is concluded that consistently higher LAD in varieties Pooja, MACS-58 and MACS-124 resulted in to higher seed yield.

The most meaningful growth analysis term for crop canopies is dry matter accumulation per unit land area per unit of time, or the crop growth rate (CGR), CGR is measured by harvesting (sampling) a crop community at

confirmatory with Bisht and Chandel (1989), Jain *et al.* (1996) who observed that, the CGR increased with plant age and it declined at the maturity of crop.

The pooled data showed that, at 30 DAS high yielded varieties Pooja (23.41 g. m⁻², day⁻¹), MACS-58 (22.2 g. m⁻², day⁻¹), and MACS-124 (21.60 g. m⁻², day⁻¹) had significantly highest CGR over rest of all varieties. It is concluded from CGR should be higher at 30-60 DAS for getting higher seed yield. At 60 to 90 DAS the varieties DS-186 and JS-335 had highest CGR as these are short durational varieties and matures early. However, at 90 DAS to harvest of crop the CGR values of varieties Pooja and Arati were higher as biomass production was higher also the maturity period was maximum of these varieties.

The correlation studies during year 2000, 2003 and pooled data (Table 2) showed that, there was positive correlation at 30-60 DAS and 90 DAS to harvest of crop. However, there was negative association observed at 60-90 DAS. These results are confirmatory with conclusions of Nirmalakumari and Balsubramanian (1989).

From the present investigation., the following conclusions were drawn

1. The high yielding variety Pooja (24.045 q/ha) had significantly the highest leaf area index (LAI) at 30 DAS (2.16), 60 DAS (9.03/plant) and 90 DAS (7.12/plant). There was significantly positive correlation of LAI at 30, 60 and 90 DAS with seed yield.
2. The high yielding variety Pooja (24.045 q/ha) had significantly highest leaf area duration (LAD) at 30-60

Table 2 : The yearwise and pooled data of correlation analysis of soybean yield (q/ha) with various growth function

S. No	Plant character		'r' values of		
			2000	2003	Pooled
1	LAI	30 DAS	0.659**	0.883**	0.707**
		60 DAS	0.877**	0.849**	0.864**
		90 DAS	0.919**	0.812**	0.888**
2	LAD	30 -60 DAS	0.876**	0.872**	0.861**
		60-90 DAS	0.918**	0.843**	0.862**
		90 DAS- harvest	0.843**	0.809**	0.841**
3	CGR	30-60 DAS	0.781**	0.779**	0.756**
		60-90 DAS	-0.290*	-0.063	-0.175
		90 DAS-harvest	0.393**	0.481**	0.420**

*'r' values, *Significance at 5 % (0.284) , ** Significance at 1 % (0.358)

frequent intervals and calculating the increase in dry weight from one sampling to the next (Franklin *et al.* 1988).

The mean pooled data of CGR (Table 1) revealed that, there were significant differences among all varieties at 30-60, 60-90 and 90 DAS to harvest of crop. This result is

DAS (167.90 days), 60-90 DAS (242.40 days) and at 90 DAS to harvest (99.79 days). There was significant positive correlation of LAD 30-60, 60-90 DAS and 90 DAS harvest with seed yield.

3. Highest CGR (27.61 g/m²/day) was recorded in Pooja

variety at 90 DAS to harvest which gave highest yield (24.045 q/ha). There was significantly positive correlation of CGR (30-60 DAS and 90 DAS to harvest) with seed yield.

4. There was significantly positive correlation of LAI at 30, 60 and 90 DAS with seed yield. It also showed that there was significant positive correlation of LAD and CGR at 30-60, 60-90 DAS and 90 DAS harvest with seed yield.

Hence it is concluded from these studies that, the Pooja soybean variety was found to be suitable for cultivation over the seasons in Ahmednagar jurisdiction.

It is concluded from these studies that, the highest values of LAI, LAD and CGR at all crop growth stages are desirable for getting higher seed yield q/ha.

REFERENCES

- Anonymous (2004).** Annual Report 2002-03. Agharkar Research Inst. M. A. C. S., Pune.
- Bhardwaj, H. L. and Bhagsari, A. S. (1989).** Harvest index, yield and physiological characters of soybean as related to seed size. *Soybean Genetics Newsletter* **16** : 133-136.
- Bisht, J. K. and Chandel, A. S. (1989).** Cultivar variation in some Agrophysiological traits of soybean. *Legume Research* **12 (1)** : 31-34.
- Duncan, W. G., McCloud, D. C., McGrow, R. L. and Boote, K. G. (1978).** Physiological aspects of peanut yield improvement. *Crop Sci.* **18** : 1015-1020.
- Franklin, P., Gardner, R., Brent Pearce, Roger, L. Michell (1988).** A book on "Physiology of Crop Plants" Scientific Publishers, Ratanada Road, Jodhapur pp. 33.
- Jain, M. P., Paradkar, N. R., Khan, R. A., Ambawatia, G. R. (1996).** Effect of time of harvest on germination and field emergence capacity in soybean cultivars. *Field Crop Abst.* **50 (6)** : 3942, pp. 534.
- Jodhavar, D. V. (1992).** Studies on nitrogen and plant densities on growth, yield and quality of soybean [*Glycine max* (L.) Merrill] variety MACS-58. M. Sc. (Agri.) Thesis submitted to MPKV, Rahuri, pp. 5-9.
- Liu, K. (1997).** A book on soybeans chemistry, Technology and utilization. International Thomson publishing 102, Tokyo, Japan pp. 25-27.
- Martin, D. E., Santaolla, M. F., Juan, Valero, J. A., Fabeiro, D. E., Cortis, C. (1995).** Growth and yield analysis of soybean under different irrigation schedules in Spain. *Field Crop Abst.* **48 (4)** : 2577, pp. 310.
- Mcblain, B. A. and Hume, D. J. (1980).** Physiological studies of higher yield in new early maturing soybean cultivars. *Can. J. Pl. Sci.* **60** : 1315-1326.
- Nirmala Kumari, A. and Baisubramanian, M. (1990).** Physiological analysis of growth in soybean. *Indian J. Pl. Physiol.* **33 (3)** : 248-252.
- Panse, V. G. and Sukhatme, P. V. (1985).** Statistical methods for agricultural workers. ICAR, New Delhi (4th Edn.) pp. 48-123.
- Pushpa Kumari, R., Nair, R. V. and Geetakumari, V. L. (1993).** Varietal variation in the growth pattern of soybean. *Legume Research* **16 (2)** : 63-66.
- Sharma, J. P. and Sharma, S. P. (1993).** Influence of genotypes and plant densities on physiological parameters seed yield and quality of soybean. *Indian J. Agron.* **38 (2)** : 311-313.
- Watson, D. J. (1947).** Comparative physiological studies on the growth of field crops I. Variation in NAR and LAR between species and varieties and within and between years. *Ann. of Bot. (London)* **11** : 41-46.

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