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Effect of spacing and weed management practices on growth and yield of soybean (*Glycine max* L.)

Himanshu Jaiswal and Rajendra Lakpale

Abstract
Experiment was conducted during *kharif* season of 2021 at Instructional cum Research Farm, D.K.S. College of Agriculture and Research Station, Bhatapara (C.G.). The experiment was laid out in split plot design with three replication. The result of present experiment revealed that the growth attributes *viz.*, plant height, number of leaves, number of branches, dry matter accumulation as well as yield attributes *viz.*, number of pods plant^{-1}, number of seed pods^{-1}, seed index (100 seed), seed yields, stover yields, harvest index as well as lowest weed index and highest weed control efficiency were found maximum under wider row spacing (45 cm × 10 cm) and weed free check which was at par with two hand weeding 20 and 40 DAS.

Keywords: Plant growths, yield attributes, yields, weed control efficiency, weed index

Introduction
Soybean (*Glycine max* (L.) Merill) is a leguminous crop, belongs to family Fabaceae with sub family Faboideae. It is an important crop in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. It contains approximately 40-45% protein and 18-22% oil (Goyal *et al*., 2012) [3]. Planting density and geometry is an important determinant of crop yield and it plays important role in modulating crop growth and development related environmental factors. Soybean planting in rows facilated intercultural activity and helps to achieve greater yields (BARI, 2005) [1]. Crop geometry plays an important role in contributing the higher yield because thick plant population will not get proper light for photosynthesis and can easily attacked by disease, on the other hand very small population reduces the yield due to this reason nominal population is necessary for the higher yields. Weeds are the primary biotic factor causing low soybean yields. The simultaneous emergence and rapid growth of a large number of weed species causes weed competition in the field, resulting in crop yield reductions of 30 to 80 percent, depending on the type of weed flora and density (Kuruchania *et al*., 2000) [6]. Weeds are major threat in *kharif* season, which adversely affect the yield of soybean. The extent of yield reduction depends upon the density of weed species, crop varieties, weather conditions and fertility of the soil. Weed species infesting soybean vary according to the agro-ecosystem of the growing region. *Echinochloa colona*, *Phyllanthus niruri*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria* and *Alternanthera sessilis* are the major weeds in soybean.

Materials and Methods
The experiment was carried out at Instructional Farm of D.K.S. College of Agriculture and Research Station, Bhatapara situated at latitude of 21°43′ N, longitude of 81°59′ E and altitude of 273 m above mean sea level. The climate of Bhatapara region is sub-humid to semi-arid. The source of rainfall is south west monsoon. The average annual rainfall is 1326 mm (based on 80 year mean), of which mostly concentrated during the period from mid-June to September and very little during October to February. Soybean variety 'C.G. Soya-1' (Chhattisgarh soya-1) was grown as a test crop. Seed rate of 75 kg ha^{-1}. Recommended dose of nutrients was used 20:60:40 kg ha^{-1} N: P2O5: K2O applied through Urea, Single Super Phosphate and Muriate of potash. The treatments comprised of two main plot (Row spacing) *viz*., S_1- 30 cm and S_2-45 cm and five sub plot (Weed management practices) *viz*., W_1 – Weedy check, W_2-Weed free check, W_3 – Two hand weeding at 20 and 40 DAS, W_4

– Imazethapyr 35% + Imazamox 35%WG – @ 100 gm ha^{-1} (PoE) and W_5 - Fusiflex (fluazifop-p-butyl 11.1%EC) @ 1 liter ha^{-1} (PoE).

Results and Discussion

Plant height (cm)

The data on plant height of soybean as influenced by row spacing and different weed management practices (Table 1). At 30 and 60 DAS, there was no significant effect of row spacing. The plant height among the row spacing 30 cm x 10 cm spacing recorded the significantly highest at 90 DAS and at harvest were 64.63 and 64.15 cm respectively. It might be due to possible factors explaining increased plant height in higher plant densities due to reduced inter-row spacing influenced light quantity and quality. The stem section of plants that receive more light usually tends to slower elongation rate. These results are close conformity with the findings of Sevgi *et al.* (2007) [18] and Rahman *et al.* (2013) [16]. Among the weed management treatments weed free check treatment recorded significantly highest plant height at 30, 60, 90 DAS and at harvest were 23.20, 56.96, 68.21 and 67.46 cm respectively, but was at par with W_3 - Two hand weeding at 20 and 40 DAS and W_5 - Fluazifop-p-butyl 11.1% EC @ 1 liter ha^{-1} (PoE). This might be due to less crop-weed competition for light, nutrients and space in weed free environment. These results are close conformity with the findings of Prachand *et al.* (2014) [15].

Number of leaves plant^{-1}

The data revealed that the number of leaves plant^{-1} increased with the advancement of crop age up to 90 DAS (Table 1). At 30, 60 and 90 DAS, there was no significant effect of row spacing. Among the weed management treatments weed free check treatment recorded significantly highest number of leaves plant^{-1} of soybean at 30, 60 and 90 DAS (7.97, 17.77 and 24.33 respectively), but was at par with W_3 - Two hand weeding at 20 and 40 DAS. This might be due to higher plant density of crop might have competed weeds more vigorously and suppressed it similarly, more inter row spacing which enhanced availability of all resources like moisture, nutrients and light interception due to less crop weed competition which resulted in more photosynthesis and vigorous growth of soybean crop. These results were close conformity with the findings of Nainwal *et al.* (2010) [10] and Habimana *et al.* (2013) [4].

Number of branches plant^{-1}

Different treatment of herbicides showed significant impact on number of branches at all the stages of soybean (Table 1). At 30, 60 and 90 DAS, there was no significant effect of row spacing. Among the weed management treatments weed free check treatment recorded significantly highest number of branches plant^{-1}of soybean at 30, 60, 90 DAS and at harvest were 5.27, 8.50, 12.08 and 11.32 respectively, but was at par with W_3 - Two hand weeding at 20 and 40 DAS. This might be due to apply two hand weeding at 20 and 40 DAS controlled later emerged weeds ultimately resulted in less crop weed competition and favourably created congenial nutritional environmental might have increases metabolic processes in plants resulted in greater meristematic activities and apical growth and thereby improving branches formation and retention of higher number of leaves plant^{-1} which resulted in enhanced plant growth and number of branches. These results were close conformity with the findings of Nainwal *et al.* (2010) [10] and Habimana *et al.* (2013) [4].

Dry matter accumulation (g plant^{-1})

The dry matter plant^{-1} (g) of soybean with the row spacing 45 cm x 10 cm spacing recorded the significantly highest at 30, 60, 90 DAS and at harvest and were 7.25, 16.03, 30.06 and 35.05 (g), respectively. At 45 cm x 10 cm spacing, more dry matter plant^{-1} was recorded (Table 1). Among the weed management treatments weed free check treatment recorded significantly highest dry matter plant^{-1} of soybean at 30, 60, 90 DAS and at harvest which were 7.40, 17.70, 31.92 and 36.76 (g), respectively, but was at par with W_3 - Two hand weeding at 20 and 40 DAS. This is attributed to apply of hand weeding might have taken care of later emerged weeds resulted in less crop-weed competition for space, light and nutrients which resulted in vigorous growth of plant and ultimately increases the dry matter plant^{-1}. These results were close conformity with the findings of Prachand *et al.* (2014) [15].

Number of pods plant^{-1}

Soybean was observed the 45 cm x 10 cm spacing recorded significantly the highest number of pods plant^{-1} (48.11) as compared to 30 cm x 10 cm spacing (43.21) (Table 2). It could be due to the reason that wider rows had intercepted more light and enjoyed more space, therefore, had greater vegetative growth resulted in increased number of pods plant^{-1}. These results are close conformity with the findings of Mohammed *et al.* (1999) [8]. Among the weed management treatments weed free check treatment recorded significantly highest number of pods plant^{-1} (56.60) but was at par with treatments W_3 - Two hand weeding at 20 and 40 DAS. This might be due to less weed density and corresponding weed dry matter created less crop weed competition for light, space and nutrients, resultantly more pod setting was recorded. These results were close conformity with the findings of Malik *et al.* (2006) [7], Nainwal *et al.* (2010) [10] and Prachand *et al.* (2014) [15].

Number of seed pod^{-1}

In row spacing, number of seeds pod^{-1} at harvest, did not show significant difference (Table 2). Weed management practices, weed free check treatment gave the significantly highest number of seeds pod^{-1} (2.83), which was found comparable to hand weeding twice at 20 and 40 DAS (2.58).

100-seed weight (g)

Test weight of soybean seeds was influenced by row spacing and weed management practices. The data did not show significant difference by row spacing (Table 2). Weed management practices, significantly superior 100-seed weight was obtained under weed free check (11.50 g). The lowest 100-seed weight (10.50 g) was recorded under weedy check.

Seed yield (kg ha $^{-1}$)

Row spacing 45 cm x 10 cm recorded significantly the highest soybean seed yield (1850 kg ha^{-1}) as compared to 30 cm x 10 cm spacing (1532 kg ha^{-1}). The result suggested that, in wider spacing lowest weed competition due to suppression of weeds and more interception of sun light increased photosynthetic activities resulted in better utilization of nutrients, light, moisture and space was done by soybean crop for growth and

development which reflects its effect into reproductive growth of soybean crop in terms of yield (Table 2). Among the weed management treatments weed free check treatment recorded significantly highest soybean seed yield (2217 kg ha^{-1}) but was at par with treatments W_3 - two hand weeding at 20 DAS & 40 DAS (2050 kg ha^{-1}). This might be due to maximum availability of nutrients, moisture and light interception which favoured more photosynthesis resulted in luxurious growth of soybean. This ultimately resulted in higher seed yield. These results were close conformity with the findings of Sankaranarayan *et al.* (2002) [17], Habimana *et al*. (2013) [4], Monsefi *et al*. (2014) [9], Prachand *et al.* (2014) [15] and Panda *et al.* (2015) [12].

Stover yield (kg ha^{-1})

Row spacing 45 cm x 10 cm recorded significantly the highest soybean stover yield (2499 kg ha^{-1}) as compared to 30 cm x 10 cm spacing (2009 kg ha^{-1}) (Table 2). This was mainly due to the fact 45 cm x 10 cm spacing suppress the growth of weeds and reduced the crop weed competition for light, nutrients, space and moisture which resulted in luxurious growth of soybean crop and which ultimately resulted in maximum straw yield. These results were close conformity with the findings of Pandya *et al.* (2005) [13]. Among the weed management treatments weed free check treatment recorded significantly highest soybean stover yield (3068 kg ha^{-1}) but was at par with treatments W_3 - two hand weeding at 20 and 40 DAS (2797 kg ha^{-1}). This might be due less crop weed competition for light, nutrients, space and moisture which resulted in enhanced photosynthetic activities of soybean crop and which ultimately resulted in maximum stover yield. These results were close conformity with the findings of Sankaranarayan *et al.* (2002) [17], Habimana *et al*. (2013) [4], Peer *et al.* (2013) [14] and Prachand *et al.* (2014) [15].

Harvest index (%)

Non-significant affected by row spacing. Among the weed management treatments W_2 - Weed free check treatment recorded significantly highest harvest index (47.68%) but was at par with treatments W_4 - Imazethapyr 35% + Imazamox 35% WG @ 100 gm ha^{-1} (PoE). This might be due to fact that reduced weed density and weed dry matte resulted in diversion of more photosynthesis from source to sink. These results are close conformity with the findings of Habimana *et al.* (2013) [4].

Weed control efficiency (%)

Weed control efficiency was unaffected due to row spacing (Table 3). Among the weed management practices weed free check treatment recorded significantly highest weed control efficiency (100%) which was followed by the two hand weeding at 20 and 40 DAS (92.92, 90.53 and 91.67% at 30, 60 and 90 DAS) and W_5 - Fluazifop-p-butyl 11.1%EC @ 1 liter ha^{-1} (PoE) (61.93, 60.24 and 61.28% at 30, 60 and 90 DAS), the post emergence might have effectively controlled most of the emerged grassy and broadleaved weeds and thereby reduced its density, weed dry matter effectively and resulted in increased weed control efficiency. This could also be explained based on the fact that, maximum uptake and better assimilation of herbicide was pronounced as soon as weeds emerged. These results were in close conformity with the findings of Jadhav *et al*. (2013) [5] and Prachand *et al.* (2014) [15].

Weed index (%)

The maximum weed index was unaffected due to row spacing (Table 3). Among the weed management practices weed free check treatment recorded significantly minimum weed index (0.00%) which was followed by the two hand weeding at 20 and 40 DAS (7.06%) and W_5 - Fluazifop-p-butyl 11.1%EC @ 1 liter ha^{-1} (PoE) (23.71%). The weed index was influenced due to rate of application of herbicide. These results were in close conformity with the findings of Gowri Priya *et al.* (2009) [2] and Nainwal *et al.* (2010) [10].

Conclusion

Crop geometry of 45 cm x 10 cm spacing recorded significantly highest weed control efficiency (100%), weed index (0.00%). Similarly crop geometry of 45 cm x 10 cm spacing recorded significantly superior all the growth attributing characters. The yield attributing characters of soybean were significantly superior with crop geometry of 45 cm x 10 cm spacing than 30 cm x 10 cm spacing. Highest grain, straw and biological yield of soybean was observed with in the treatment combination of crop geometry 45 cm x 10 cm spacing with weed free check treatment combinations. However, it was at par with treatment combination of S2W3 (S2 - 45 cm x 10 cm with W3 - two hand weeding at 20 DAS and 40 DAS) and S2W5 (S2 - 45 cm x 10 cm spacing with W5 - fluazifop-p-butyl 11.1%EC @ 1 liter ha^{-1} (PoE).

Table 1: Row spacing and weed management practices on Plant height (cm), Number of branches^{-1} and Dry matter accumulation (g plant^{-1}) of soybean

Treatment	Plant height (cm)				Number of branches plant-1				Dry matter accumulation			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Row spacing												
S_1 - 30 cm	21.97	55.55	64.63	64.15	4.56	7.17	10.49	10.19	6.52	14.70	29.23	34.00
S_2 - 45 cm	21.85	51.86	58.63	58.01	4.85	7.47	10.50	10.32	7.25	16.03	30.06	35.05
SE(m) ±	0.37	0.68	0.74	0.80	0.17	0.27	0.34	0.22	0.11	0.08	0.04	0.06
CD (P=0.05)	NS	NS	4.53	4.90	NS	NS	NS	NS	0.70	0.48	0.27	0.37
Weed management practices												
W_1-Weedy check	21.07	49.43	55.99	55.55	4.10	6.43	9.02	9.55	6.20	12.98	27.52	32.39
W_2-Weed free check	23.20	56.96	68.21	67.46	5.27	8.50	12.08	11.32	7.40	17.70	31.92	36.76
W_3-Two hand weeding at 20 & 40 DAS	22.65	56.08	64.54	63.94	5.03	7.50	11.30	10.68	7.22	16.24	30.37	35.75
W_4-Imazethapyr 35% + Imazamox 35%WG – @ 100 gm ha^{-1} (PoE)	21.29	52.18	58.33	57.73	4.40	7.03	9.80	9.68	6.36	14.24	28.89	33.31
W_5-Fluazifop-p-butyl 11.1% EC @ 1 liter ha^{-1} (PoE)	21.33	53.89	61.08	60.73	4.73	7.13	10.28	10.05	7.26	15.66	29.53	34.42
S.E(m) ±	0.47	1.73	1.61	1.56	0.23	0.39	0.56	0.22	0.12	0.13	0.15	0.17
CD (P=0.05)	1.44	5.23	4.83	4.67	0.70	1.18	1.69	0.66	0.37	0.38	0.44	0.51

Table 2: Row spacing and weed management practices on number of Pods plant^{-1}, number of seed pod^{-1}, Seed index, Seed yield and Stover yield and Harvest index (%)

Treatment	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Row spacing						
S_1 - 30 cm	43.21	2.47	10.53	1532	2009	45.21
S_2 - 45 cm	48.11	2.33	10.27	1850	2499	44.81
SE(m) ±	0.41	0.12	0.33	28.96	69.36	0.38
CD (P=0.05)	2.48	NS	NS	176.2	422.02	NS
Weed management practices						
W_1-Weedy check	31.88	2.00	10.50	947.1	1405	46.41
W_2-Weed free check	56.60	2.83	11.50	2217	3068	47.68
W_3-Two hand weeding at 20 & 40 DAS	54.01	2.58	10.83	2050	2797	41.26
W_4-Imazethapyr 35% + Imazamox 35%WG – @ 100 gm ha^{-1}	37.35	2.33	9.17	1302	1804	46.59
W_5-Fluazifop-p-butyl 11.1%EC @ 1 liter ha^{-1} (PoE)	48.56	2.25	10.00	1939	2196	43.10
S.E(m) ±	1.17	0.16	0.50	58.51	95.23	1.40
CD (P=0.05)	3.51	0.70	1.49	175.40	285.5	4.19

Table 3: Row spacing and weed management practices on weed control efficiency (%) and weed index (%)

Treatment	Weed control efficiency			Weed index
	30 DAS	60 DAS	90 DAS	
Row spacing				
S_1 - 30 cm	57.43	58.30	58.93	31.07
S_2 - 45 cm	60.30	59.41	59.26	21.62
SE(m) ±	0.88	0.58	0.64	2.50
CD (P=0.05)	NS	NS	NS	NS
Weed management practices				
W_1-Weedy check	0.00	0.00	0.00	58.46
W_2-Weed free check	100.00	100.00	100.00	0.00
W_3-Two hand weeding at 20 & 40 DAS	92.92	90.53	91.67	7.06
W_4-Imazethapyr 35% + Imazamox 35%WG – @ 100 gm ha^{-1} (PoE)	39.49	43.52	42.54	42.50
W_5-Fluazifop-p-butyl 11.1%EC @ 1 liter ha^{-1} (PoE)	61.93	60.24	61.28	23.71
S.E(m) ±	1.73	1.13	1.30	2.59
CD (P=0.05)	5.20	3.40	3.89	7.76

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