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Weed management in soybean with broad spectrum herbicides

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Abstract
A field experiment was conducted to study the bio-efficacy of broad spectrum herbicides and their effect on productivity of soybean during *kharif* season of the year- 2017. Application of imazethapyr + pendimethalin (RM) 1000 g/ha PRE (RM) was found to be more efficient to control monocot and dicot weeds in soybean which recorded lowest weed density, dry matter and weed index. It also found superior in respect of various growth and yield attributes. Highest seed yield (1730 kg/ha) and straw yield of soybean and maximum net return (Rs. 41427/-) was also recorded in imazethapyr + pendimethalin (RM) 1000 g/ha PRE (RM) with highest B:C ratio of 1.89. It was also found responsible for highest uptake of N, P and K by soybean crop and lowest uptake of these plant nutrients by weed plants.

Keywords: Weed management, soybean, broad spectrum herbicides

Introduction
Soybean (*Glycine max*), is an important oil-yielding rainy-season (*kharif*) crop having multiple uses. Losses due to weeds have been regarded as one of the major limiting factors in soybean production. The competition between weeds and crop for the nutrients, water, light and space are responsible for poor yield of soybean. The grain yield reduction due to the weed infestation in soybean may be up to 31- 84% (Kachroo *et al.* 2003). Most of the yield reduction due to weed competition occurs during the first six weeks after planting; therefore, major emphasis on control should be given during this period. Good soybean weed control involves utilizing all methods available and combining them in an integrated weed management system, but considering the present day labour scarcity and their higher wages for cultural and mechanical weed control, the economics and feasibility of soybean cultivation is quiet disturbed. Hence the emphasis should be given to adapt the chemical methods of weed control to solve the problem of minimum available labour and their high cost. Therefore, the present investigation is carried out to assess the efficacy of different herbicide when applied alone or in combination with other herbicides to provide weed free environment during entire growing period of soybean through easy, efficient and economically viable weed management practices.

Materials and Methods
A field experiment was carried out at Instructional farm of Rajasthan College of Agriculture, Udaipur during *Kharif*, 2017 at which is situated at $24^0$35' N latitude and $74^0$42' E longitude. The region falls under the agro climatic zone IVa of Rajasthan i.e. Sub-humid Southern Plain and Aravali Hills of Rajasthan in randomized block design with eight treatments replicated thrice. Treatments consisting of nine treatment combinations i.e weedy check, imazethapyr 100 g/ha PoE 15 DAS, pendimethalin 1000 g/ha PE, quizalofop-ethyl 75 g/ha PoE 15 DAS, propaquizafop 100 g/ha PoE 15 DAS, imazethapyr + imazamox (RM) 70 g/ha PoE 15 DAS,imazethapyr + pendimethalin (RM) 1000 g/ha PE, imazethapyr 75 g/ha PoE + quizalofop-ethyl 60 g/ha PoE 21 DAS (TM) and imazethapyr 75 g/ ha + propaquizafop 75 g/ha PoE 21 DAS (TM). A knapsack sprayer fitted with a flat fan nozzle was used for herbicide application. Total rainfall received during crop growing season was 648.0 mm. The soil of the experimental site was low in available nitrogen, medium in organic carbon and phosphorus and high in available potassium. Soybean variety RKS-24 (Pratap Raj 24) was sown at 30 x 10 com spacing on 4 July, 2017. Protective irrigations were given to crop whenever dry spells appeared during the crop growth. Other plant protection practices for disease and pest

control were also applied in similar manner for all the treatments.

Weed control efficiency was calculated using the following formula (Mani *et al.*, 1968) [10].

$$WCE\ (\%) = \frac{\text{Dry weight of weeds in unweeded control} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in unweeded control}} \times 100$$

The crop was harvested at physiological maturity when plants turned golden yellow. After winnowing and cleaning was done and seeds were weighed separately to record seed yield and al the yield attributing parameters.

Results and Discussion

Effect on weeds

Imazethapyr + pendimethalin was found the most effective in order to reduce the density and dry matter of all categories of weeds at all stages compared to other treatments. The data of total weed density and dry matter at all successive stages indicated overall superiority of imazethapyr + pendimethalin followed by imazethapyr + propaquizafop.

The total weed population of 114.12/m^2 recorded in weedy check plot at 30 DAS attaining its maximum value of 135.68/m^2 at 60 DAS. Similarly, total weeds dry matter of 68.47 g/m^2 and 81.41 g/m^2 was recorded at 30 and 60 DAS, respectively (Table 1). The profound increase in population and dry matter of weeds to such an extreme level under weedy check might be attributed to uninterrupted growth of weeds throughout the crop season coupled with slow growing nature of soybean during its initial stage and short stature of plants that was completely smothered by accelerated growth of weeds. Heavy weed infestation and dry weight under weedy check have also been reported by Bodake *et al*., (2012) [1]. Among all the herbicidal treatments imazethapyr + pendimethalin recorded the highest weed control efficiency (91.87 and 91.89 %) followed by imazethapyr + propaquizafop (Table 1). The herbicide combination of imazethapyr + pendimethalin were more effective and had activity on a wide spectrum of weeds including grasses and broadleaf weeds in soybean thus their performance is directly proportional to the weed control efficiency. The higher weed control efficiency under these treatments could be attributed to the lower weed population and total weed dry matter as well. Imazethapyr an important herbicide is identified in reducing broad-leaved weeds and it belongs to imidazolinone group of herbicides. The ALS inhibitors thus, stop cell division and reduce carbohydrate translocation in the susceptible plants. Saltoni *et al*., (2004) [16] have suggested that imazethapyr absorbed both by the roots and the shoot. Pendimethalin has also a role to play in microtubal disruption and stops mitosis because it blocks synthesis of proteins, nucleic acid or any other requisites for mitosis (Devine *et al*., 1993). The superiority of pendimethalin over other herbicide could be ascribed to be due to the fact that pendimethalin is less susceptible to degradation in soil system (Eshel *et al.* 1979) [7] and it appears that the efficacy of this herbicide in suppressing the weed growth could be continuous for a longer time during crop growth period. Accordingly, its half life in soil has been assessed between 42-54 days (Zimdahl *et al*., 1984) [21].

Effect on crop

Application of imazethapyr + pendimethalin recorded the maximum plant height at harvest. The correlation studies further substantiate positive correlationship between seed & haulm yield and plant height (r= 0.764** & r=0.845**), respectively. Greater accumulation of plant dry matter at each successive stage *viz.*30, 60 DAS and at harvest was observed under different weed control treatments compared to weedy check. In a potential situation where light, temperature, physiological and morphological characters determine the growth of the plant community, crops only compete for light (Kropff, 1993) [8]. The increase in dry matter yield of soybean with these treatments was due to significant reduction in dry matter yield of weed. In weedy condition crop plants have to compete for solar radiation in addition to nutrients. Consequently, it resulted in better plant growth. The results corroborate with the findings of Balyan *et al.* (2016) [2].

Highest yield attributing characters *viz.*, number of pods/plant, number of seeds /pod, pod length, and 1000-seed weight (32.10, 2.46, 4.99 cm and 85.10 g, respectively) were recorded under imazethapyr + pendimetalin as well as seed, haulm and biological yield of 1730, 2182 and 3912 kg/ha, respectively, which was significantly superior over other weed control treatments (Table 2). These weed management practices reduced the weed infestation and create condition more favourable for crop. Verma, *et al*. (2017) [20] also reported similar results. It is established fact that least crop weed competition during the early phase of crop growth exerts an important regulatory function on complex process of yield formation due to better availability of water, space and nutrient to the crop plant. It also helps in improving aeration and nutrient uptake by plant resulting in higher metabolic activity. The better expression of yield attributes in herbicide and manually weeded plots might be due to poor resurgence frequency and growth of weeds in these treatments. Hence, weeds were unable to compete with the crop plants for different growth factors. Improvement in yield attributes occurred when weeds were controlled in the early growth stages particularly during critical growth period either manually or chemically, which scaled down competition and created congenial micro-environment for better establishment and growth of the crop. Under present investigation existence of high positive correlation between number of pods plant, number of seeds per pod and test weight (r= 0.943**, r= 0.871** and r= 0.971**) on seed yield, also validate the aforesaid statement. Similarly, total weed dry matter at 60 DAS was also negatively correlated with seed yield (r= -0.905**).

Table 1: Effect of herbicides on total weed density, weed dry matter and weed control efficiency

Treatments	Total weed density (No./m^2)		Weed dry matter (g/m^2)		Weed control efficiency (%)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Imazethapyr 100 g/ha PoE at 15 DAS	4.67 (21.40)	5.15 (26.02)	12.84	15.61	81.25	80.81
Pendimethalin 1000 g/ha PRE	4.89 (23.53)	5.33 (27.93)	14.12	16.76	79.40	79.39
Quizalofop-ethyl 75 g/ha PoE at 15 DAS	7.90 (61.92)	8.65 (74.32)	37.58	44.63	45.12	45.14
Propaquizafop 100 g/ha PoE at 15 DAS	7.89 (61.72)	8.54 (72.42)	37.14	44.13	45.77	45.77
Imazethapyr + imazamox (RM) 70 g/ha PoE at 15 DAS	5.76 (32.71)	6.28 (38.88)	19.62	23.33	71.35	71.31

Imazethapyr + pendimethalin (RM) 1000 g/ha PRE	3.13 (9.28)	3.39 (10.98)	5.57	6.59	91.87	91.89
Imazethapyr 75 g/ha PoE + quizalofop 60 g/ha (TM) PoE at 21 DAS	5.59 (30.79)	6.09 (36.57)	18.47	21.94	73.02	73.01
Imazethapyr 75 g/ ha + propaquizafop 75 g/ha (TM) PoE at 21 DAS	3.90 (14.73)	4.02 (15.69)	8.84	9.42	87.09	88.42
Weedy check	10.71(114.12)	11.67 (35.68)	68.47	81.41	0.00	0.00
SEm±	0.11	0.07	0.73	0.90	-	-
CD (P=0.05)	0.34	0.22	2.20	2.69	-	-

Table 2: Effect of herbicides on plant height and dry matter accumulation of soybean

Treatments	Plant height (cm)		Dry matter accumulation (g/plant)		
	30 DAS	At harvest	30 DAS	60 DAS	At harvest
Imazethapyr 100 g/ha PoE at 15 DAS	21.73	45.93	4.56	25.26	53.85
Pendimethalin 1000 g/ha PRE	21.67	44.93	4.40	24.62	52.08
Quizalofop-ethyl 75 g/ha PoE at 15 DAS	20.45	42.27	3.60	21.21	49.49
Propaquizafop 100 g/ha PoE at 15 DAS	20.46	44.27	3.74	21.94	50.08
Imazethapyr + imazamox (RM) 70 g/ha PoE at 15 DAS	21.50	44.50	4.05	22.60	51.71
Imazethapyr + pendimethalin (RM) 1000 g/ha PRE	22.90	47.67	5.19	27.62	58.78
Imazethapyr 75 g/ha PoE + quizalofop 60 g/ha (TM) PoE at 21 DAS	21.38	44.67	4.19	23.92	52.01
Imazethapyr 75 g/ ha + propaquizafop 75 g/ha (TM) PoE at 21 DAS	21.75	46.40	4.73	26.25	56.00
Weedy check	18.71	40.20	3.48	20.04	34.63
SEm±	0.35	0.27	0.14	0.32	0.87
CD (P=0.05)	1.05	0.81	0.42	0.95	2.60

Table 3: Effect of herbicides on yield and economics of soybean

Treatments	Yield (kg/ha)			Net returns (₹ /ha)	B C ratio
	Seed	Haulm	Biological		
Imazethapyr 100 g/ha PoE at 15 DAS	1564	1874	3438	35193	1.62
Pendimethalin 1000 g/ha PRE	1518	1755	3273	33574	1.56
Quizalofop-ethyl 75 g/ha PoE at 15 DAS	1348	1692	3040	27729	1.28
Propaquizafop 100 g/ha PoE at 15 DAS	1396	1703	3099	30439	1.49
Imazethapyr + imazamox (RM) 70 g/ha PoE at 15 DAS	1438	1709	3147	30844	1.44
Imazethapyr + pendimethalin (RM) 1000 g/ha PRE	1730	2182	3912	41427	1.89
Imazethapyr 75 g/ha PoE + quizalofop 60 g/ha (TM) PoE at 21 DAS	1458	1732	3190	30459	1.35
Imazethapyr 75 g/ ha + propaquizafop 75 g/ha (TM) PoE at 21 DAS	1612	1949	3560	37069	1.71
Weedy check	631	846	1477	3242	0.16
SEm±	38.94	56.58	72.44	-	-
CD (P=0.05)	116.74	169.61	217.17	-	-

Conclusion

It is concluded that imazethapyr + pendimethalin (RM) 1000 g/ha PRE (RM) recorded the highest seed yield (1730 kg/ha). This treatment also recorded the maximum net return (₹ 41427) as well as BC ratio (1.89) compared to rest of the treatments. Application of imazethapyr + pendimethalin (RM) can be an effective weed control option in soybean crop with higher seed and haulm yield under rainfed agroecosystem in semi-arid and arid region of Rajasthan.

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