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Growth and yield attributes as influenced by integrated weed management in soybean [*Glycine max* (L.) Merrill]

■ R.R. JAKHAR AND R. SHARMA

AUTHORS' INFO
Associated Co-author :
[1]Division of Agronomy, Indian Agricultural Research Institute, NEW DELHI (INDIA)

Author for correspondence:
R.R. JAKHAR
Division of Agronomy, Indian Agricultural Research Institute, NEW DELHI (INDIA)
Email : ruparamjakhar@gmail.com

ABSTRACT : A field experiment was conducted in alluvial loamy soil at Experimental Farm of Division of Agronomy, IARI, New Delhi during *Kharif* season of 2010. The experiment was laid out in Randomized Block Design and replicated thrice. The experiment consisted of twelve treatments of weed control measures (T_1- pendimethalin @ 1000 g/ha PE; T_2- pendimethalin @ 750 g/ha PE + 1 cono weeding at 30 DAS; T_3- diclosulam @ 18 g/ha PE; T_4- diclosulam @ 16 g/ha PE + 1 cono weeding at 30 DAS; T_5- diclosulam @ 22 g/ha PE; T_6- diclosulam @ 20 g/ha PE + 1 cono weeding at 30 DAS; T_7- diclosulam @ 26 g/ha; T_8- diclosulam @ 24 g/ha PE + 1 cono weeding at 30 DAS; T_9- imazethapyr @ 75 g/ha at 20 DAS; T_{10}- two cono weedings at 20 and 40 DAS; T_{11}- weedy-check; T_{12}- weed-free check). The result in treatment weed-free check significantly higher of CGR and plant population/m^2 were at harvest and remained at par with two cono weedings at 20 and 40 DAS (30-90 DAS). However, application of pendimethalin @ 1000 g/ha PE being significantly was higher and it remained at par with application of diclosulam @ 24 g/ha PE + 1 cono weeding 30 DAS (60-at harvest). The application of pendimethalin @ 1000 g/ha PE being significantly higher it remained at par with application of weedy check over the rest of treatments at 60-at harvest of RGR. The result in treatment weed-free check significantly higher harvest and remained at par with diclosulam @ 20 g/ha PE +1 cono weeding at 30 DAS and two cono weedings at 20 and 40 DAS (30-90 DAS) over other treatments. The application of pendimethalin @ 1000 g/ha PE in case of HI and remained at par with the application diclosulam @ 18 g/ha PE, diclosulam @ 22 g/ha PE, diclosulam @ 24 g/ha PE + 1 cono weeding at 30 DAS, imazethapyr @ 75 g/ha 20 DAS and weedy-check over rest of treatments. The treatment weed-free check was significantly higher in case of 1000-seed weight over the rest of treatments. They did not significantly affect the integrated weed management on RGR (30-60 DAS) and seed per pods. Season long weed free condition brought the higher increase in the yield attributes, seed yield and stover yield of soybean which was statistically similar with two cono weedings at 20 and 40 DAS and pre-emergence application of diclosulam @ 20 g/ha + 1 cono weeding at 30 DAS. Season long weed free situation recorded 76.96 per cent increase in grain yield as compared to season long weed competition. Herbicidal treatments provided a yield advantage of 54.44 to 74.53 per cent over weedy-check.

KEY **W**ORDS : CGR, Diclosulam, Imazethapyr, Pendimethalin, Pre-emergence, RGR, Soybean, Yield

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Soybean [*Glycine max* (L.) Merrill] is one of the most important rainy season oilseed crops. In India it is cultivated as rainy season crop on 8.88 M ha, producing 9.99 M t with average productivity of 1.12 t/ha (FAOSAT, 2008). Soybean plays an important role in solving problem of malnutrition as it contains about 20 per cent oil and 40 per cent high quality protein. Soybean protein is rich in valuable amino acid lycine (5%), in which, most of the cereals are deficient. It grows well in warm and moist climatic conditions. Amongst the major constraints in its cultivation, weed infestation is the most important one. Soybean is very sensitive to early weed competition. Weed infestation in soybean field may reduce yield by 19-33 per cent depending upon the intensity, nature and duration of weed competition (Mishra and Singh, 2003).

Annual grasses like *Echinochloa colona*, *Dactyloctenium aegyptium*, *Eleusine indica* and *Digitaria* spp. are the major problem in the soybean fields. *Celosia argentia* and *Trianthema monogyna* are the most important broad-leaved weeds. *Cyperus rotundus*, *Cynodon dactylon* and *Sorghum halepense* are important among perennial weeds. Effective and economical weed management in soybean on large scale is not possible through manual operations and use of mechanical means. Traditional methods of weed control cannot be performed in time due to uncertainty of rains, unworkable soil conditions and higher cost. Non-availability of labour further accentuates the weed problem. Under these situations, use of herbicides in this crop can be a viable and effective method of weed control (Idapuganti *et al.*, 2006). Continuous use of some herbicides like alachlor, fluchloralin and pendimethalin has resulted in weed shift in some areas in favour of non-grassy weeds like *Cleome viscosa*, *Celosia argentea* and *Trianthema monogyna*, which are highly competitive with soybean (Singh *et al.*, 2001). Sometimes continuous rains may also reduce the efficacy of recommended herbicides like pendimethalin and fluchloralin. Thus, there is need to have alternate herbicides possessing different mobility and leaching behaviour which may provide wide range of weed management to avoid weed shift and also possible development of herbicide-resistant weeds. Moreover, carryover effect of some of herbicides on succeeding crops limits their choice for successful weed management.

Recently diclosulam has been introduced for effective weed management in soybean against complex weed flora. Evaluation of the pre-emergence application of diclosulam at various doses coupled with cultural practices and post-emergence herbicides needs to be explored as cheap and quick method of weed management. Thus, keeping the above facts in view, the present investigation was carried out to know the effect of integrated weed management on growth and yield of soybean.

RESEARCH PROCEDURE

The experiment was conducted at Experimental Farm of Division of Agronomy, Indian Agricultural Research Institute, New Delhi situated at 28° 35'N latitude, 27° 12'E longitude and at an altitude of about 228.6 m above mean sea level. It has a semi-arid and sub-tropical climate characterized by hot summers and severe cold winter. The mean maximum temperature was 32.5^0 C while the mean minimum temperature was 23.6^0 C during crop growth. Crop received 713.8 mm precipitation in 34 rainy days. The soil of experimental field was sandy loam with pH 7.6, organic carbon 0.38 per cent (low), available P and K were 9.01 (low) and 259.4 (medium) kg/ha, respectively.

Twelve weed control treatments comprised of pendimethalin @ 1000 g/ha PE; pendimethalin @ 750 g/ha PE + 1 cono weeding at 30 DAS; diclosulam @ 18 g/ha PE; diclosulam @ 16 g/ha PE + 1 cono weeding at 30 DAS; diclosulam @ 22 g/ha PE; diclosulam @ 20 g/ha PE + 1 cono weeding at 30 DAS; diclosulam @ 26 g/ha; diclosulam @ 24 g/ha PE + 1 cono weeding at 30 DAS; imazethapyr @ 75 g/ha at 20 DAS; two cono weedings at 20 and 40 DAS; weedy-check; weed-free check were laid out in Randomized Block Design with three replications. A uniform dose of 20 kg N/ha in the form of urea, 60 kg P_2O_5/ha through SSP and 40 kg K/ha through MOP was applied. Half dose of N and full dose of P ad K was applied at the time of sowing while the remaining N was applied at 40 days after sowing. Soybean seed of variety 'Pusa 9702' was sown in line at a seed rate of 80 kg/ha using kera method of sowing at row spacing of 45 cm on July 14, 2010. Herbicides were applied with the help of a manually operated knapsack sprayer fitted with flat-fan nozzle at spray volume of 500 lit./ha. Post-emergence application of imazethapyr was done at 20 days after sowing as per the treatment. Data on weeds were recorded at 30, 60 and at 90 days after sowing in each plot in two quadrates having the size of 0.25 m^2 from two randomly selected points of individual plot.

Weeds were counted species-wise and were removed for recording their dry weight as well as total weed density and total dry weight at various observation stages and then converted in per square meter. Weed sample were sun dried before oven drying at 70° C until constant weight was attained. Weed data were subjected to square root $\sqrt{(X+0.5)}$ transformation before statistical analysis to normalise their distribution (Panse and Sukhatme, 1976). Data on yield and yield attributes were recorded at maturity by adopting the standard procedure. The crop was harvested on 28 October 2010.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Growth parameters :

Results revealed that CGR values were higher for period of 30 to 60 days as compared to 60 DAS to at harvest. At 30 to 60 days, the maximum CGR value (0.456 g/plant/day) was recorded in weed- free check which was statistically similar with the CGR values recorded in two cono weedings at 20 and 40 DAS and pre-emergence application of diclosulam @ 20 g/ha supplemented with one cono weeding at 30 DAS, while the CGR value at 60 days to at harvest was the higher with pre-emergence application of pendimethalin @ 1000 g/ha followed by diclosulam @ 24 g/ha + one cono weeding at 30 DAS. The higher rate of diclosulam is reported to delay the germination of soybean by 3-4 days and resulted in slight mortality of emerging seedlings which gradually recovered at later stages of crop growth (Nainwal *et al.*, 2010). However, the lower rates of diclosulam did not show any adverse effect on crop growth attributes right from beginning. The variation in the RGR values of soybean crop at 30 to 60 days was not found significant though the higher value was 0.027 g/g/day and the lower value was 0.022 g/g/day. But the variation in values of RGR at 60 days to harvest was found significant (Table 1). The maximum RGR value (0.0087 g/g/day) was recorded with pre-emergence application pendimethalin whereas minimum value (0.0048 g/g/day) was recorded in two cono weedings carried out at 20 and 40 DAS.

Yield attributes :

Results further indicated that significant variations in the value of plant population per meter square, pods per plant, number of seeds per pod and test weight were recorded due to different weed control measures (Table 2). Maximum plant population was observed in weed-free environment closely followed by two cono weedings at 20 and 40 DAS. In herbicidal treatments, the higher plant population was recorded with diclosulam 20 g/ha + one cono weeding at 30 DAS which was statistically at par with other integrated weed management treatments except diclosulam @ 24 g/ha + one cono weeding at 30 DAS. The lower population per meter square was

Table 1 : Crop growth rate (g/plant/day) and relative growth rate (g/g/day) at different growth stages in soybean as influenced by weed management

Treatments	CGR		RGR	
	30-60 DAS	60-at harvest	30-60 DAS	60-at harvest
Pendimethalin @ 1000 g/ha PE	0.269	0.320	0.022	0.0087
Pendimethalin @ 750 g/ha PE + 1 cono weeding 30 DAS	0.366	0.261	0.026	0.0064
Diclosulam @ 18 g/ha PE	0.297	0.249	0.023	0.0069
Diclosulam @ 16 g/ha PE + 1 cono weeding 30 DAS	0.392	0.250	0.027	0.0059
Diclosulam @ 22 g/ha PE	0.362	0.264	0.027	0.0065
Diclosulam @ 20 g/ha PE +1 cono weeding 30 DAS	0.397	0.249	0.026	0.0058
Diclosulam @ 26 g/ha PE	0.296	0.239	0.027	0.0070
Diclosulam @ 24 g/ha PE + 1 cono weeding 30 DAS	0.303	0.273	0.026	0.0074
Imazethapyr @ 75 g/ha 20 DAS	0.316	0.240	0.026	0.0066
Two cono weedings at 20 and 40 DAS	0.448	0.223	0.027	0.0048
Weedy-check	0.141	0.150	0.025	0.0083
Weed-free check	0.456	0.234	0.026	0.0049
S.E.±	0.016	0.017	0.002	0.0004
LSD (P=0.05)	0.48	0.049	NS	0.0012

PE= Pre-emergence DAS = Days after sowing NS=Non-significant

recorded under weedy-check which was statistically similar with pre-emergence application of diclosulam @ 26 g/ha. Weed-free check, two cono weedings at 20 and 40 DAS and pre-emergence application of diclosulam @ 20 g/ha + one cono weeding at 30 DAS were at par in term of number of pods per plant. Among the herbicidal treatment, pre-emergence application of diclosulam @ 20 g/ha + one cono weeding at 30 DAS recorded significantly higher increase in number of pods per plant which however, was at par with all other integrated weed management treatment except diclosulam @ 24 g/ha + one cono weeding at 30 DAS. The lower number of pods were recorded in those plots which were treated with the diclosulam @ 26 g/ha and diclosulam @ 24 g/ha + one cono weeding at 30 DAS. Number of seeds per pod was not affected due to variation in weed control treatments. In herbicidal treatments, pre-emergence application of diclosulam @ 20 g/ha + one cono weeding at 30 DAS achieved the higher 1000 seed weight but it was at par with two cono weedings at 20 and 40 DAS and other integrated weed management measures except diclosulam @ 24 /ha + one cono weeding at 30 DAS. These results are also in close agreement with those also obtained by Vyas and Kushwaha (2008). This might be due to less competition, leading to better establishment of plant and their growth and resulted in overall increment in yield contributing characters. Among herbicides, pre-emergence application of diclosulam @ 20 g/ha integrated

Table 2 : Yield attributes of soybean as affected by weed control measures

Treatments	Plant population/m^2 at harvest	Pods /plant	Seeds/pod	1000-seed weight(g)
Pendimethalin @ 1000 g/ha PE	24.8	38.9	2.1	125.00
Pendimethalin @ 750 g/ha PE + 1 cono weeding 30 DAS	30.8	45.2	2.2	127.20
Diclosulam @ 18 g/ha PE	26.0	38.0	2.1	124.90
Diclosulam @ 16 g/ha PE + 1 cono weeding 30 DAS	31.2	45.0	2.2	127.50
Diclosulam @ 22 g/ha PE	25.8	40.0	2.0	124.40
Diclosulam @ 20 g/ha PE +1 cono weeding 30 DAS	32.6	47.9	2.2	128.40
Diclosulam @ 26 g/ha PE	23.6	29.0	2.0	121.10
Diclosulam @ 24 g/ha PE + 1 cono weeding 30 DAS	24.0	32.1	2.0	122.00
Imazethapyr @ 75 g/ha 20 DAS	27.8	40.1	2.0	125.00
Two cono weedings at 20 and 40 DAS	33.6	48.6	2.3	128.70
Weedy-check	22.0	25.9	2.0	115.80
Weed-free check	34.8	50.3	2.4	131.60
S.E.±	0.66	1.02	0.14	0.78
LSD(P=0.05)	1.96	2.98	NS	2.29

PE= Pre-emergence DAS = Days after sowing NS=Non-significant

Table 3 : Seed yield, stover yield, biological yield and harvest index of soybean as affected by weed control measures

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	HI
Pendimethalin @ 1000 g/ha PE	1.08	1.75	2.83	0.382
Pendimethalin @ 75 g/ha PE + 1 cono weeding 30 DAS	1.43	2.79	4.22	0.339
Diclosulam @ 18 g/ha PE	1.08	1.85	2.93	0.369
Diclosulam @ 16 g/ha PE + 1 cono weeding 30 DAS	1.53	2.78	4.31	0.355
Diclosulam @ 22 g/ha PE	1.14	1.90	3.04	0.375
Diclosulam @ 20 g/ha PE +1 cono weeding 30 DAS	1.61	2.99	4.60	0.350
Diclosulam @ 26 g/ha PE	0.90	1.65	2.55	0.353
Diclosulam @ 24 g/ha PE + 1 cono weeding 30 DAS	1.02	1.70	2.72	0.375
Imazethapyr @ 75 g/ha 20 DAS	1.16	1.90	3.06	0.379
Two cono weedings at 20 and 40 DAS	1.65	3.00	4.65	0.355
Weedy-check	0.41	0.71	1.12	0.366
Weed-free check	1.78	3.20	4.98	0.357
S.E.±	0.040	0.033	0.052	0.006
LSD(P=0.05)	0.120	0.096	0.153	0.016

PE= Pre-emergence DAS = Days after sown

with one cono weeding at 30 DAS gave the higher values for most of yield attributes, being at par to other integrated treatments.

Yield :

All weed control measures resulted in marked changes in seed, stover and biological yield, and their effect was found significantly superior over weedy-check (Table 3). Amongst herbicidal treatments, pre-emergence application of diclosulam @ 20 g/ha + one cono weeding at 30 DAS brought the higher increase in seed yield but it was found at par with two cono weedings at 20 and 40 DAS, diclosulam @ 16 g/ha + one cono weeding at 30 DAS and pendimethalin @ 750 g + one cono weeding at 30 DAS. However, the lower seed yield (0.41 t/ha) was recorded with the higher dose of diclosulam @ 26 g/ha closely followed by diclosulam @ 24 g/ha + one cono weeding at 30 DAS (1.02 t/ha). The application of diclosulam @ 20 g/ha + one cono weeding at 30 DAS resulted in the higher increase in stover yield (2.99 t/ha) which however, was at par with two cono weedings at 20 and 40 DAS and with all integrated weed management treatments except diclosulam @ 24 g/ha + one cono weeding at 30 DAS. The better performance of these treatments in term of seed and stover yield could be attributed to better expression of their yield attributes due to reduction in crop-weed competition as an evidenced by higher weed control efficiency and lower weed index. This could be attributed to their selectivity to crop and significant reduction in the weed growth (Nainwal *et al.*, 2010). The maximum biological yield of 4.98 t/ha was recorded in weed free treatment which, however, was found statistically at par with two cono weedings carried out at 20 and 40 DAS and diclosulam @ 20 g/ha + one cono weeding at 30 DAS. However, the lower biological yield was recorded in weedy-check plot (1.12 t/ha). Among all the treatments, diclosulam @ 20 g/ha + one cono weeding at 30 DAS recorded the higher biological yield (4.60 t/ha) amongst the herbicidal treatments. This treatment remained statistically similar to diclosulam @ 16 g/ha + one cono weeding at 30 DAS and pendimethalin @ 750 g/ha + one cono weeding at 30 DAS. Significantly less increase in the biological yield of soybean was recorded with diclosulam @ 26 g/ha and closely followed by diclosulam @ 24 g/ha + one cono weeding at 30 DAS which, however was found statistically superior over weedy-check. Significantly higher value of harvest index was recorded in pre-emergence application of pendimethalin @ 1000 g/ha. The better performance of these treatments might be attributed to better weed control through pre-emergence application of diclosulam since early stages of crop which was supplemented with one cono weeding for less weed competition in later stages of crop growth. These results are also in close agreement with those also obtained by Vyas and Kushwaha (2008).

Conclusion :

Weed-free treatment recorded the higher increase in seed and stover yield of soybean, followed by two cono weedings at 20 and 40 DAS. Pre-emergence application of diclosulam @ 26 g/ha and diclosulam @ 24 g/ha integrated with one cono weeding at 30 DAS showed phytotoxicity to soybean in early stages of crop growth. Among herbicides, pre-emergence application of diclosulam @ 20 g/ha integrated with one cono weeding at 30 DAS was found most effective in reducing weed growth and augmenting seed and stover yield which subsequently resulted in attaining the highest biological yield.

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