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Studies on effect of nitrogen and weed management on yield and economics of late sown wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted during *rabi* season of 2014-15 and 2015-16 with an objective to assess the economic feasibility of various treatment combinations. The experiment was laid out in Split plot design with 16 treatment combinations *viz.* F_1:RDN (120 Kgha^{-1}), F_2:25% N FYM+75% N through chemical fertilizer, F_3:50% N FYM+50% N through chemical fertilizer, F_4:75% N FYM+25% N through chemical fertilizer under nitrogen management practices in main plot and W_0:Weedy check, W_1:Weed free, W_2:VESTA (Clodinafop 15% + metsulfuron methyl 1%), W_3:TOTAL (Sulfosulfuron 75% + metsulfuron methyl 5%) under weed management treatments in sub plot with three replications. Results revealed that the treatment F_1:100% RDF was found significantly superior over rest of the treatments in all aspects of yield and yield attributes. The length of spike and test weight (1000-grain weight) was found non-significant. No. of grains spike^{-1}, maximum grain & straw yield was recorded with F_1 100% RDF which was significantly superior over rest of the treatments and remained at par with F_2 25% N-FYM + 75% N through chemical fertilizer under nitrogen management practices while the application of herbicide VESTA 400 g (Clodinafop 15% + metsulfuron methyl 1%) given maximum yield and yield attributing characters remained at par with TOTAL 32 g (Sulfosulfuron 75% + metsulfuron methyl 5%) and found significantly superior over rest of the treatments. The treatment combination F_1W_2:100% RDF along with VESTA 400 g (clodianfop 15% + metsulfuron methyl 1%) was found maximum with respect to net income and B-C ratio over rest of the treatment combinations.

Keywords: Nitrogen management, Weed management, FYM, Yield, Economics, Late sown wheat

Introduction
Wheat (*Triticum aestivum* L.) is a staple food of the world and comes under Poaceae family. It is *rabi* season crop primarily grown in temperate regions and also at higher altitude under tropical climatic areas in winter season. It is the single most important cereal crop that has been considered as integral component of the food security system of the several nations. It ranks first in the world among the cereals both in respect of area (225.07 m ha) and production (736.98 m tonnes). In India, total area under wheat is 31.72 m ha with the production and productivity of 96.0 m tonnes and 3.13 tonnes ha^{-1}, respectively (USDA, 2017) [23].
Major wheat producing countries in the world are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. As far as India is concerned, about 90% of the total wheat production is contributed by northern states. Among them, Uttar Pradesh ranks first with respect to area (9.75 m ha) and production (30.30 m tonnes) but the productivity is much lower (3113 kgha^{-1}) than Punjab (5097 kgha^{-1}) and Haryana (5182 kgha^{-1}) (Anonymous, 2015). The productivity of wheat in eastern U.P. is very low (2500 kgha^{-1}) might be due to adoption of cereal-cereal (Rice-Wheat) cropping system, late sowing, poor weed management and imbalance fertilization, etc. Among these causes of low productivity, reduction in wheat yield has been very substantial due to the infestation of weeds. Weeds are the major problem in yield and quality of wheat crop. Weeds are considered as one of the major constraints in wheat cultivation. The prominent weeds noted in wheat fields are *Phalaris minor*, *Chenopodium album*, *Anagallis arvensis*, *Avena fatua*, *Convolvulus arvensis*, *Lathyrus aphaca*, *Cyperus rotundus* and *Cynodon dactylon* etc. which alone cause 33 per cent reduction in wheat yield.
The late transplanting of rice or use of long duration varieties of rice in low land delays the sowing of wheat from mid November to December. The preceding crops such as sugarcane, potato, toria etc. and other factors forced to sow the wheat as late as in the month of December and January. Due to delay sowing wheat yield is declined drastically.

Low temperature, poor mineral accumulation, less translocation of photosynthates from source to sink, hot desiccating wind during milking stage forced premature drying, unsuitable location specific varieties, imbalanced nutrient management are responsible for low yield under late sown wheat.

It is well known that management practices with organic materials influence agricultural sustainability by improving physical, chemical and biological properties of soils. Wastes of animal and plant origin are one of the major under-utilized resources in many countries (Jeyabal and Kuppsuwamy, 2001) and these organic wastes could easily be used in agriculture.

However, modern chemical based agriculture practices have led to several new challenges, *viz.*, declining productivity, degradation of soil and water resources, diminishing biodiversity and increase in environmental pollution. Under such situation organic nutrient management has significant role in improving productivity of crop and soil fertility. Continuous use of chemical fertilizer has increased the crop yield, but caused many environmental problems including soil, air and water pollution and finally human health hazard and making the crop productivity unsustainable (Eid *et al.* 2006). Application of organo–inorganic combination is very effective in realization of high yield and high responses to added nutrients. Incorporation of farm waste as biological as well as practice of green manuring in cereals is viable options, which improves the productivity and partially substitutes the fertilizer nitrogen requirement of the subsequent crop. Organic manures provide regulate supply of N by releasing it slowly resulting in increased yield of crop and nutrient use efficiency (Sharma 2002) [17]. Keeping all above facts in view the present study was undertaken to assess the economic feasibility of various treatment combinations.

Materials and Methods

The present investigation entitled "Effect of nitrogen and weed management on performance of late sown wheat" was under taken during *rabi* 2014-15 and 2015-16 initiated at the Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The experiment was conducted which is situated on Faizabad-Raibarely road about 42 km away from Faizabad. The experimental site falls under subtropical climate in Indo-Gangetic plains having alluvial calcareous soil and lies between 26°47' North latitude and 82°12' East longitude at an altitude of 113m from mean sea level. The region receives annual rainfall ranging from 1000-1200 mm and 90 per cent of which is received in Mid-June to end of September. The soil of the experimental field was silt loam, having of pH 8.15 & 8.21, organic carbon (%) 0.38 & 0.40, available N, P and K 115.47 & 126.46 kgha^{-1}, 15.60 & 17.22 kgha^{-1} and 245.46 & 250.47 kgha^{-1} respectively. The sowing was done on 26th Dec. 2014 and 20th Dec. 2015 using wheat cultivar HUW-234 at the spacing of 20x20 cm. There are 4 main plot and 4 sub plot as detailed below:

Main plots are F_1: RDN (120 Kgha^{-1}), F_2:25% N FYM+75% N through chemical fertilizer, F_3: 50% N FYM+50% N through chemical fertilizer, F_4: 75% N FYM+25% N through chemical fertilizer and under sub plots treatments are W_0: Weedy check, W_1: Weed free, W_2: VESTA (Clodinafop 15% + metsulfuron methyl 1%), W_3: TOTAL (Sulfosulfuron 75% + metsulfuron methyl 5%).

Observations were recorded at the time of harvesting and grain yield was recorded after threshing of rice. Five ear head were sampled from the tagged plants in each plot and then length was measured in centimeter. The average length of ear head was calculated. The total number of grains of ten selected spikes were counted and averaged to get the number of grains spike^{-1}. A random sample of grains was drawn from grain yield of each plot. From this sample, 1000-grain were counted at random and their weight (g) was recorded. Threshed grains were separated out manually and grains were sun dried to moisture of 12 % before recording their weight. Straw yield was recorded by subtracting the weight of grains from the weight of each net plot. Harvest index of each plot was calculated with the help of following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (q/ha)}}{\text{Total biological yield (q/ha)}} \text{x100}$$

Soil pH was determined with the help of glass electrode pH meter in 1:2.5 soil water suspensions as described by Jackson (1973) [5]. Electrical conductivity was determined with the help of EC meter in 1:2.5 soil water suspensions as described by Jackson (1973) [5]. Organic carbon was determined with the help Walkley and Black's rapid titration method as advocated by Walkley and Black's (1934). The available nitrogen content in soil samples was determined by alkaline permanganate method as described by Subbiah and Asija (1956). The available phosphorus in soil determined by Olsen's method as per procedure described by Olsen's *et al.* (1954). The available potassium in soil was determined by Morgan's method as advocated by Jackson (1973) [5].

Results and Discussion

Yield and yield attributes

The yield attribute data are present in (Table-1) which clearly shows that the Treatment F_1 (100% RDF) was recorded best treatment amongst all of the rest treatments. Treatment F_1 100% RDF was found significantly superior over rest of the treatments and being at par with F_2 (25% N-FYM + 75% N through chemical fertilizer) with respect to number of grains spike^{-1} whereas, the length of spike and test weight (g) was found non-significant during both the years under nitrogen management practices. The yield contributing characters viz., length of spike, number of grains spike-1, test weight (1000-grain weight) increased but not to a level of significantly different, except number of grains spike^{-1}. The number of grains spike^{-1} increased significantly with 100% RDF which was par with 25% N FYM + 75% N through chemical fertilizer. This might be due to enhanced tillering, photosynthetic area and increased sink size in presence of adequate nitrogen. Similar research findings were reported by Singh and Singh (1989) [19], Patel *et al.* (1994) [14] and Patel *et al.* (1995) [13]. Application of VESTA 400 g (clodinafop 15% + MSM 1%) found significantly superior over other treatments and being at par with TOTAL (Sulfosulfuron 75% + MSM 5%) during both the years of investigation. To some extent, spike length is a genetic trait but at the same time environmental factors may also affect the yield attributes and yield especially spike length and test weight. As far as the 1000-grain weight or test weight was concerned, it was not affected significantly due to different weed control treatment as it is directly related with genetic behaviour of the crop or variety. However, highest test weight was recorded with VESTA 400 g ha^{-1} *fb* TOTAL 32 g ha^{-1} although differences were not significant. The data regarding grain and straw yield presented in (Table-2) reveal that grain yield and straw yield was influenced due to nitrogen management treatments. The maximum grain yield of (37.64 and 38.48 q ha^{-1}) was recorded with 100% RDF being at par with 25% N FYM + 75% N through chemical fertilizer (35.75 and 36.54 q ha^{-1}) with during both the years which was significantly superior over rest of the treatments under nitrogen management practices. This might be due to more spike length, number of grains spike^{-1}, grain weight spike^{-1} and 1000-grain weight. Similar findings were reported by Nakhtore and Kewat (1989) as well as Jain and Jain (1993). Under weed management treatments, the grain yield obtained with different herbicides application indicated that the maximum grain yield was recorded with VESTA (Clodinafop propargyl 15% + MSM 1%) (37.97 and 39.21 q ha-1) followed by TOTAL (Sulfosulfuron 75% + MSM 5%) (36.52 and 37.91 q ha-1) during both the respective years. Application of VESTA (Clodinafop propargyl 15% + MSM 1%) was found significantly superiority over other treatments and being at par with TOTAL (Sulfosulfuron 75% + MSM 5%) during both the years. However, maximum and minimum grain yield found with weed free and weedy check, respectively. It might be because of the fact that these both the herbicides have the potential to control both type of weeds more effectively. The same trend was also found with straw yield. The maximum straw yield (54.03 and 56.16 q ha^{-1}) recorded with 100% RDF followed by (51.79 and 52.75 q ha^{-1}) with 25% N FYM + 75% N through chemical fertilizer. Application of 100% RDF being at par with 25% N FYM + 75% N through chemical fertilizer produced significantly higher straw yield during the both years under nitrogen management practices. Straw yield was influenced significantly with 100% RDF. This may be probably due to higher shoots and increased rate of dry matter accumulation. Roy *et al.* (1991) also reported similar results. Under weed management treatments, the maximum straw yield was recorded (51.31 and 53.22 q ha-1) with application of VESTA (Clodinafop propargyl 15% + MSM 1%) herbicide followed by (51.11 and 53.14 q ha-1) with application of TOTAL (Sulfosulfuron 75% + MSM 5%) during respective years. However, maximum and minimum straw yield found with weed free and weedy check, respectively. Straw yield is the fraction of total biological yield which is contributed by the net photosynthates in the form of dry matter accumulation. The treatments in which dry mater accumulation of the crop was higher also gave the higher value of the straw yield. In this experiment VESTA 400 g ha^{-1} *fb* Total 32g ha^{-1} being at par, recorded significantly higher levels of straw yield over rest of the treatments. The possible reason may be same as given in case of grain yield. These results are in conformity with the work done at Faizabad (Anonymous, 2013). The Harvest Index (HI) data are presented in (Table-2). A cursory glance over the data revealed that the highest harvest index of 41.8 and 41.4 per cent during both the years, respectively was recorded with 50% N FYM + 50% N through chemical fertilizer and 75% N FYM + 25% N through chemical fertilizer while it was recorded lowest with RDF 100% application during both the year of study. Harvest index of wheat was not affected significantly due to nitrogen management practices. Similar results were given by Singh (1998) [18]. A cursory glance over the data revealed that the highest harvest index was recorded with VESTA (Clodinafop propargyl 15% + MSM 1%), while it was recorded lowest in weedy check during both the year of study. The highest value of HI was recorded with VESTA 400 g ha-1 (42.5 and 42.4 %) fb weed free (41.9 and 41.7%), Overall, different weed control treatments did influenced the HI to greater extent.

FYM being store-house of both macro and micro nutrients which might have enhanced the metabolic process vis-à-vis enlarged source and sink capacity, which ultimately enhanced the grain and straw yields. The results are in agreement with those of the fording of Sowmya *et al.* (2011) [21], Singh *et al.* (2011) [20].

Table 1: Effect of nitrogen and weed management on yield attributes of wheat crop

Treatments	Length of spike (cm)		No. of grains spike^{-1}		Test weight (g)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Nitrogen management (Main plot)						
F_1	7.96	8.52	36.77	38.15	34.89	35.24
F_2	7.71	8.25	34.36	35.74	34.54	34.88
F_3	7.67	8.20	32.34	33.03	34.19	34.54
F_4	7.22	7.72	30.53	31.68	33.85	34.19
SEm±	0.14	0.19	0.62	0.76	0.81	0.66
CD at 5%	NS	NS	2.47	3.01	NS	NS
Weed management (Sub plot)						
W_0	6.80	7.28	30.48	31.87	34.38	34.72
W_1	8.29	8.87	35.73	36.95	34.68	35.02
W_2	7.76	8.33	34.57	35.78	34.28	34.62
W_3	7.58	8.11	33.22	34.01	34.13	34.48
SEm±	0.18	0.17	0.78	0.72	0.86	0.79
CD at 5%	0.52	0.50	2.25	2.08	NS	NS

Where

F_1	:	RDN (120 kgha^{-1})	W_0	:	Weedy check
F_2	:	25% N through FYM + 75% N chemical fertilizer	W_1	:	Weed free
F_3		50% N through FYM + 50% N chemical fertilizer	W_2		VESTA (Clodinafop 15% + MSM 1%)
F_4		75% N through FYM + 25% N chemical fertilizer	W_3	:	Total (sulfosulfuron + Metsulfuron methyl)

Table 2: Effect of nitrogen and weed management on grain and straw yield and harvest index of crop.

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Harvest index (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Nitrogen management (Main plot)						
F_1	37.64	38.48	54.03	56.16	41.1	40.7

F_2	35.75	36.54	51.79	52.75	41.2	40.9
F_3	33.85	34.60	47.13	48.98	41.8	41.4
F_4	32.72	33.43	45.53	47.32	41.8	41.4
SEm±	0.80	0.67	1.18	0.96	-	-
CD at 5%	3.15	2.64	4.65	3.79	-	-
Weed management (Sub plot)						
W_0	24.82	25.65	39.30	41.09	38.7	38.4
W_1	39.64	40.65	54.75	56.78	41.9	41.7
W_2	37.97	39.21	51.31	53.22	42.5	42.4
W_3	36.52	37.91	51.11	53.14	41.7	41.6
SEm±	0.88	0.89	1.05	1.21	-	-
CD at 5%	2.53	2.55	3.02	3.48	-	-

Where,

F_1 : RDN (120 kgha^{-1})
F_2 : 25% N through FYM + 75% N chemical fertilizer
F_3 50% N through FYM + 50% N chemical fertilizer
F_4 75% N through FYM + 25% N chemical fertilizer

W_0 : Weedy check
W_1 : Weed free
W_2 VESTA (Clodinafop 15% + MSM 1%)
W_3 : Total (sulfosulfuron + Metsulfuron methyl)

Table 3: Economics of cost of cultivation, gross income, net income and net return Re^{-1} (B:C) invested as influenced by nitrogen and weed management in wheat crop.

Treatment combination	Total cost of cultivation		Gross income		Net income		B:C	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
F_1W_0	30170	31170	63382	69107	33212	37937	1.10	1.22
F_1W_1	36170	37170	90433	99485	54263	62315	1.50	1.68
F_1W_2	31845	32845	86144	94809	54299	60439	1.71	1.89
F_1W_3	31782	32782	84643	91793	52861	59011	1.66	1.80
F_2W_0	30190	31190	60377	65262	30187	34072	1.00	1.09
F_2W_1	36190	37190	85156	93644	48966	56454	1.35	1.52
F_2W_2	31865	32865	81967	89680	50102	56815	1.57	1.73
F_2W_3	31802	32802	78986	86455	47184	53653	1.48	1.64
F_3W_0	30210	31210	57058	62093	26848	30883	0.89	0.99
F_3W_1	36210	37210	80681	88713	44471	51503	1.23	1.38
F_3W_2	31885	32885	75272	82866	43387	49981	1.36	1.52
F_3W_3	31822	32822	73410	80140	41588	47318	1.31	1.44
F_4W_0	30230	31230	55331	60173	25101	28943	0.83	0.93
F_4W_1	36230	37230	77994	85764	41764	48534	1.15	1.30
F_4W_2	31905	32905	72662	80009	40757	47104	1.28	1.43
F_4W_3	31842	32842	70976	77445	39134	44603	1.23	1.36

Economics

The maximum gross income (Rs.90433 and Rs.99485) was recorded with treatment combination F_1W_1 (100% RDF + Weed free) and lowest recorded (Rs. 55331 and Rs. 60173) was under F_4W_0 (75% N FYM + 25% N through chemical fertilizer + weedy check) during 2014-15 and 2015-16, respectively. The maximum net income of (Rs. 54299 and Rs. 60439) was calculated under F_1W_2 (100% RDF + VESTA (clodinafop 15% + MSM 1%) and minimum net income (Rs. 25101 and Rs. 28943) was recorded with the treatment combination F_4W_0 (75% N FYM + 25% N through chemical fertilizer + weedy check). It was due to the lower yield value as compared to value of input required to apply in crop. The data further revealed that the highest benefit-cost ratio (1.71 and 1.89) was obtained with the treatment combination F_1W_2 (100% RDF + VESTA (clodinafop 15% + MSM 1%), while lowest benefit-cost ratio of (0.83 and 0.93) was noted with the treatment combination F_4W_0 (75% N FYM + 25% N through chemical fertilizer + weedy check) during both the years.

On the basis of experiment, it may be concluded that 100% RDF combined with VESTA 400 g ha^{-1} (Clodinafop propargyl 15% + metsulfuron methyl 1%) (60+4g) at 31 DAS proved superior with respect to grain yield (37.97 and 38.94 q ha-1) and economics (Net return Rs. 54299 ha^{-1} and Rs. 60439 ha^{-1} and (BCR Rs. 1.71 and Rs. 1.89) of wheat over rest of the treatment combinations.

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