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Soybean yield and economics as influenced by weed management practices and its carryover effect on follow up crops

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Abstract
An experiment was conducted at AICRP on Weed Management Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during two consecutive *Kharif* season of the year 2017-18 and 2018-19 on loamy sand soil. Results indicated that maximum seed yield (2.73 t/ha) and gross realization of Rs. 90145/ha was achieved under IC *fb* HW at 20 and 40 DAS while net realization of Rs. 51212/ha and BC ratio of 2.51 was recorded under application of propaquizafop + imazethapyr 125 g/ha PoE (PM) closely followed by imazethapyr 100 g/ha PoE *fb* IC +HW at 30 DAS and fluazifop-p-butyl + fomesafen 250 g/ha PoE (PM). The plant stand, plant height and dry matter production of wheat, chickpea and mustard were not affected by the application of different herbicides in preceding soybean.

Keywords: Herbicide, new molecules, yield, follow up

Introduction
Soybean [*Glycine max* (L.) Merill] is become the miracle crop of 21st century. It has very high potential among seed legume crops for combating acute problem of malnutrition. Soybean is also a good source of dietary fibre, calcium, magnesium, phosphate, thiamine, riboflavin, niacin, etc. Looking to the important source of food, protein and oil, more research is essential to increase its yield under different conditions, including stress. Both at national and state level the low productivity of soybean is attributed mainly due to biotic and abiotic stresses *viz*., weeds, insect-pests and disease. Among all these factors, weeds are important biotic constraints reducing yield of soybean. The initial growth of soybean is slow and crop face severe competition with weed. The first 30 days after sowing of soybean is considered to be critical with respect to weed-crop competition. Heavy infestation of weeds leads to reduction in yield and quality also affected adversely. Panneerselvam and Lourduraj (2000) [6] concluded that critical period of crop weed competition in soybean is reported to be first 45 DAS. Sandil *et al.* (2015) [8] reported that weeds alone are responsible for reduction in seed yield of soybean to the extent of 25 to 70% depending upon the weed flora and intensity. The herbicides presently available are either pre-emergence (PE) or pre-plant incorporated (PPI) have a narrow spectrum weed control. Herbicide combination offer wide spectrum control of weeds and also increased the yield attributes, yield and economics. Upadhyay *et al.* (2012) [10] reported that yield and B:C ratio were found superior under application of imazethapyr + imazamox + adjuvant (87.5 g + 1000 ml/ha) than other treatment. As a consequence of herbicide use, the presence of residues in field may cause damage to succeeding crop. Herbicides residues also remain on the soil surface due to the adsorption process which may potentially affect quality and yield of succeeding crop cultivated on the same field. Hence, present investigation was conducted to study the soybean yield and economics as influenced by weed management practices and its carryover effect on follow up crops.

Materials and Methods
The present investigation was planned and undertaken with the objectives framed out to study the soybean yield and economics as influenced by weed management practices and its carryover effect on follow up crops during two consecutive *Kharif* season of the year 2017-18 and 2018-19 at AICRP-Weed Management, B.A. College of Agriculture, Anand Agricultural

University, Anand (Gujarat). The soil of the experimental field was loamy sand in texture having low in available nitrogen and medium in available phosphorus and high in potassium with pH 8.0. The experiment was laid out in a randomized lock design with three replications. Twelve treatment *viz.*,T_1: Pendimethalin 750 g/ha PE *fb* IC+HW at 30 DAS, T_2: Clomazone 1000 g/ha PE *fb* IC+ HW at 30 DAS, T_3: Diclosulam 25.2 g/ha PE *fb* IC+HW at 30 DAS, T_4: Pendimethalin + imazethapyr 960 g/ha PE (PM) *fb* HW at 30 DAS, T_5: Quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS, T_6: Imazethapyr 100 g/ha PoE *fb* IC+HW at 30 DAS, T_7: Imazethapyr + imazamox 70 g/ha PoE (PM), T_8: Propaquizafop + imazethapyr 125 g/ha PoE (PM), T_9: Sodium acifluorfen + clodinafop propargyl 245 g/ha PoE (PM), T_{10}: Fluazifop-p-butyl + fomesafen 250 g/ha 250 g/ha (PM), T_{11}: IC *fb* HW at 20 & 40 DAS and T_{12}: Weedy check were included in the experiment. Soybean variety NRC 37 was selected and sown in the experimental field on 12 and 03 July 2017 and 2018, respectively keeping the row to row distance of 45 cm. Recommended dose of fertilizer *i.e.* 30 kg N/ha and 60 kg P_2O_5/ha were applied wherein, entire quantity of nitrogen and phosphorous were applied as basal dose in the form of urea and single super phosphate at the time of sowing directly in the furrow. As per the treatments, herbicides were applied with the help of a Knapsack sprayer fitted with flat fan nozzle with a spray volume of 500 l/ha. Other mechanical operation was also imposed as per the treatment. The other recommended packages of practices were followed throughout the growing season to raise the crop during both the years of investigation. Observation on growth and yield attributes were recorded from the previously randomly selected plants from net plot area. Whereas, seed and haulm yield of soybean was recorded from the net plot area and converted in to hectare. To know the residual effect of applied herbicides in soybean on succeeding *rabi* crops *viz.*, wheat, chickpea and mustard were grown keeping layout as such by adopting recommended package of practices. Observations on crop growth parameters (Plant stand/m row length at 15 DAS, plant height and dry matter accumulation of plant at 30 DAS) and phytotoxicity (up to 30 DAS) were recorded. Data on various parameters recorded during the course of investigation was statistically analyzed as per the standard procedure suggested by Cochran and Cox (1957) [2].

Results and Discussion

Effect on yield

Yield of crop is an important parameter, which decides the superiority or stability of a particular management practices over other treatments. Pooled results presented in Table 1 indicated that among herbicidal treatments, significantly higher seed and haulm yield (2.68 and 3.46 t/ha, respectively) was recorded under application of imazethapyr 100 g/ha PoE *fb* IC+HW at 30 DAS but it was at par with diclosulam 25.2 g/ha PE *fb* IC+HW at 30 DAS, pendimethalin + imazethapyr 960 g/ha PE (PM) *fb* HW at 30 DAS and propaquizafop + imazethapyr 125 g/ha PoE (PM). Results corroborate with the finding Bagotiya *et al*. (2018) [1]. Among mechanical treatment, IC *fb* HW at 20 and 40 DAS recorded higher seed and haulm yield but statistical differences was not observed except imazethapyr + imazamox 70 g/ha PoE (PM), sodium acifluorfen + clodinafop propargyl 245 g/ha PoE (PM) and weedy check. The increase in yield under these treatments could be attributed to reduction in density and weed dry matter, which accounted for reduction in crop weed competition which provided congenial environment to the crop for better reproductive potential. Parmar *et al*. (2016) and Singh *et al*. (2016) [7, 9] also reported that twice hand weeding treatment recorded maximum seed yield of soybean than other treatments. Further, effectiveness of pendimethalin + imazethapyr may be due to pendimethalin prevented emergence of monocot and grassy weeds by inhibiting root and shoot growth while imazethpyr was responsible for inhibition of acetolactate synthases (ALS) or acetohydroxyacide synthesis (AHAS) in broad-leaves which caused destruction of weeds in 3-4 leaf stage and later germinated weeds was control by manual weeding. Further, it was observed that pre-emergence application of pre-mix herbicides provide higher yield as compared to post emergence application. Similarly, Meena *et al*. (2018) [5] also observed that application of pendimethalin 30% EC + imazethapyr 2% SL premix 960 g/ha as PE recorded higher seed yield of soybean but it was at par with other herbicidal treatments. Among herbicidal treatment, significantly lower seed and haulm yield (1.96 and 2.38 t/ha, respectively) was recorded under application of sodium acifluorfen + clodinafop propargyl 245 g/ha PoE (PM) but was remain at par with quizalofop-ethyl 50 g/ha PoE *fb* IC +HW at 30 DAS and imazethapyr + imazamox 70 g/ha PoE (PM). Weedy check registered significantly the lowest seed and haulm yield (0.343 and 0.557 t/ha, respectively) of soybean.

Economics

Data on economics of the different treatment presented in Table 1 further indicated that maximum gross realization of Rs. 90145 and 88660/ha was achieved under IC *fb* HW at 20 and 40 DAS and imazethapyr 100 g/ha *fb* IC +HW at 30 DAS, respectively. Whereas, maximum net realization of Rs. 51212/ha and benefit cost ratio of 2.51 was recorded under propaquizafop + imazethapyr 125 g/ha PoE (PM) closely followed by imazethapyr 100 g/ha PoE *fb* IC +HW at 30 DAS and fluazifop-p-butyl + fomesafen 250 g/ha PoE (PM) which recorded net realization and benefit cost ratio of Rs.51142 and 49037/ha and 2.36 and 2.46, respectively. The higher net returns due to low investment under combined application of herbicides coupled with good yield might be the reason for higher net monetary return and Benefit Cost ratio than other treatments. Similarly, Bagotiya *et al*. (2018) [1] also recorded higher net return (Rs. 41478/ha with post emergence application of imazethapyr 75 g/ha + propaquizafop 60 g/ha in soybean.

Table 1: Yield and economics of soybean as influenced by integrated weed management in soybean (Mean of two years)

Treatment	Seed yield (t/ha)	Haulm yield (t/ha)	Gross return (₹/ha)	Additional cost over control (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	B:C
T_1: Pendimethalin 750 g/ha PE *fb* IC+HW at 30 DAS	2.58^{ab}	3.27^{a}	85230	5495	37373	47857	2.28
T_2: Clomazone 1000 g/ha PE *fb* IC+ HW at 30 DAS	2.63^{ab}	3.34^{a}	86895	6910	38788	48107	2.24
T_3: Diclosulam 25.2 g/ha PE *fb* IC+HW at 30 DAS	2.62^{ab}	3.26^{a}	86430	5591	37469	48961	2.31
T_4: Pendimethalin + imazethapyr 960 g/ha PE (PM) *fb* HW at 30 DAS	2.66^{a}	3.39^{a}	87910	5768	38626	49284	2.28
T_5: Quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS	2.36^{abc}	2.90^{ab}	77780	6022	37900	39880	2.05
T_6: Imazethapyr 100 g/ha PoE *fb* IC+HW at 30 DAS	2.68^{a}	3.46^{a}	88660	5640	37518	51142	2.36
T_7: Imazethapyr + imazamox 70 g/ha PoE (PM)	2.16^{bc}	2.76^{ab}	71400	2470	33548	37852	2.13
T_8: Propaquizafop + imazethapyr 125 g/ha PoE (PM)	2.58^{ab}	3.25^{a}	85190	2900	33978	51212	2.51
T_9: Sodium acifluorfen + clodinafop propargyl 245 g/ha PoE (PM)	1.96^{c}	2.38^{b}	64540	2750	33828	30712	1.91
T_{10}: Fluazifop-p-butyl +fomesafen 250 g/ha 250 g/ha (PM)	2.51^{ab}	2.98^{ab}	82515	2400	33478	49037	2.46
T_{11}: IC *fb* HW at 20 & 40 DAS	2.73^{a}	3.44^{a}	90145	10500	43358	46787	2.08
T_{12}: Weedy check	0.343^{d}	0.557^{c}	11576	0	31078	-19503	0.37
S. Em.±	0.142	0.243	-	-	-	-	-
CD (P=0.05)	Sig.	Sig.	-	-	-	-	-
CV%	9.3	11.2	-	-	-	-	-

Note: Data subjected to $\sqrt{(x+1)}$ transformation. Figures in parentheses are means of original values. Treatment means with the letter/ letters in common are not significant by Duncan's New Multiple Range Test at 5% level of significance

Succeeding crops

The results (Table 2) indicated that the herbicides *viz.*, pendimethalin, clomazone, diclosulam, pendimethalin + imazethapyr, quizalofop-ethyl, imazethapyr, imazethapyr + imazamox, propaquizafop-p-butyl + imazethapyr, sodium acifluorfen + clodinafop propargyl and fluazifop-p-butyl + fomesafen applied to soybean did not show any significant effect on plant stand, plant height and plant dry biomass of suceeding mustard, wheat and chickpea. This may be due to long gap between application of herbicides and sowing of succeeding crops, during this period microbial degradation and precipitation cause the degradation and leaching down of the herbicide (Idapuganti *et al.* 2005). Kewat (1998) [3, 4] observed that application of pendimethalin at 1.0 and 1.5 kg/ha remained biologically active up to 25 to 26 days in sandy loam soil wherein, 75% pendimethalin was lost in 45 days. In the present experiment, there was sufficient time was available after application of different herbicides to soybean for degradation of the herbicides. Hence, all the herbicides applied for weed control in soybean with a tested rate are safe for growing of succeeding mustard, wheat and chickpea. The results are in accordance with the finding of Yadav and Bhullar (2014) [11].

Table 2: Growth parameters of succeeding crops as influenced by integrated weed management practices followed in preceding soybean crop (Mean of two years)

Treatment	Plant stand at 15 DAS (No./m row length)			Plant height (cm)			Plant dry biomass (g/plant)		
	Mustard	Wheat	Chickpea	Mustard	Wheat	Chickpea	Mustard	Wheat	Chickpea
T_1: Pendimethalin 750 g/ha PE *fb* IC+HW at 30 DAS	10.9	53.8	9.33	19.8	31.0	14.5	1.45	0.847	1.32
T_2: Clomazone 1000 g/ha PE *fb* IC+ HW at 30 DAS	11.1	48.7	8.85	20.3	28.9	14.4	1.48	0.860	1.27
T_3: Diclosulam 25.2 g/ha PE *fb* IC+HW at 30 DAS	10.6	51.3	9.67	19.4	30.8	14.0	1.60	0.861	1.30
T_4: Pendimethalin + imazethapyr 960 g/ha PE (PM) *fb* HW at 30 DAS	11.2	53.7	9.35	20.0	31.8	14.6	1.55	0.849	1.29
T_5: Quizalofop-ethyl 50 g/ha PoE *fb* IC+HW at 30 DAS	11.6	51.8	9.67	20.4	30.6	15.2	1.63	0.879	1.35
T_6: Imazethapyr 100 g/ha PoE *fb* IC+HW at 30 DAS	11.6	54.0	9.87	20.4	30.8	14.3	1.67	0.911	1.32
T_7: Imazethapyr + imazamox 70 g/ha PoE (PM)	10.5	52.5	9.65	20.0	30.7	15.3	1.79	0.894	1.36
T_8: Propaquizafop + imazethapyr 125 g/ha PoE (PM)	11.1	51.4	9.47	21.1	29.9	14.6	1.84	0.857	1.37
T_9: Sodium acifluorfen + clodinafop propargyl 245 g/ha PoE (PM)	11.0	48.7	9.50	19.0	29.6	14.7	1.67	0.802	1.22
T_{10}: Fluazifop-p-butyl + fomesafen 250 g/ha 250 g/ha (PM)	1.9	51.0	9.47	20.0	29.3	14.7	1.66	0.894	1.32
T_{11}: IC *fb* HW at 20 & 40 DAS	11.5	52.2	9.53	20.2	30.8	15.2	1.78	0.953	1.38
T_{12}: Weedy check	11.0	50.9	9.60	20.3	29.9	14.3	1.65	0.848	1.19
S. Em.±	0.405	1.40	0.225	0.547	0.704	0.495	0.097	0.039	0.075
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	8.7	7.1	5.6	6.6	6.0	8.3	13.8	12.0	15.0

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