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Conservation and organic management practices influenced wheat (*Triticum aestivum*) productivity, profitability and weed dynamics

SATYA NARAYAN MEENA[1]*, S K SHARMA[2], PRATAP SINGH[1], ASHA RAM[3], BHARAT PRAKASH MEENA[4], KAILASH PRAJAPAT[5], N K SHARMA[1], B L KUMHAR[6] and B S MEENA[1]

Agriculture University, Kota, Rajasthan, 324 001, India

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ABSTRACT

Present study was carried out during winter (*rabi*) seasons of 2018–19 and 2019–20 at the Agricultural Research Station of Agriculture University, Kota, Rajasthan to assess the effects of conventional and conservation tillage with organic and chemical management on growth, yield attributes, yields, economics and weed dynamics in wheat (*Triticum aestivum* L.) in Vertisols. Five different crop-management practices, viz. conservation tillage with organic management (CAO), conservation tillage with chemical management (CAC), conventional tillage with chemical management (CTC), conventional tillage with organic management (OCT) and package of practice (PoPs) were studied in a randomized block design (RBD) with 4 replications. Pooled data revealed that significantly higher plant height (97.7 cm), dry matter accumulation (169.24 g/0.5 metre row length), number of tillers (47.05/0.5 meter row length), chlorophyll content of leaves (2.186 mg/g), number of effective tillers (43.15/0.5 meter row length), spike length (12.86 cm), weight per spike (2.49 g), test weight (45.61 g), grain yield (5214 kg/ha), straw yield (7941 kg/ha), and net returns (₹ 90891/ha) were recorded under CAC practice over CAO and OCT, although it was observed to be comparable to the PoPs and CTC management practices. Comparing conservation tillage with chemical management to other crop management techniques at 60 DAS, it was found to be the most successful practice for controlling total weeds (9.40/m^2) and decreasing the buildup of weed dry matter (167.21 kg/ha).

Keywords: Conservation, Conventional, Organic management, Wheat, Weed dynamics

India's food grain production increased from 176.4 million metric tonnes in 1991 to 315.72 million tonnes in 2021 (Economic Survey 2022–23). India's second-largest food crop after rice, wheat (*Triticum aestivum* L.) covers 31.61 million ha and produces 109.52 million tonnes (DES 2021). Use of high yielding cultivars, irrigation and crop management techniques has resulted in enhancing the crop productivity and foodgrain production. In India, three different crop management practices are being used by the farmers, viz. conventional, conservation and organic farming practices. Inorganic fertilizers that are used to improve crop yields without organic inputs severely damage the soil's physical, chemical and biological characteristics (Devi *et al.* 2013). It is now necessary to combine organic manures with chemical fertilizers in order to sustain agricultural productivity (Behera *et al.* 2007). In addition to providing balanced nutrition, organic manures also improve soil physico-biological properties by decreasing bulk density, increasing water holding capacity, and increasing soil biological properties (Meena *et al.* 2019).

Conservation agriculture practices enhance crop productivity, improve soil health, and impart environmental sustainability (Sharma *et al.* 2021). Through a recent study, Chandra *et al.* (2023) showed that zero tillage with residue retention improved soil biological health, yield and sustainability in rice-barley crop sequence. As a result of increased moisture and nutrient availability, as well as reduced weed competition, applying crop residue significantly increased crop yields under conservation agriculture (Ram *et al.* 2016). We hypothesized that the performance of wheat weed dynamics and economics would vary differently under differently adopted cultivation practices. Therefore, the present experiment was conducted to study the effect of conservation and organic crop management practices on wheat productivity, profitability, and weed dynamics in Vertisols of Rajasthan.

MATERIALS AND METHODS

An experiment was conducted during the winter (*rabi*) seasons of 2018–19 and 2019–20 at the Agricultural

[1]Agriculture University, Kota, Rajasthan; [2]Human Resource Management Division, KAB-II, ICAR-New Delhi; [3]ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh; [4]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh; [5]ICAR-Central Soil Salinity Research Institute, Karnal, Haryana; [6]Agriculture University, Jodhpur, Rajasthan. *Corresponding author email: meenasnagro@gmail.com

Research Station (25° 10' 57" N; 75°50' 20" E and 267 msl) of Agriculture University, Kota, Rajasthan. The climatic condition of the region belongs to sub-tropical and is marked by mild winters and moderately long summers. The average maximum temperature ranges from 40 to 48.4°C during May-June and the minimum from 3.5 to 14.7°C during December-January. The annual precipitation was 660.6 mm, most falling during the rainy (*kharif*) season (June-September). The soil of the experimental site was deep black, well-drained, and clay-loam in texture (sand 25.86%, silt 35.11%, clay 38.94%), with soil reaction of (*p*H) 7.41. At the start of the experiment, the top soil's (0–15 cm) bulk density (Mg/m^3), porosity (%), soil organic carbon (g/kg soil), and EC (dS/m) were estimated to be 1.28, 51.0, 5.10, and 0.65, respectively. The experimental soil was low in available N (234.0 kg/ha), medium in available P (21.13 kg/ha) and high in exchangeable K (440.0 kg/ha). The 5 agronomic management practices viz., T_1, conservation tillage with organic management (CAO); T_2, conservation tillage with chemical management (CAC); T_3, conventional tillage with chemical management (CTC); T_4, conventional tillage with organic management (OCT), and T_5, package of practices (PoPs) were tested in a randomized block design with 4 replications. Under CAO and CAC fields were prepared by one ploughing and direct sowing through seed drill with previous crop biomass retention (soybean residue 1.5 t/ha). While in CTC, OCT and PoPs 3 ploughings were done followed by sowing of wheat.

Wheat (cv. Raj 4079) was sown at inter-row spacing of 22.5 cm using a seed rate of 100 kg/ha. The sowing was done on 14th and 13th December, and reaped on 11th and 12th April during 2018–19 and 2019–20, respectively. In PoPs, the recommended rate of nutrients through farmyard manure (FYM @10 t/ha once at beginning of experiment) and fertilizers (N:P:K:Zn @120:40:30:25 kg/ha) were applied as recommended (Sharma 2018). For other practices (CAC, CTC) the dose of N was kept 50% higher as the soil was low in available N content, so fixed as 180:40:30 kg/ha N:P:K. In CAC and CTC, the recommended dose of nutrients was applied through 5 t FYM/ha and the remaining N:P:K through fertilizers (Urea 337 + SSP 169 + MOP 42 kg/ha). Under organic management practices (CAO and OCT), nutrients were supplied through well-decomposed FYM (36 t/ha) equivalent to 180 kg N/ha. Seeds were also treated with PSB biofertilizer (600 g/100 kg seed) before sowing in all the practices. Mean nutrients contents of FYM were estimated as N (0.50%), P_2O_5 (0.26%), K_2O (0.50%), S (0.03%), Zn (24.80 ppm), Fe (173.90 ppm), Cu (5.15 ppm) and Mn (97.45 ppm). In CAC, CTC and PoPs, weeds were controlled through ready mix herbicide Clodinafop-propargyl 15% WP + Metsulfuron methyl 1% WP (48+4 g *a.i.*/ha) as PE spray at 32 DAS. Non-chemical methods i.e. dust mulch at 20 DAS and hand weeding at 35 DAS were adopted under organic practices. The soybean crop was raised as the preceding wheat crop during rainy (*kharif*) season for both years of the experiment.

Dry matter accumulation and number of tillers were recorded as per standard procedures. Total chlorophyll content in leaf at 60 DAS were analysed following the standard procedure. The total chlorophyll content was computed as:

$$\text{Total chlorophyll content (mg/g fresh weight of leaf)} = \frac{20.2\,(A645) + 8.02\,(A663) \times V}{a \times 1000 \times W}$$

where, A, absorbance of specific wavelength (nm); V, Volume of extract in ml; W, Weight of leaf sample in g; a, Length of light path in cell (1 cm).

The length of 10 spikes collected randomly from each plot was measured and the average was expressed as length of spike in centimeter (cm). After threshing and winnowing, grain yield/plot was weighed, and expressed in kg/ha.

In order to determine dominant weed species in the experimental plots, weed flora was surveyed randomly at 4 places in each plot using 0.25 m^2 quadrate. The weed density and dry matter were recorded at 45 and 60 DAS. The distribution of the data on weeds was normalized using the square-root transformation $\sqrt{x+1.0}$, and all data were statistically analysed using ANOVA (Gomez and Gomez 1984). A critical difference at $P<0.05$ was used to differentiate treatment means.

RESULTS AND DISCUSSION

Growth: Results (Table 1) revealed that all the growth parameters of wheat, viz. plant height (97.7 cm), dry-

Table 1 Effect of tillage, organic and chemical management practices on growth parameters of wheat

Treatment	Plant height (cm) at harvest			Dry matter accumulation (g/0.5 metre row length) at harvest			Number of tillers/0.5 meter row length at 60 DAS			Chlorophyll content (mg/g fresh weight) at 60 DAS		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
CAO	85.1	89.2	87.2	148.41	157.31	152.86	42.35	43.39	42.87	2.103	2.139	2.121
CAC	93.3	98.5	95.9	163.87	178.04	170.95	45.63	48.01	46.82	2.160	2.204	2.182
CTC	90.5	95.3	92.9	150.80	172.01	161.40	43.25	47.01	45.13	2.117	2.168	2.142
OCT	84.3	87.1	85.7	144.82	149.71	147.26	41.78	42.34	42.06	2.084	2.105	2.095
PoPs	97.7	91.9	94.8	169.24	165.93	167.58	47.05	44.36	45.70	2.186	2.144	2.165
SEm±	2.12	2.45	1.87	5.55	5.82	4.64	1.18	1.21	0.98	0.019	0.020	0.016
CD (P= 0.05)	6.52	7.55	5.46	17.10	17.94	13.56	3.63	3.74	2.85	0.059	0.062	0.047

Treatment details are given under Materials and Methods.

matter accumulation (169.24 g), number of tillers (47.05) and total chlorophyll content of leaves (2.186 mg/g) were observed significantly higher under PoPs over the treatments having conservation and conventional tillage with organic management. But in 2019–20, conservation tillage with chemical management practices significantly outperformed other management practices by registering maximum values for plant height (98.5 cm), dry-matter accumulation (178.04 g), number of tillers/0.5 mrl (48.01) and chlorophyll content of leaves (2.204 mg/g). But growth attributes under CTC, PoPs, and CAC remained statistically at par in pooled data of two years. The CAC treatment significantly outperformed OCT in terms of plant height (10.03 and 11.95%), dry-matter accumulation (11.84 and 16.08%), number of tillers (11.84 and 16.08%), and total chlorophyll content (2.99 and 5.43%), respectively, in both the years.

The better growth of wheat under conservation tillage with chemical management could be attributed to the presence of crop residues and the application of soil-based nutrients. By applying residues to the soil, moisture and soil nutrients were increased, resulting in improved wheat growth parameters. The integrated application of FYM and fertilizers also results in favourable changes in different nutrient release patterns and soil properties, which positively affect plant growth (Moharana *et al.* 2012, Meena *et al.* 2022a).

Yield attributes and yield: Results (Table 2 and Fig 1) indicated that the PoPs management recorded significantly higher yield attributing characters, viz. number of effective tillers/0.5 mrl (43.42), spike length (12.88 cm), weight per spike (2.56 g), test weight (45.79 g), grain yield (5085 kg/ha) and straw yield (7338 kg/ha) compared to CTC, CAO and OCT during 2018–19. However, during second year, CAC practice significantly outperformed conservation and conventional tillage with organic management (CAO and OCT) in terms of effective tillers (44.39), spike length (13.05 cm), weight per spike (2.56 g), test weight (45.89 g), grain yield (5396 kg/ha) and straw yield (8204 kg/ha) and observed statistically at par with package of practices and conventional tillage with chemical management.

Better growth under CAC, CTC, and PoPs practices translates into higher yield attributes. The supplementation of FYM with chemical fertilizers under these practices led to better nutrient uptake by wheat crop, which might have resulted in better yield in these practices over both the organic practices. In wheat crops, FYM as the sole source of nutrients did not provide an adequate amount of nutrients, which led to poor growth and yield. Chandra *et al.* (2022) also demonstrated that continuous application of FYM at 30 t/ha could not reach yield levels comparable to those of NPK fertilization through fertilizers in wheat. Similar results were found by Aulakh *et al.* (2012) and Gao-Bao *et al.* (2012).

Meena *et al.* (2022a; 2022b) stated that conservation tillage with chemical management was found to be a better management practice producing the highest possible yields and profitability in soybean. According to Ma and Tong (2007), winter wheat yields utilizing conservation tillage were 10–20% greater than those using conventional tillage. According to Gosh *et al.* (2022), conservation agriculture results in higher yields and economic benefits when compared to conventional tillage. Although we did not observe any significant differences between conservation and conventional tilled wheat in our study, we believe that a long-term study is necessary to establish a definitive conclusion.

Economics: Based on the pooled analysis of two years of study (Table 2), conservation agriculture with chemical management yielded significantly higher net returns than OCT. However, it remained statistically at par with CTC and PoPs. The B:C ratio of wheat was also markedly higher in the CAC (4.11) than the PoPs (3.75), CTC (3.59), OCT (2.35) and CAO (2.32).

Weed interferences: The no. of monocot, dicot, and total weeds at 45 DAS during both the two years did not change noticeably due to different crop-management techniques (Table 3). However, at 60 DAS, the CAC was shown to be the most effective in reducing the total weed density compared to the other treatments. In comparison to OCT, there was a 19.52%, 16.82%, 13.12% and 2.57% reduction in overall weed density and 36.86%, 30.37%, 25.84%, and 5.52% reduction in weed dry-matter under CAC, CTC, PoPs and CAO, respectively.

Table 2 Effect of tillage, organic and chemical management practices on yield attributes and net returns of wheat

Treatment	Number of effective tillers at harvest (0.5 meter row length)			Spike length (cm)			Weight/spike (g)			Test weight (g)			Net returns (₹/ha)	B:C ratio
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	Pooled	Pooled
CAO	38.07	39.05	38.56	11.25	11.48	11.36	2.23	2.33	2.28	43.95	44.20	44.08	59707	2.32
CAC	41.91	44.39	43.15	12.68	13.05	12.86	2.43	2.56	2.49	45.32	45.89	45.61	90891	4.11
CTC	39.17	42.83	41.00	12.10	12.35	12.23	2.31	2.46	2.39	44.99	45.62	45.30	80903	3.59
OCT	37.42	37.95	37.68	11.08	11.18	11.13	2.20	2.25	2.23	43.33	43.46	43.40	58498	2.35
PoPs	43.42	39.80	41.61	12.88	12.25	12.56	2.56	2.43	2.49	45.79	45.45	45.62	86007	3.75
SEm±	1.29	1.43	1.11	0.26	0.31	0.23	0.04	0.04	0.03	0.56	0.58	0.46	3302	0.10
CD (P= 0.05)	3.98	4.41	3.25	0.79	0.94	0.67	0.12	0.12	0.09	1.72	1.77	1.35	9638	0.29

Treatment details are given under Materials and Methods.

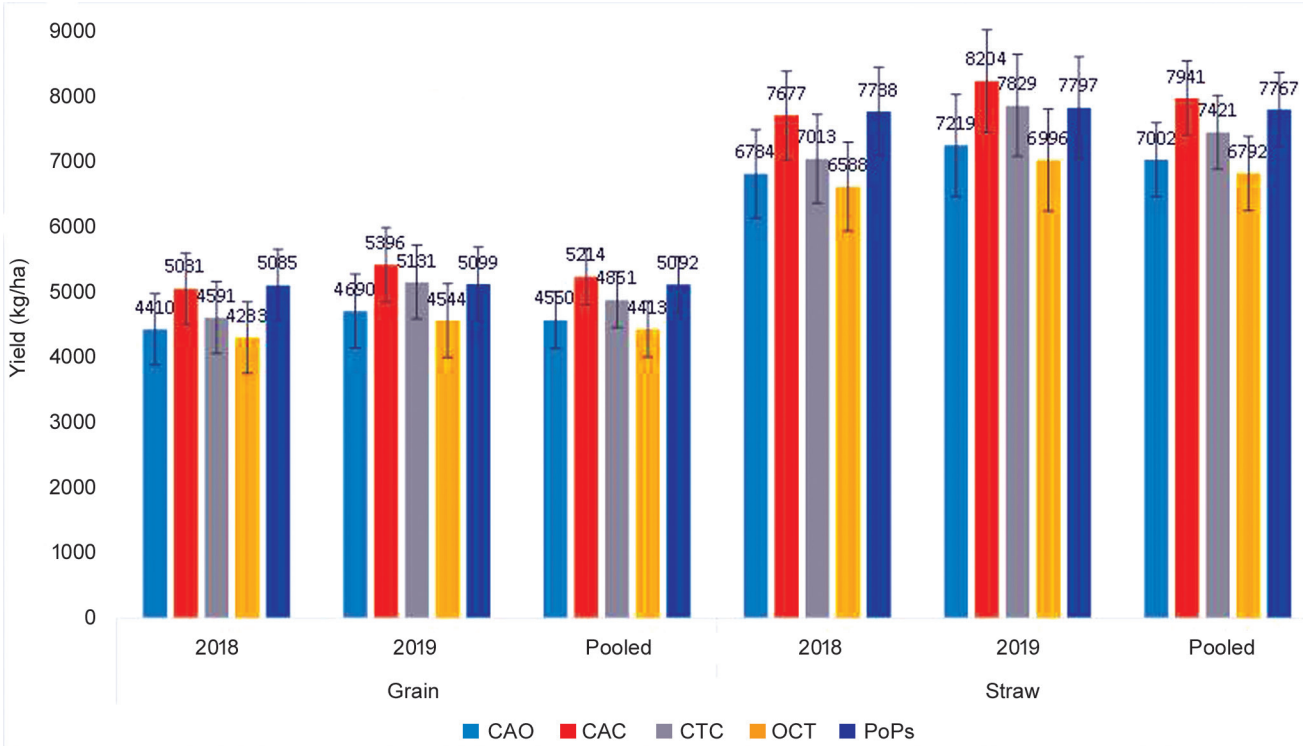

Fig 1 Effects of tillage, organic and chemical management practices on grain and straw yield of wheat. The error bars show LSD values (P=0.05). Treatment details are given under Materials and Methods.

During early growth stages of wheat, chemical weed control along with crop residues (under CAC, CTC and PoPs) and mechanical weed control under CAO and OCT were equally effective in suppressing weeds. By retaining crop residues followed by weedicide application, we were able to reduce weed emergence, and growth, fostering more favourable conditions for crop growth as well as longer wheat growth periods. The results of present study indicated that Aryloxyphenoxy propionate products, such as Clodinafop-propargyl, should be applied post-emergence to wheat crop to control grasses such as *Phalaris minor* and *Avena fatua*. The *P. minor* infestation was eradicated, and the herbicide raised crop yields to pre-infestation levels (Kaur *et al.* 2016). In the current study, it was observed that Clodinafop-propargyl 15% WP + Metsulfuron methyl 1% WP @48 + 4 g ai /ha were efficient for controlling grassy and broadleaf weeds in wheat. In terms of wheat crop, Malik *et al.* (2013) came to a similar conclusion. Singh *et al.* (2017) found that

Table 3 Effect of tillage, organic and chemical management practices on weed dynamics of wheat

Treatment	Weed density (no./m^2)						Weed dry weight (kg/ha)					
	45 DAS			60 DAS			45 DAS			60 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
CAO	3.16 (9.05)	3.62 (12.50)	6.78 (21.55)	5.22 (26.50)	6.16 (37.00)	11.38 (63.50)	22.63	42.05	64.67	100.33	149.89	250.21
CAC	3.38 (10.53)	4.27 (18.00)	7.65 (28.53)	4.10 (16.00)	5.30 (27.25)	9.40 (43.25)	26.31	65.92	92.23	56.78	110.44	167.21
CTC	3.53 (11.63)	4.73 (22.00)	8.26 (33.63)	4.59 (20.13)	5.55 (29.88)	10.15 (50.00)	29.44	73.74	103.18	76.29	120.11	196.40
OCT	3.28 (9.80)	3.84 (14.13)	7.12 (23.93)	5.27 (27.00)	6.40 (40.13)	11.68 (67.13)	24.50	45.20	69.70	102.31	162.53	264.84
PoPs	3.45 (11.00)	4.47 (19.38)	7.92 (30.38)	4.35 (18.00)	5.36 (28.13)	9.71 (46.13)	27.81	70.40	98.21	68.33	116.09	184.41
SEm±	0.12	0.33	0.33	0.17	0.18	0.27	3.55	11.50	12.48	7.02	9.40	10.67
CD (P= 0.05)	NS	NS	NS	0.51	0.51	0.79	NS	NS	NS	20.48	27.43	31.14

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

Treatment details are given under Materials and Methods.

the population and dry weight of *Medicago polymorpha, Chenopodium album* and *Phalaris minor* were highest in wheat grown in conventional tillage system. Sharma *et al.* (2023) also reported the lesser weed density and weed dry-matter accumulation under conservation agriculture.

Based on two years' study, it can be concluded that the highest growth, yield contributing parameters, grain and straw yields, and profitability were noticed with the adoption of conservation tillage along with chemical management (CAC) as compared to others. Similarly, it has also been observed that CAC is the most effective way to manage weeds in wheat. Hence, it can be suggested that CAC-conservation tillage along with chemical management [Clodinafop-propargyl 15% WP + Metsulfuron methyl 1% WP (48+4 g a.i. /ha) and 180:40:30 kg/ha NPK through 5 t/ha FYM + remaining N, P, and K through urea, SSP and MOP + 600 g PSB] is the best conservation agricultural practice in terms of achieving higher productivity and profitability in the wheat crop.

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