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Effect of fertility levels and weed management practices on yield and economics of wheat crop (*Triticum aestivum* L.)

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Abstract
The field experiment was conducted during the *rabi* season of 2018–19 and 2019–20 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya, U.P. with two factor, 3 fertility levels (100% DRF through inorganic fertilizer, 75% RDF through inorganic + 25% N through FYM and 50% RDF through inorganic + 50% N through FYM) and 5 weed control practices (Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}, Clodinafop + Metsulfuron @ 60 g a.i. + 4 g a.i. ha^{-1}, Mesosulfuron + Iodosulfuron @ 12.2 g a.i + 2.2 g a.i. ha^{-1}, weed free upto 60 Days and Weedy check. The treatments were replicated three times in a factorial randomized block design with fifteen treatment combinations. Among the treatment combinations 100% RDF (NPK-150:60:40) with weed free upto 60 days was recorded maximum value of grain yield, straw yield, biological yield, gross returns and net returns during both the years. Higher benefit cost ratio was recorded with the treatment combinations of 100% RDF and Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}. Thus, it may be concluded that application of 100% recommended dose of NPK ha^{-1} with Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1} as proved most superior to other treatment in respect to higher benefit cast ratio of wheat crop.

Keywords: Fertility levels, weed management, yield and economics of wheat

Introduction
Wheat is one of the most important stable foods and prime cereal crop among the food-grain was grown in an area of 30 m ha in India, with the production 99.70 million tonnes and average productivity 33.71 q ha^{-1} (Ramadas *et al.* 2019) [6]. Though it is grown under a wide range of climates and soils but wheat is best adapted to temperate regions with rainfall between 30 and 90 cm.

Wheat crop is highly responsive to applied nutrient through various sources; A proper fertility management is an important parameter for optimizing the productivity. Despite the past gains in wheat production through chemical fertilizers, recent observations of stagnant or declining yields have raised concerns about the long-term sustainability of the crop production. Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical, and biological properties, and soil health. The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients. Organic materials such as FYM have traditionally been used by wheat farmers. FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Improvement in the soil structure due to FYM application leads to a better environment for root development. FYM also improves soil water holding capacity. The fact that the use of organic fertilizers improves soil structure, nutrient exchange, and maintains soil health has raised interests in organic farming. The use of FYM alone as a substitute to inorganic fertilizer is not be enough to maintain the present levels of wheat crop productivity. Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is the most effective method to maintain a healthy and sustainably productive soil.

In general, the application of organic amendments such as crop residues and/or farmyard manure increases significantly soil organic carbon (Yadav *et al.*, 2000) [11].

Weed problem is one of the major barriers responsible for low productivity of wheat because, weed competes with the crop for moisture, nutrients, space, light etc. Moreover, they increase production cost, decrease yield of the crop, harbours insects and plant diseases, decrease quality of farm produce and reduce values of the land. The weed in India are causing substantial losses to agriculture production and the annual losses in terms of money come to the Rs.1650 crores (Joshi, 2002) [2]. In agriculture weed causes more damage compared to insects, pests and diseases but due to hidden loss by weed in crop production, it has not drawn much attention of agriculturists (Rao, 2010) [7]. Wheat is generally infested by both grassy weeds *viz.*, *Phalaris minor* and *Avena* species and broad leaf weeds i.e. *Chenopodium album*, *Fumaria parviflora*, *Melilotus indica*, *Anagalles arvensis*, *Lathyrus aphaca* and *Vicia sativa* (Malik *et al.*, 1989) [3] In wheat, yield losses due to weeds may range from 10 to 82 percent depending upon the density and species of weed, duration of infestation and competing ability of crop plants under different agro-ecological conditions (Rao, 1994) [8].

Day by day, weed control through herbicides is increasing and popularizing among farmers. Because, weed control through manual methods is time consuming and tedious and become very costly due to unavailability of labour in peak period and labour charges are also high due to shifting of agricultural labours to industries for better and assured wages. Wheat is sown at very narrow row spacing. Therefore, cultural methods of weed control could not be performed and manual control becomes unaffordable. Hence, use of herbicides popularized particularly in irrigated wheat crop. The farmers are not aware of proper dose of herbicides, time of application, economics and their persistence in the soil. Several selective herbicides are available in the market, which are treated to be effective for particular crop. The farmers have to make decisions about the selection of right type of herbicides. Several grassy and broadleaf weeds infect wheat causing severe competition for essential nutrient, moisture and space thus reducing wheat yield and also its quality significantly (Singh *et al.*, 1995; Gupta *et al.*, 2011) [9, 1]. Keeping these facts in view, the present investigation was under taken to study the effect of fertility levels and weed management practices on yield and economics of wheat crop (*Triticum aestivum* L.).

Materials and Methods

A field experiment was conducted during the *rabi* season of 2018–19 and 2019–20 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya, Uttar Pradesh. Soil was silty loam in texture having pH 8.30 and 8.20, organic carbon 0.33 and 0.32% and available N, P and K were 137.60 and 136.82; 15.20 and 14.70; and 249.30 and 248.32 kg ha^{-1} respectively during both the year of experimentation. The treatment comprised of three fertility levels *viz.;* 100% DRF through inorganic fertilizer, 75% RDF through inorganic + 25% N through FYM and 50% RDF through inorganic + 50% N through FYM and 5 weed control practices *viz*.; Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}, Clodinafop + Metsulfuron @ 60 g a.i. + 4 g a.i. ha^{-1}, Mesosulfuron + Iodosulfuron @ 12.2 g a.i + 2.2 g a.i. ha^{-1}, weed free upto 60 Days and Weedy check. The treatments were replicated three times in a factorial randomized block design with fifteen treatment combinations.

A promising wheat variety PBW-154 was sown on 20 November and 24 November during 2018-19 and 2019-20, respectively. Farmyard manure was applied on the individual plot as per treatments basis after pre-sowing irrigation and before the final preparatory tillage. The experimental crop was uniformly fertilized with 150 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} in the form of urea, diammonium phosphate and muriate of potash (MOP), respectively as per treatment basis individually. Half dose of nitrogen, full dose of P_2O_5 and MOP was applied as basal dressing. Remaining half dose of nitrogen was top-dressed in two equal splits at CRI stage and tillering stage to ensure good growth of the crop. First irrigation was given at crown root initial stage after that crop was irrigated 20-25 days interval to avoid any kind of water stress. Herbicides were applied as post emergence *i.e*. 35 DAS with the help of hand-operated Knapsack sprayer, fitted with flat fan nozzle with 250 litter ha^{-1}water. First hand weeding was done at 20 and second at 40 DAS.

Results and Discussion

Effect on yield

The yield of a crop depends upon the yield attributes *viz*., number of effective tillers, spikelets $spike^{-1}$, grains $spike^{-1}$, length of spike and test weight (1000 grain weight). Any factor affecting their parameters ultimately affects the biological and economic yield of a crop. Source components may be number of tillers, plant height, leaf area index and dry matter of the plants before an thesis and sink components *viz*., number of effective $tillers^{-2}$, no. of spike m^{-2}, number of spikelets $spike^{-1}$, length of spike, no. of grain $spike^{-1}$ and test weight. Final yield of wheat is the function of no. of spike m^{-2}, no. of grain $spike^{-1}$ and test weight.

The yield attributing characters (Table-1) *viz.* number of effective tillers m^{-2}, number of spikelets ear^{-1} and 1000-grain weight was significantly influenced by fertility levels except length of spike (cm) and number of grains ear^{-1} and were increased with increase infertility levels during both the year of experiments. The maximum values of all these characters were observed with 100% RDF – through inorganic fertilizer which was at par with 75% RDF – through inorganic fertilizer + 25% N through FYM except test weight during first year of experiments and superior over 50% RDF – through inorganic fertilizer + 50% N through FYM. This might be due to enhanced tillering, photosynthetic area and increased in sink size due to availability of higher quantity of nitrogen at higher level. A similar research finding was reported by Nehra *et al.* (2001) [4]. All weed management practices produced significantly higher number of effective tillers m^{-2}, number of spikelets ear^{-1}, number of grains ear^{-1} and 1000-grain over weedy check while length of spike was found non-significant but numerically higher with weed management practices over weedy check. Weed free upto 60 days produce maximum values of all these characters being at par with Sulfosulfuron + Metsulfuron @ (30 g a.i. + 4 g a.i. ha^{-1}), - Clodinafop + Metsulfuron @ (60 g a.i. + 4 g a.i. ha^{-1}) and superior over weedy check. The treatment combinations F_1W_4 (100% RDF + weed free upto 60 days) was recorded maximum value of grain yield, straw yield, biological yield (Table-2). Similar findings were reported by Tomar and Vivek (2003) [10].

Effect on economics

The cost of cultivation (Table-3) varied with fertility levels and weed management practices. The maximum cost of cultivation (Rs 38290.00 and 37267.00 $ha^{-1)}$ was recorded with treatment combination F_3W_4 (50% RDF – through

inorganic fertilizer + 50% N through FYM + Weed free upto 60 Days) due to high input cost and minimum cost of cultivation (Rs 33615.00 and 32022.00 ha^{-1}) was noted with treatment combination F_1W_5 (100% RDF – through inorganic fertilizer + Weedy check) respectively, during both the years due to low cost of input.

The maximumt gross return (Rs 107490.00 and 116340.00 ha^{-1}) and net return (Rs 72135.00 and 82578.00 ha^{-1}) was recorded under the treatment combination F_1W_4 (100% RDF – through inorganic fertilizer + Weed free upto 60 days) followed by treatment combination F_1W_1 (100% RDF – through inorganic fertilizer + Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}) and minimum gross return (Rs 59802.00 and 64795.00 ha^{-1}) and net return (Rs. 23252.00 and Rs. 29268.00) was recorded under the treatment combination F_3W_5 (50% RDF – through inorganic fertilizer + 50% N through FYM + Weedy check) respectively, during both the year (Table-3). Similar findings were reported by Pandey *et al.* (2006) [5].

Maximum benefit cost ratio (2.05 and 2.45) was obtained with treatment combination F_1W_1 (100% RDF – through inorganic fertilizer + Sulfosulfuron @ 30 g a.i. ha^{-1} + Metsulfuron @ 4 g a.i. ha^{-1}) followed by treatment combination F_1W_4 (2.04 and 2.44) and minimum benefit cost ratio (0.63 and 0.82) was recorded under the treatment combination F_3W_5 (50% RDF – through inorganic fertilizer + 50% N through FYM + Weedy check), respectively, during both the years. Similar findings were reported by Gupta *et al.* (2007)

Table 1: Effect of different treatments on yield contributing characters of the wheat crop

Treatments	No. of effective tillers (m^{-2})		Length of spike (cm)		Number of spikelets ear^{-1}		Number of grains spike^{-1}		Test weight (g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Fertility levels										
F_1 - 100% RDF – through inorganic fertilizer	257.80	255.22	10.30	10.50	16.16	15.96	42.60	43.46	40.21	40.98
F_2 - 75% RDF – through inorganic fertilizer + 25% N through FYM	257.56	255.02	10.10	10.30	16.12	15.84	42.40	43.26	38.30	39.07
F_3 - 50% RDF – through inorganic fertilizer + 50% N through FYM	237.24	234.90	9.90	10.10	14.80	14.60	41.92	42.70	36.68	37.44
SEm±	4.686	4.730	0.151	0.140	0.299	0.235	0.672	0.638	0.574	0.743
CD at 5%	13.575	13.703	NS	NS	0.866	0.682	NS	NS	1.664	2.153
Weed management										
W_1 - Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}	260.23	257.63	10.30	10.50	16.33	16.07	44.43	45.27	40.19	41.00
W_2 - Clodinafop + Metsulfuron @ 60 g a.i. + 4 g a. i. ha^{-1}	251.33	248.80	10.10	10.30	15.73	15.47	43.80	44.67	38.30	39.08
W_3 - Mesosulfuron + Iodosulfuron @ 12.2 g a.i + 2.2 g a.i. ha^{-1}	250.53	248.07	10.00	10.20	15.67	15.47	43.40	44.27	37.28	38.03
W_4 - Weed free upto 60 DAS	261.30	258.73	10.40	10.60	16.33	16.13	44.50	45.37	40.40	41.20
W_5 - Weedy check	230.93	228.67	9.70	9.90	14.40	14.20	35.40	36.13	35.80	36.50
SEm±	6.050	6.107	0.195	0.180	0.386	0.304	0.867	0.824	0.741	0.960
CD at 5%	17.526	17.690	NS	NS	1.118	0.881	2.512	2.387	2.148	2.780

Table 2: Effect of different treatments on grain, straw, biological yield and harvest index of the wheat crop

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})		Harvest index (%)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Fertility levels								
F_1 - 100% RDF – through inorganic fertilizer	44.50	45.83	64.32	65.15	108.82	110.98	40.81	41.21
F_2 - 75% RDF – through inorganic fertilizer + 25% N through FYM	42.20	43.47	61.59	62.38	103.79	105.85	40.55	40.96
F_3 - 50% RDF – through inorganic fertilizer + 50% N through FYM	36.76	37.86	54.70	55.41	91.46	93.27	40.11	40.51
SEm±	0.740	0.912	0.968	1.200	2.122	1.649	0.614	0.727
CD at 5%	2.144	2.642	2.803	3.476	6.146	4.778	NS	NS
Weed management								
W_1 - Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a. i. ha^{-1}	46.50	47.89	66.86	67.73	113.36	115.62	41.00	41.40
W_2 - Clodinafop + Metsulfuron @ 60 g a.i. + 4 g a. i. ha^{-1}	42.27	43.53	61.61	62.42	103.88	105.95	40.67	41.07
W_3 - Mesosulfuron + Iodosulfuron @ 12.2 g a.i + 2.2 g a.i. ha^{-1}	40.67	41.89	59.80	60.56	100.47	102.45	40.46	40.87
W_4 - Weed free upto 60 DAS	47.03	48.45	67.45	68.31	114.48	116.76	41.06	41.48
W_5 - Weedy check	29.30	30.18	45.29	45.88	74.59	76.06	39.27	39.67
SEm±	0.955	1.177	1.249	1.549	2.739	2.129	0.793	0.938
CD at 5%	2.768	3.411	3.619	4.487	7.935	6.169	NS	NS

Table 3: Effect of different treatments on total cost of cultivation, gross return, net return and net return Re^{-1} (B:C)

Treatment combinations	Total cost of cultivation (Rs ha^{-1})		Gross returns (Rs ha^{-1})		Net returns (Rs ha^{-1})		B:C	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
F_1W_1	34990	33397	106551	115355	71561	81958	2.05	2.45
F_1W_2	34927	33334	99216	107424	64289	74090	1.85	2.22
F_1W_3	35195	33602	96204	104203	61009	70601	1.74	2.10

F_1W_4	35355	33762	107490	116340	72135	82578	2.04	2.44
F_1W_5	33615	32022	69000	74763	35385	42741	1.05	1.33
F_2W_1	36458	35149	100899	109226	64441	74077	1.76	2.10
F_2W_2	36395	35086	95615	103557	59220	68471	1.62	1.95
F_2W_3	36663	35354	92030	99654	55367	64300	1.51	1.81
F_2W_4	36823	35514	102345	110823	65522	75309	1.77	2.12
F_2W_5	35083	33774	64185	69610	29102	35836	0.82	1.06
F_3W_1	37925	36902	92061	99714	54136	62812	1.42	1.70
F_3W_2	37862	36839	78548	85080	40686	48241	1.07	1.30
F_3W_3	38130	37107	75497	81777	37367	44670	0.97	1.20
F_3W_4	38290	37267	92873	100590	54583	63323	1.42	1.69
F_3W_5	36550	35527	59802	64795	23252	29268	0.63	0.82

In conclusion, based on two year experiments conducted at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya, U. P. found better results of treatment combinations of F_1W_4 (100% RDF + Weed free upto 60 days) in respect to maximum value of grain yield, straw yield, biological yield, gross returns and net returns during both the years. Higher benefit cost ratio was recorded with the treatment combinations of F_1W_1 (100% RDF + Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1}). Thus, it may be concluded that application of 100% recommended dose of NPK ha^{-1} with Sulfosulfuron + Metsulfuron @ 30 g a.i. + 4 g a.i. ha^{-1} as proved most superior to other treatment in respect to higher benefit cast ratio of wheat crop.

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