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Research Paper

Crop-management practices influence weed dynamics, yield and economics of soybean (*Glycine max*)

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ABSTRACT

A field experiment was conducted during 2018 and 2019 at Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, to study the effect of crop-management practices on weed dynamics, yield and economics of soybean [*Glycine max* (L.) Merr.]. The experiment was laid out in randomized block design with 4 replications, comprising 5 treatments of different crop-management practices, viz. conservation organic, conservation chemical, conventional chemical, organic management + conventional tillage and package of practices. The results showed that, conservation chemical was found the most effective in controlling total weeds (5.5 m^2) and reduction of dry-matter accumulation by weeds (24.8 kg/ha) as compared to the package of practices, conventional chemical, conservation organic and organic management + conventional tillage at 30 days after sowing (DAS). However, at 45 DAS, conservation organic was the most effective in controlling total weeds (5.9 m^2) and reduction of dry-matter accumulation by weeds (35.9 kg/ha) as compared to organic management + conventional tillage, conservation chemical, package of practices and conventional chemical on pooled basis. Significantly higher seed (1,850 kg/ha), haulm (2,824 kg/ha), net returns (₹48,913/ha) and benefit : cost ratio (3.2) of soybean were recorded under conservation chemical followed by package and practices and conventional chemical.

Key words: Conservation tillage, Convention tillage, Weed management, Yield, Soybean

Soybean is the most important oilseed crop in India. In India, it is grown in an area of 11.0 million ha with the production of 13.7 million tonnes (IISR, Indore, 2020a). Soybean occupies the second position in terms of area (1.12 million ha) after rapeseed–mustard and the third in terms of production (0.53 million tonnes) among oilseeds in the state after rapeseed–mustard and groundnut (IISR, Indore, Government of Rajasthan, 2020b). Soybean has a high yield potential and can play a vital role in enhancing the country's oilseed supply and strengthens the country's economy through reduction in edible oil import, as the India is producing only 55% of its required edible oils. The carry-over effect of soybean on the following wheat crop was mentioned by Behera *et al.,* (2007). In addition its beneficial residual effect on soil fertility, soybean has a lot of potential as a highly nutritious and protein-rich food. It fulfils the dietary requirement of protein. Soybean is enriched with more than 38–40% high-quality protein that includes all essential amino acids, including glycine, tryptophan, and lysine, and is comparable to cow's milk and animal proteins. Soybeans also contain 18–20% oil, which contains essential fatty acids, lecithin, and vitamins A and D. (Jadon *et al.*, 2019). Soybean is also high in mineral salts like phosphorus and calcium, which are essential for nutritional security. The majority of farmers either grow soybean without fertilizer application or use relatively little amounts of fertilizer during crop period. Besides, there is lack of disease and insect-pest management among the soybean farmers which drastically affects the production negatively. In India, 3 different crop-management practices are generally followed by the farmers, viz. conventional, conservation and organic crop-management practices. These practices vary from crop to crop and play an important role in overall crop growth, production, economics and

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soil health. Weeds are one of the major biological constraints in conservation agriculture system. Weeds can be effectively controlled through tillage operations, which uproot and bury the weeds deep into the soil. Lack of tillage under conservation agriculture augments the weed growth. Integrated weed-control technology integrates preventive, cultural, mechanical, chemical and biological methods, in which the use of herbicides is most important for weed management (Sharma and Singh, 2014). Therefore, keeping above in view, the present investigation was carried out to study the effect of various crop-management practices on weed management, yield and economics of soybean in soil and climatic conditions of South-Eastern Rajasthan.

MATERIALS AND METHODS

An experiment was conducted during the rainy (*kharif*) seasons of 2018 and 2019 at Research Farm, Agricultural Research Station, Maharana Pratap university of Agriculture and Technology, Ummedganj, Kota, Rajasthan, which is located at South-Eastern part of Rajasthan. The experiment comprising 5 treatments, viz. conservation organic [minimum tillage, crop-residue retention + cultural (dust mulch) and mechanical (HW) weed-management and organic nutrient management], conservation chemical [minimum tillage, crop-residue retention + chemical weed-management with a ready-mixed herbicide, viz. sodium acilfluorfen 16.5% + clodinafop propargyl 8% EC (165 + 80 g a.i./ha), and organic + inorganic nutrient management], conventional chemical [conventional tillage + chemical method of weed-management and soil test-based application of manure and fertilizers], organic management + conventional tillage [conventional tillage + hand-weeding and organic method of nutrient management] and package of practices. Clodinafop-propargyl is a herbicide of aryloxyphenoxypropionics (APP's) group and exert its post-emergence herbicidal activity mostly on grassy weeds. These are readily absorbed by narrow-leaf weeds. The active ingredient of herbicide is translocated both acropetally as well as basipetally in the plant system of weeds which, checks the activity of enzymes at the site of action, viz. meristematic regions, in tillers, leaf, shoot and roots. The soil of the experimental field was medium black and clay loam (Vertisols) in texture, alkaline in reaction (*p*H 7.4 and 7.3), medium in organic carbon (0.51 and 0.57%), available nitrogen (234.0 and 260.0 kg/ha), available phosphorus (21.1 and 20.7 kg/ha) and high in available potassium (440.0 and 459.1 kg/ha) and low in available S (16.7 and 18.9 kg/ha), with good drainage during 2018 and 2019 respectively. The soybean crop was sown in July and harvested in October during both the years. In order to determine dominant weed species in experimental field, weed flora was surveyed from 4 places in each plot using 0.25 m^2 quadrate randomly. The weed density and dry-matter were taken at 30, 45 and 60 days after sowing (DAS) of soybean. The data were subjected to square-root transformation $\sqrt{x+1.0}$ to normalize their distribution (Gomez and Gomez, 1984). The data on crop yield were also statistically analyzed. The economics of different treatments were worked out in terms of net return (₹/ha) and benefit: cost (B: C) ratio.

RESULTS AND DISCUSSION

Weed dynamics in soybean

A data pertaining to weed dynamics presented in Tables 1 and 2 demonstrated a substantial triming in weed density and dry matter as a result of various crop management approaches at different growth stages of soybean. The results showed that, conservation chemical was found the most effective in controlling weed density and dry matter of monocot and dicot at 30 DAS. The total weed density was notably reduced with conservation chemical compared with conservation organic and organic management + conventional tillage to the tune of 21.8, and 32.3%, respectively, and found at par with conventional chemical and package of practices. Further, conservation chemical reduced the weed dry-matter 43.2, 21.4, and 61.3%, respectively, but recorded at par with package and practices. This may be owing to application of sodium acifluorfen 16.5% + clodinafop propargyl 8% EC (premix) at 20 DAS which were effective in controlling the weeds at early stage in soybean. The active ingredient of herbicide is translocated both acropetally as well as basipetally in the plant system of weeds and inhibits enzymatic activities at the site of action, viz. meristematic regions, in tillers, leaf, shoot and roots. Aryloxyphenoxypropionics inhibit acytyl-CoA carboxylase (ACCase), the enzyme catalyzing the fatty acid synthesis presumably blocks the production of phospholipids used in building of new membranes required for cell growth (Rao, 2000). Biochemically, this inhibits the synthesis of fatty acids in meristematic tissues of grassy weeds. Clodinafop propargyl in combination of sodium acifluorfen increased the efficacy for effective control of weeds. The results obtained in the present investigation are in close agreement with the findings of; Singh *et al.,* (2016); Harithavardhini *et al.* (2016); Panda *et al.,* (2017) and Meena (2020).

Data at 45 DAS indicated that conservation organic effectively reduced the weed density compared with conservation chemical, conventional chemical and package of practices by 30.5, 39.0 and 37.3%, respectively, and were found non-significant with organic management + conventional tillage (Table 1). Further, organic management + conventional tillage significantly reduced the weed density

compared with conservation chemical, conventional chemical and package of practices to the tune of 26.2, 34.4 and 32.8%, respectively. Conservation organic and organic management + conventional tillage treatments significantly controlled the weed dry matter accumulation compared with conservation chemical, conventional chemical and package of practices by 273.0, 312.0, 305.9 and 241.6, 277.3 and 271.7%, respectively. This might owing to deep burying of seeds which, enhanced the seed dormancy and reduced the emergence. Similarly, it is well known that the implementation of different tillage systems has varied effect on soil nutrients, soil structure, temperature and *p*H, water conservation and weed seed burial depth (Al-Kaisi *et al.,* 2005), all of which may affect the germination and growth of certain weed species and lead to changes in weed density and weed composition (Carter and Ivany, 2006; Sosnoskie *et al*., 2006). Further, in conservation tillage systems the soil temperature and moisture levels may be altered due to presence of crop residues on the soil surface which, affect weed seed germination and emergence pattern over the growing season (Spandl *et al.,* 1998; Teasdale and Mohler, 2000; and Bullied *et al.,* 2003). Likewise, Xuan *et al*., (2005) found that rice straw inhibited the germination and seedling growth of weed plants by 70% and increased crop yield by 20%. However, later stage conservation organic revealed more efficacy in weed management aspect. This could be because of organic sources/ crop residues of preceding crop which, give more competitive capacity to crop over weeds. These results are in line with findings of Eltiti (2003) and Khaliq *et al.,* (2013).

Different crop-management practices had no significant effect on weed density and dry matter accumulation of monocot, dicot and total weeds at 60 DAS in soybean (Tables 1, 2).

Yields and harvest index of soybean

Significantly higher seed yield of soybean was obtained under conservation chemical (1,850 kg/ha) compared to conservation organic (1636 kg/ha) and organic management + conventional tillage (1564 kg/ha) by 13.1 and 18.3%, respectively, but statistically at par with package of practices (1,847 kg/ha) and conventional chemical (1,767 kg/ha) (Table 3). Similarly, higher haulm yield of soybean was recorded in conservation chemical (2,824 kg/ha) over the conservation organic (2,523 kg/ha) and organic management + conventional tillage (2,421 kg/ha) by 11.9 and 16.7%, respectively. However, its effect was found statistically at par with package of practices (2,820 kg/ha) and conventional chemical (2,713 kg/ha). Further, the effect of conservation organic on seed and haulm yields of soybean was observed to be at par with organic management + conventional tillage. The similar results were reported by Jaybhay *et al.,* (2015), Singh *et al*., (2016), Meena *et al.,* (2019) and Singh *et al.,* (2020). However, crop-management practices did not significantly influence the harvest index.

Economics

The net returns of soybean were significantly higher under conservation chemical (₹48,913/ha) than conservation organic (₹35,463/ha) and organic management + conventional tillage (₹34,667/ha) by 37.9 and 41.1%, respectively, but were recorded at par with package of practices (₹45,127/ha) and conventional chemical (₹43,889/ha).

Table 1. Weed density of monocot and dicot in soybean as influenced by conservation, organic and conventional crop management practices under soybean–wheat cropping system at 30, 45 and 60 days after sowing (category wise)

Treatment	Weed density/(m^2)								
	30 DAS			45 DAS			60 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Conservation organic	3.5 (11.3)	3.2 (9.1)	6.7 (20.4)	3.1 (8.4)	2.8 (7.1)	5.9 (15.5)	6.4 (40.1)	5.2 (26.6)	11.6 (66.8)
Conservation chemical	2.9 (7.5)	2.6 (5.8)	5.5 (13.3)	3.8 (13.6)	3.9 (14.4)	7.7 (28.0)	6.7 (44.5)	5.5 (29.5)	12.3 (74.0)
Conventional chemical	3.3 (9.6)	2.9 (7.3)	6.1 (16.9)	4.1 (16.2)	4.1 (15.8)	8.2 (32.0)	7.0 (47.0)	5.7 (31.8)	12.7 (79.8)
Organic management + conventional tillage	3.8 (13.6)	3.5 (11.4)	7.3 (25.0)	3.2 (9.3)	2.9 (7.6)	6.1 (16.9)	6.4 (40.8)	5.4 (28.1)	11.8 (68.9)
Package of practices	3.2 (9.1)	2.7 (6.6)	5.9 (15.8)	4.1 (16.0)	4.1 (15.6)	8.1 (31.5)	6.9 (46.6)	5.7 (31.4)	12.6 (78.1)
SEm±	0.12	0.15	0.24	0.14	0.14	0.21	0.28	0.20	0.33
CD (P=0.05)	0.35	0.44	0.70	0.42	0.41	0.62	NS	NS	NS

DAS, Days after sowing

Square-root transformed values are $\sqrt{x + 1.0}$ and actual values are in parentheses

Table 2. Iinfluence of conservation, organic and conventional crop management practices on weed dry weight of monocot and dicot in soybean under soybean–wheat cropping system at 30, 45 and 60 days after sowing (category wise)

Treatment	Weed dry weight (kg/ha) at 30 days after sowing								
	30 DAS			45 DAS			60 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Conservation organic	18.7	16.8	35.5	17.3	18.7	35.9	115.5	120.3	235.8
Conservation chemical	13.4	11.4	24.8	60.9	73.0	133.9	145.2	149.8	295.0
Conventional chemical	16.1	14.1	30.1	65.9	82.0	147.9	149.3	162.9	312.2
Organic management + conventional tillage	21.0	18.9	40.0	19.0	20.2	39.2	127.4	134.4	261.8
Package of practices	14.9	13.4	28.4	64.6	81.2	145.7	146.4	151.9	298.2
SEm±	1.30	1.17	1.68	3.16	3.80	4.98	14.78	14.59	21.87
CD (P=0.05)	3.78	3.42	4.89	9.23	11.08	14.53	NS	NS	NS

DAS, Days after sowing

Table 3. Yield and harvest index of soybean as influenced by conservation, organic and conventional crop management practices

Treatment	Seed yield (kg/ha)			Haulm yield (kg/ha)			Harvest index (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Conservation organic	1,578	1,694	1,636	2,428	2,618	2,523	39.39	39.29	39.34
Conservation chemical	1,805	1,895	1,850	2,772	2,877	2,824	39.45	39.72	39.58
Conventional chemical	1,673	1,861	1,767	2,574	2,853	2,713	39.43	39.48	39.45
Organic management + conventional tillage	1,512	1,617	1,564	2,329	2,514	2,421	39.36	39.12	39.24
Package of practices	1,884	1,809	1,847	2,865	2,776	2,820	39.60	39.45	39.53
SEm±	67	60	52	91	82	71	0.337	0.754	0.477
CD (P=0.05)	207	184	152	280	253	206	NS	NS	NS

Table 4. Effect of conservation, organic and conventional crop management practices on net returns and benefit : cost ratio of soybean

Treatment	Net returns (₹/ha)			Benefit : cost ratio		
	2018	2019	Pooled	2018	2019	Pooled
Conservation organic	30,683	40,243	35,463	2.15	2.45	2.30
Conservation chemical	44,058	53,768	48,913	3.05	3.43	3.24
Conventional chemical	37,289	50,490	43,889	2.59	3.10	2.84
Organic management + conventional tillage	30,108	39,226	34,667	2.21	2.53	2.37
Package of practices	40,863	49,391	45,127	2.49	3.14	2.81
SEm±	2,415	2,316	1,932	0.093	0.094	0.076
CD (P=0.05)	7,443	7,137	5,639	0.288	0.290	0.223

Besides, significantly higher benefit : cost (B : C) ratio of soybean was obtained in conservation chemical (3.2) over conventional chemical (2.8), package of practices (2.8), organic management + conventional tillage (2.4) and conservation organic (2.3). The conservation chemical revealed an increase of 14.1, 15.3, 36.7 and 40.8% in B : C ratio over conventional chemical, package of practices, organic management + conventional tillage and conservation organic respectively. Present results are close agreement with Meena *et al.,* (2016) and Raghuwanshi *et al.,* (2018) in which conservation chemicals were determined the most effective in controlling total weeds and reducing weed dry-matter accumulation at early crop stage. However, at later crop stages conservation organic was found most successful in decreasing total weeds and reducing dry matter buildup of weeds as compared to other crop-management practices.

It was concluded that the conservation chemical and conservation organic was effective to control monocot and dicot weeds in soybean at 30 DAS and 45 DAS, respectively. Whereas, conservation chemical was found better crop management practices, which produce Maximum Seed yield, haulm yield, net return and B:C ratio of soybean as compared to other management practices.

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