Himachal Journal of Agricultural Research 42(2): 131-136 (2016)

Effect of genotype, sowing schedule and row spacing on growth indices of soybean (*Glycine max*) under mid hill conditions of Himachal Pradesh

Aastha and Janardan Singh
Department of Agronomy, Forages and Grassland Management
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 062, India.
Corresponding author: singhjdr@rediffmail.com

Received: 05 October 2016; Accepted: 09 November 2016

Abstract

A field experiment was conducted during rainy season of 2015 at Palampur, Himachal Pradesh to evaluate the effect of genotype, sowing schedule and row spacing on growth indices of soybean. The experiment was laid out in factorial randomized block design with 12 treatment combinations comprising of two genotypes (Harasoya and HIMSO 1685), three sowing schedules (last week of May, 1st week and 2nd week of June) and two row spacings (45 cm and 60 cm). A genotype, HIMSO 1685,resulted in significantly better growth over Harasoya except plant height and absolute growth rate. Soybean sown during last week of May followed by 1st week of June resulted in significantly higher dry matter accumulation, leaf area index, leaf area duration, leaf area ratio, crop growth rate, relative growth rate and net assimilation rate. Narrow row spacing of 45 cm resulted in significantly better growth.

Key words: Growth indices, row spacing, sowing schedule, soybean.

Soybean attains special importance in India and other Asian countries because of acute shortage of proteins and fats. In India, it is cultivated on an area of 11.72 million hectares having total production of 11.86 million tonnes with an average yield of 1012 kg/ha. In Himachal Pradesh, it is cultivated in 600 hectares area with a total production of 900 tonnes and the average yield of 1450 kg/ha (Anonymous 2014). Oil and protein contents account for about 60% of dry soybean by weight (protein 40% and oil 20%). The remainder consists of 35% carbohydrate and about 5% ash. It is also very rich in vitamin A and vitamin B, fibres, potassium and iron (Hou *et al.* 2009). Sowing time plays a significant role in determining growth, development and yield of soybean. Growth and yield are generally better from earlier sown soybean due to longer duration of vegetative and reproductive growth stages. Sowing prior to or later than the optimal sowing time can greatly reduce soybean growth and yield since photoperiodism controls not only the number of days to flowering, but also the amount of time available for vegetative plant growth and development (Berger *et al.* 2014). Row spacing is considered to be the foremost step to achieve proper and uniform distribution of plants over cultivated area thereby better availability of above and below ground resources towards increasing growth/yield and decreasing competition among plants. It influences crop growth through its influence on light interception, rooting pattern, nutrient extraction and moisture extraction pattern etc. Soybean sown in narrow-row spacing can produce higher productivity which is mainly attributed to greater light interception. In addition to greater light interception and potential yields, narrow row spacing promotes rapid canopy closure, which can effectively reduce weed seedling growth, compared with wider-row spacing (Board *et al.* 1996). Keeping in view the above said facts, the present investigation was carried out to find out the optimum time of sowing and inter row spacing for different soybean genotypes.

Materials and Methods

The field experiment was conducted during the rainy (*Kharif*) season of 2015 at the Research Farm, Department of Agronomy, Forages and Grassland Management, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at 32˚6' N latitude, 76˚3' E longitude and at an altitude of 1290.8 m above mean sea level. The soil of the experimental site was silty clay loam with 5.4 pH, 0.224 dS/m EC, 0.54% organic carbon, 125.44 kg/ha available nitrogen, 14.25 kg/ha available phosphorus and 159 kg/ha available potassium. The weekly minimum and maximum temperature ranged from 3.5°C to 21.89°C and 13.06°C to 32.39°C, respectively. The mean relative humidity ranged from 52.43% to 94.15% and total of 2569.5 mm rainfall were received during the crop season. The mean bright sunshine hours were 1870.30 during the whole of the crop season. The experiment was laid out in factorial randomized block design comprising of two genotypes of soybean (Harasoya and HIMSO 1685), three sowing schedules (last week of May, 1st week and 2nd week of June) and two row spacings (45 cm and 60 cm). Each treatment was allocated randomly and replicated thrice. Treated seeds with Bavistin were applied at the rate of 100 kg/ha. Recommended dose of nitrogen, phosphorus and potassium was applied at the rate of 20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha, respectively at the time of sowing. Pendimethalin (stomp 30 EC) was applied at the rate of 5 l/ha within 48 hours of sowing for the control of weeds.

The genotype, HIMSO 1685, exhibited higher seed yield as compared to the green seeded Harasoya though, it matures slightly later than Harasoya. It has green and bold seeds with an average oil content of 23.85%. It ranked first for 100 seed weight in North Hill zone, North Eastern zone, Central zone and Sothern zone. It is highly resistant to frogeye spot and resistant to pod blight and bacterial pustules as compared to Harasoya which is susceptible to frogeye leaf spot and moderately resistant to pod blight.

Other package of practices recommended for the region was also followed. In order to assess the plant growth indices, the periodical plant height, dry matter accumulation and leaf area measurements were done at 30, 60 and 90 days after sowing, and at harvest following standard procedures:

Absolute growth rate (AGR)was determined by using the formula given by Radford (1967):

$$\text{AGR (cm/day)} = \frac{h_2 - h_1}{t_2 - t_1}$$

where, h_1 and h_2 are the plant height at t_1 and t_2 times, respectively.

Crop growth rate (CGR)was determined by using the formula given by Watson (1956):

$$\text{CGR (g/m}_2\text{/day)} = \frac{(w_2 - w_1)}{p\ (t_2 - t_1)}$$

where, w_1 and w_2 are whole plant dry weight at t_1 and t_2 time, respectively. p is the ground area on which w_1 and w_2 are recorded.

Leaf area index (LAI) was determined by using the formula given by Sestak *et al.* (1971):

$$\text{LAI} = \frac{\text{Total leaf area of the plant}}{\text{Ground area occupied by the plant}}$$

Leaf area duration (LAD) was determined by using the formula given by Power *et al.* (1967):

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

where, L_1 and L_2 are leaf area index at times t_1 and t_2, respectively.

Leaf area ratio (LAR) was determined by using the formula given by Power et al.(1967):

$$\text{LAR (cm}_2\text{/g)} = \frac{\text{Leaf area per plant}}{\text{Plant dry weight}}$$

Net assimilation rate (NAR) was determined by using the formula given by Gregory (1926):

$$\text{NAR (g/g/day)} = \frac{(w_2 - w_1)}{p\ (t_2 - t_1)} \times \frac{(\text{loge } l_2 - \text{loge } l_1)}{(l_2 - l_1)}$$

where, w_1 and w_2 are dry weight of whole plant at times t_1 and t_2, respectively.

l_1 and l_2 are leaf area at times t_1 and t_2, respectively.

Relative growth rate (RGR)was determined by using the formula given by Fisher (1921).

$$\text{RGR (g/g/day)} = \frac{(\text{loge } w_2 - \text{loge } w_1)}{(t_2 - t_1)}$$

where, w_1 and w_2 are dry weight of whole plant at times t_1 and t_2, respectively.

Results and Discussion

Plant height was significantly influenced by different genotypes. Harasoya produced taller plants. Crop sown during 1st week and 2nd week of June produced taller plants at 60 and 30 days after sowing, respectively (Table 1). Decreasing plant height from May to June could be attributed due to a shorter vegetative period and low canopy competition among the plants at the early sowings. The results are in conformation with Uslu and Esendel (1998) and Singh (2010). Taller plants were observed at 45 cm inter-row spacing at 90 days after sowing. This may be due to the fact that in early growth stages of the crop, when the plants are small, much of the light is not intercepted by the leaves and thus at this stage, narrow spacing provides better utilization of light. The reduction in row spacing from 60 cm to 45cm resulted in increased plant height mainly because of increased competition within plants in closer row spacing. Similar results were observed by Rehman *et al.* (2013).

Dry matter accumulation was significantly influenced by different genotypes at 90 days after sowing. HIMSO 1685 produced significantly higher dry matter accumulation over Harasoya. Crop sown during last week of May followed by 1st week of June resulted in significantly higher dry matter accumulation (Table 1). This might be due to favourable and sufficient growing period for vegetative and reproductive stages in early sowing. Similar results were reported by Pederson and Lauer (2004) and Dogra *et al.* (2014). Higher dry matter accumulation was observed in the crop sown at 45 cm inter-row spacing. This might be related to PAR interception in addition of more number of plants per unit area. Similar findings were observed by Chauhan and Opena (2013) and Zhou *et al.* (2011).

Number of nodules and fresh weight of nodules per plant were not influenced by different genotypes and row spacing (Table 1). However, maximum nodules per plant were recorded in HIMSO 1685 sown at 60 cm inter-row spacing. The highest number of nodules per plant was recorded in the crop sown during first week of June. This could be attributed due to optimum temperature during 1st week of June and the decline in nodule number in 2nd week of June may be due to increase in temperature. Maximum fresh weight of nodules per plant was noted in HIMSO 1685. It was significantly affected by dates of sowing at 60 days after sowing. Fresh weight of nodules noted in the crop sown during last week of May followed by 1st week of June was significantly higher over the crop sown during 2nd week of June. The highest dry weight of nodules per plant was recorded in HIMSO 1685 sown during 1st week of June. This might be due to more number of nodules in early sowing. The observations recorded by Muhammad *et al.* (2012) showed a direct relationship between nodule number and nodule weight. Row spacing did not influence dry weight of nodules per plant.

The highest leaf area index (LAI) was recorded in HIMSO 1685. Crop sown during last week of May and 1st week of June resulted in maximum leaf area index at 30 and 60 days after sowing, respectively. This may be due to greater partitioning of total dry matter into branches by early sown crop or may be due to favourable temperature and greater radiation absorption. Similar findings were recorded by Daroish *et al.* (2005), Kandil *et al.* (2013) and Ebrahimi *et al.* (2012). Leaf area index was not affected by row spacing. However, maximum value of leaf area index was recorded in wider row spacing of 60 cm (Table 2). This might be due to the fact that plants get more space for growth at wider row spacing of 60 cm. Similar results were reported by Lone *et al.* (2009).The highest leaf area duration was observed in HIMSO 1685 at 60 and 90 days after sowing. The dates of sowing affected leaf area duration significantly at all growth stages. The highest leaf area duration (LAD) was noted at 30 days after sowing in the crop sown during last week of May while at 60 and 90 days after sowing, it was higher in the crop sown either during 1st week of June or 2nd week of June. This might be due to more availability of growing period for vegetative and reproductive stages. The highest leaf area ratio was recorded in HIMSO 1685 at 30 and 60 days after sowing. Crop sown during last week of May showed the highest leaf area ratio at 30 days after sowing. Significantly higher leaf area ratio (LAR) was recorded at 90 days after sowing when crop was sown either during last week of May or 2nd week of June. Row spacing did not influence leaf area duration and leaf area ratio at any growth stage (Table 2).

Absolute growth rate (AGR) was significantly affected by different genotypes only at 30 days after sowing (Table 3). The highest value of absolute growth rate was recorded in Harasoya. Since absolute growth rate is related to plant height and more plant height in Harasoya resulted in higher absolute growth rate. The result confirms the findings of Malek *et al.* (2012). Significantly higher absolute growth rate was noted at 30 and 60 days after sowing when crop was sown during 2nd week and 1st week of June, respectively. Inter row spacing of 45 cm showed significantly higher absolute growth rate at 90 days after sowing. This is because of increased competition within plant at closure row spacing. The highest value of crop growth rate (CGR) was observed in HIMSO 1685. Higher crop growth rate was noted at 30 and 60 days after sowing when crop was sown during last week of May while at 90 days after sowing, it was higher in the crop sown during last week of May followed by 1st week of June. This might be due to availability of sufficient period for vegetative and reproductive growth which resulted in higher crop growth rate. Similar results were reported by Daroish *et al.* (2005), Kandil *et al.* (2013) and Ebrahimi *et al.* (2012). Significantly higher crop growth rate was observed at 45 cm inter-row spacing at 30 and 90 days after sowing. This might be due to more interception of light in closure row spacing and more number of plants per unit area. Significantly higher net assimilation rate (NAR) was observed in HIMSO 1685 at 90 days after sowing. Crop sown during 1st week of June showed the highest net assimilation rate at 90 days after sowing. At 30 days after sowing, it was significantly higher in the crop sown during last week of May followed by 2nd week of June. It may be due to more availability of solar radiation in early planted crop. Similar results were reported by Daroish *et al.* (2005) and Kandil *et al.* (2013). Row spacing did not influence net assimilation rate at any growth stage. The highest value of relative growth rate (RGR) was recorded in HIMSO 1685 sown during 1st week of June. Row spacing did not affect relative growth rate at all crop growth stages (Table 3).

Results revealed that HIMSO 1685 is better genotype than Harasoya. Last week of May followed by 1st week of June and 45 cm inter-row spacing were found to be the optimum agronomic practices for better growth of soybean under mid hill conditions of Himachal Pradesh.

Table 1. Effect of genotype, sowing schedule and row spacing on plant height, dry matter accumulation, number of nodules, fresh and dry weight of nodules

Treatment	Plant height (cm)			Dry matter accumulation (g/m^2)			*Number of nodules/ plant	*Fresh weight of nodules/ plant(g)	*Dry weight of nodules/ plant(g)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
Genotype									
Harasoya	19.2	70.4	107	36.9	166	492	77.5	0.77	0.25
HIMSO 1685	16.0	66.5	112	32.5	189	741	83.4	1.01	0.38
SEm±	0.49	1.61	2.31	2.9	9.95	22.0	3.11	0.08	0.04
CD (P=0.05)	1.43	NS	NS	NS	NS	65.5	NS	NS	0.12
Sowing Schedule									
Last week of May	14.4	65.0	124	41.8	211	680	78.6	1.11	0.29
1st week of June	18.1	75.5	121	38.5	187	704	101	1.27	0.45
2nd week of June	20.2	64.9	83	23.7	133	466	61.3	0.29	0.20
SEm±	0.59	1.97	2.83	3.56	12.1 9	27.36	3.81	0.10	0.05
CD (P=0.05)	1.75	5.77	8.29	10.4	35.7	80.3	11.2	0.30	0.15
Row spacing									
45 cm	17.3	69.0	113	40.2	196	688	77.4	0.77	0.26
60 cm	17.9	67.9	106	29.2	158	545	83.4	1.01	0.37
SEm±	0.49	1.61	2.31	2.9	9.95	22.34	3.11	0.08	0.04
CD (P=0.05)	NS	NS	6.77	8.52	29.2	65.5	NS	NS	NS

** 60 days after sowing*

Table 2. Effect of genotype, sowing schedule and row spacing on leaf area ratio,leaf area index and leaf area duration

Treatment	LAR(cm^2/g)			LAI			LAD (days)		
	30 DAS	60DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90DAS
Genotype									
Harasoya	7.45	3.30	0.52	0.85	2.01	5.03	12.2	42.9	106
HIMSO 1685	9.97	5.33	0.56	0.94	2.29	6.58	15	48.5	103
SEm±	0.65	0.36	0.04	0.06	0.05	0.26	1.24	1.42	3.92
CD (P=0.05)	1.92	1.04	NS	NS	0.15	0.77	NS	4.17	11.5
Sowing Schedule									
Last week of May	13.2	4.04	0.67	1.06	2.64	6.32	17.1	55.6	134
1st week of June	6.16	4.60	0.38	0.90	2.53	5.95	12.7	51.3	127
2nd week of June	6.72	4.31	0.58	0.73	1.29	5.15	10.9	30.3	96.6
SEm±	0.80	0.44	0.05	0.08	0.06	0.32	2.14	1.74	4.81
CD (P=0.05)	2.35	NS	0.14	0.23	0.18	0.94	4.44	5.1	14.1
Row spacing									
45 cm	8.58	4.24	0.56	0.88	2.02	5.48	14.9	43.5	112
60 cm	8.84	4.39	0.52	0.92	2.28	6.14	12.3	48.0	126
SEm±	0.65	0.36	0.04	0.06	0.05	0.26	1.24	1.42	3.92
CD (P=0.05)	NS	NS	NS	NS	0.15	NS	NS	4.17	11.5

Table 3. Effect of genotype, sowing schedule and row spacing on absolute growth rate (AGR), crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR)

Treatment	AGR (cm/day)			CGR (g/m^2/day)			NAR (g/g/day)			RGR (g/g/day)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Genotypes												
Harasoya	0.64	2.37	3.55	1.23	4.29	10.9	0.52	0.26	0.82	0.04	0.03	0.02
HIMSO 1685	0.53	2.22	3.74	1.08	5.20	18.4	0.56	0.37	1.49	0.04	0.03	0.03
SEm±	0.02	0.05	0.08	0.1	0.3	0.81	0.04	0.09	0.14	0.002	0.002	0.002
CD (P=0.05)	0.05	NS	NS	NS	0.89	2.37	NS	NS	0.42	NS	NS	0.01
Sowing Schedule												
Last week of May	0.48	2.71	4.14	1.39	5.65	15.6	0.67	0.36	1.01	0.04	0.03	0.02
1st week of June	0.61	2.55	4.04	1.28	4.96	17.2	0.38	0.33	1.73	0.04	0.03	0.03
2nd week of June	0.68	2.16	2.77	0.79	3.63	11.1	0.58	0.25	0.72	0.04	0.03	0.02
SEm±	0.02	0.06	0.09	0.12	0.37	0.99	0.05	0.11	0.18	0.003	0.003	0.003
CD (P=0.05)	0.06	0.18	0.28	0.35	1.09	2.90	0.14	NS	0.52	NS	NS	0.01
Row spacing												
45 cm	0.58	2.30	3.77	1.34	5.18	16.4	0.56	0.4	1.01	0.04	0.03	0.02
60 cm	0.60	2.28	3.52	0.97	4.31	12.9	0.52	0.23	1.3	0.04	0.03	0.02
SEm±	0.02	0.05	0.08	0.10	0.30	0.81	0.04	0.09	0.14	0.002	0.002	0.002
CD (P=0.05)	NS	NS	0.23	0.28	NS	2.37	NS	NS	NS	NS	NS	NS

References

Anonymous. 2014. State-wise area, production and yield estimates of soybean http://eands.dacnet.nic.in/APY_96_To_06.htm.

Berger DJ, Zhang B, Smith SF and Chen P. 2014. Planting date, irrigation and row spacing effects on agronomic traits of food-grade soybean. Advances in Crop Science and Technology **2** (4):1-8.

Board JE, Zhang W and Harville BG. 1996. Yield rankings for soybean cultivars grown in narrow and wide rows with late planting dates. Agronomy Journal **88**: 240-245.

Chauhan BS and Opena JL. 2013. Effect of plant spacing on growth and grain yield of soybean.American Journal of Plant Sciences **4** (3):2011-2014.

Daroish M, Hassan Z and Ahad M. 2005. Influence of planting dates and plant densities on photosynthesis capacity, grain and biological yield of soybean (*Glycine max* L.) in Karanj Iran Journal of Agronomy **4** (3):230-237.

Dogra AK, Kaur J and Gill BS. 2014. Photoperiodic dynamics alters biomass accumulation and its partitioning in soybean genotypes under sub-tropical Punjab conditions. International Journal of Advanced Research **2** (2):322-342.

Ebrahimi M, Pouryousef M, Rastgoo M and Saba J. 2012. Effect of sowing date, plant density and weeds in soybean growth indices. Journal of Plant Protection **26** (2):178-190.

Fisher RA.1921.Some remarks on the methods formulated in a recent article on 'the quantitative analysis of plant growth'. Annals of Applied Biology **7**:367-372.

Gregory FG. 1926. The effect of climatic conditions on the growth of barley. Annals of Botany **40**:1-26.

Hou A, Chen P, Alloatti DL, Mozzoni L, Zhang B and Shi A. 2009. Genetic variability of sugar content in worldwide soybean germplasm collections. Crop Science **49** (3):903-912.

Kandil AA, Sharief AE, Morsy AR and El-sayed AIM. 2013. Influence of sowing date on some genotypes of soybean on growth, yield and seed quality. Journal of Biological Sciences **13**:146-151.

Lone BA, Hasan B, Ansar S and Khanday BA. 2009. Effect of seed rate, row spacing and fertility levels on growth and nutrient uptake of soybean under temperate conditions. ARPN Journal of Agricultural and Biological Sciences **4** (3):7-10.

Malek MA, Mondal MMA, Ismail MR, Rafii MY and Berahim Z. 2012. Physiology of seed yield in soybean: Growth and dry matter production. African Journal of Biotechnology **11** (30): 7643-7649.

Muhammad A, Khalil SK, Khan AZ and Wazir SM. 2012. Seasonal and cultivar effects on nodulation potential of soybeans. Pakistan Journal of Botany **44** (1):317-320.

Pederson P and Lauer JG. 2004. Soybean growth and development in various management systems and planting date. Crop Science **44**:508-515.

Power JF, Willis WO, Gunes DL and Peichman GA. 1967. Effect of soil temperature, phosphorus and plant age on growth analysis of barley. Agronomy Journal **59**:231-234.

Radford PJ. 1967. Growth analysis formulae-their use and abuse. Crop Science **7**: 171-175.

Rehman M, Khaliq T, Ahmad A, Wajid SA, Rasul F, Hussain J and Hussain S. 2014. Effect of planting time and cultivar on soybean performance. Academia Journal of Agricultural Research **2** (5):134-138.

Sestak Z, Catsky J and Jarvis PG. 1971. Plant photosynthetic production, Manual of Methods, Ed. by Junk, WNV publications, The Hughus, p 343-381.

Singh G. 2010. Replacing rice with soybean for sustainable agriculture in the Indo-Gangetic plains of India: Production technology for higher productivity of soybean. International Journal of Agricultural Research **5** (5):259-267.

Uslu N and Essendel E. 1998. Response of inoculation and sowing date of soybean under Bafra plain conditions in the Northern region of Turkey. Tropical Journal of Agriculture and Forestry **22**:531-525.

Watson DJ 1956. Leaf growth in relation to crop yield FL Milthrope, Butterworths scientific publications London, p 178-191.

Zhou XB, Chen YH and Oyang Z. 2011. Row spacing effect on leaf area development, light interception, crop growth and grain yield of summer soybean crops in Northern China. African Journal of Agricultural Research **6** (6):1430-1437.