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Research Article

STUDIES ON TILLAGE AND NUTRIENT MANAGEMENT FOR ENHANCING PRODUCTIVITY AND PROFITABILITY OF WHEAT (*Triticum aestivum* L.)

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Abstract- A field experiment was conducted during *Rabi season* 2014-15 on *'Vertisol' in* kymore plateau and Satpura hills Agro-climatic zone of Madhya Pradesh to study the effect of tillage and nutrient management on productivity and profitability of wheat (*Triticum aestivum* L.).Treatments comprising 4 tillage management (main plots) *viz.,* conventional tillage(TM_1), minimum tillage with broad bed furrow(TM_2), minimum tillage with roto-seed drill (TM_3) and zero tillage (TM_4) and 6 nutrient management (sub-plots) *viz.,* 100% RDF through inorganic fertilizer (NM_1), 75% RDF inorganic+25% organic manure(NM_2), 50% RDF inorganic+50% organic manure (NM_3), 25% RDF inorganic+75% organic manure (NM_4), 100% RDF through organic manure (NM_5) and Control (NM_6).The experiment was laid out in a Split plot design with 3 replications. Among tillage management treatments, significantly higher grain and straw yields, harvest index, Production efficiency and gross monetary returns (GMR) were registered under conventional tillage followed by zero tillage. However just reverse result was found in terms of net monetary returns and benefit: cost ratio. Similarly under nutrient management, treatments where 75% recommended inorganic fertilizer was applied along with+25% organic manure proved significantly superior over 25% RDF inorganic+75% organic manure, 100% organically treated plots and Control but found at par with 100% RDF through inorganic fertilizer and 50% RDF inorganic+50% organic manure in terms of grain and straw yields, harvest index, Production efficiency and gross monetary returns (GMR). However, maximum net monetary returns (NMR) and benefit: cost ratio were observed under 100% chemical fertilizers alone and followed by 75% RDF inorganic+25% organic manure treatments. Hence, the benefit: cost ratio of wheat was decreased with supplementation of recommended dose of fertilizer with increased rate of organic manures. But owing to the beneficial effect of organic manures on soil health, wheat can be grown under zero tillage condition with combined application of nutrient sources 75% RDF inorganic fertilizer+25% organic manure for getting higher production and net returns.

Keywords- Tillage, Nutrient, Productivity, profitability, Wheat

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Introduction

India achieved remarkable progress in wheat production during the last four decades with the production touching a record level of 95.91 million tonnes from an area of around 31.19 million ha^{-1} with productivity of 3.07 tonnes ha^{-1} [1]. Production has increased tremendously, but is still far below the potential yield of 11.2 tonnes ha^{-1} [2]. In MP, wheat was cultivated on 5.79 million ha area with the production of 13.93 million tonne and the productivity of 2.40 tonne ha^{-1} [1]. Hence, productivity of wheat in the state is (0.67 tonne ha^{-1}) lower than the national average. In spite of record wheat production, future need to feed the ever-increasing population will be rigorous to achieve food and nutritional security of India. Thus, the importance of wheat production is increasing day by day because of rising population with shrinking arable land. Therefore, to ensure food security, the country has to produce 105 million tonnes of wheat by 2025, demanding an average growth rate of 4% per annum [3].

Conventional agricultural system, mainly involves improved crop varieties, higher level of production inputs like fuel for land preparation, synthetic fertilizers, irrigation water and chemicals etc. Such inputs, substantially increased the food grain production and at the same time leads to deterioration of soil health and productivity too [4]. Total removal of NPK nutrient from the soil was estimated about 28-30 million tonnes in India. However, only 18-20 million tonnes of NPK are added to the soil from all the sources. Thus, a deficit of 10 million tonnes annually takes place [5], which can be met through organic sources. Price escalation of chemical fertilizers has also lead to emphases on supplementation or substitution of chemical fertilizers with organic manures through integrated nutrient management approach. Because this approach reduces the application of chemical fertilizers and cost of cultivation. Therefore, integrated management of organic and inorganic fertilizers is advocated to meet the nutrient needs, improve soil quality, and to obtain sustainable and higher yields of wheat.

Today's real agricultural challenges are resource fatigue with declining factor productivity, decreasing human resources and their rising costs and socio-economic changes. With the use of second generation drills and planters i.e. Zero till seed-cum-fertilizer drill, roto-seed drill, broad bed furrows (BBF), raised bed planter, happy seeder etc. ensures reduction in the cost of cultivation due to saving of land preparation cost and fetched higher returns with conservation of resources *viz.*, diesel, nutrients, water and labour. Thus, the high cost of cultivation associated with conventional tillage can be reduced with the use of zero

or minimum-tillage with residue retention (more than 30 per cent of crop residue) is needed to ensure production sustainability. Improved agricultural implements not only save cost but also help to improve soil manipulation resulting in less intensity of weeds, better germination and root growth, higher yield and profitability. It is therefore, essential to identify and quantify the suitable tillage and nutrient management, which can minimize the consumption of time, money and labour as well as sustain the productivity and profitability of wheat without loss of natural resources. Keeping in view of the above facts, the present experiment entitled "Studies on tillage and nutrient management for enhancing productivity and profitability of wheat" was conducted.

Materials and Methods

The field experiment was conducted during *Rabi season* 2014-15 on *'Vertisol'* at breeder seed production (Field crop) unit of JNKVV, Jabalpur (23° 90' N and 70° 90' E with an altitude of 411.78 m above the mean sea-level). It enjoys sub-humid and tropical climate with hot dry summer and cool dry winters and comes under kymore plateau and Satpura hills Agro-climatic zone of Madhya Pradesh. The soil was clay loam in texture, having neutral (7.1) pH and normal in electrical conductivity (0.38 dS/m) with low in available nitrogen (236.84kg/ha), medium in available phosphorus (17.78 kg/ha), potassium (311.62kg/ha) and organic carbon (0.64%) contents.

The experiment was laid out in a Split plot design with 3 replications. Treatments comprising 4 tillage management (main plots) *viz.*, conventional tillage (TM_1), minimum tillage with broad bed furrow(TM_2), minimum tillage with roto-seed drill (TM_3) and zero tillage(TM_4) and 6 nutrient management (sub-plots) *viz.,* 100% RDF through inorganic fertilizer (NM_1), 75% RDF inorganic+25% organic manure(NM_2), 50% RDF inorganic +50% organic manure (NM_3), 25% RDF inorganic +75% organic manure (NM_4), 100% RDF through organic manure(NM_5) and Control(NM_6).

Fertilizers were given as per nutrient management treatments through urea, single super phosphate (SSP) and muriate of potash (MOP) at the rate of 120:60:40 kg NPK per hectare. Full quantity of P_2O_5 and K_2O were given as basal dose at the time of sowing to the entire treatments except control plot (NM_6) and 100% organic manure treatment (NM_5). Half of the nitrogen was given as basal and remaining half of the nitrogen was top dressed in two equal splits just after two days of the first and second irrigation. In the treatment of 100% organic manure (NM_5) and integrated nutrient management (NM_2, NM_3 and NM_4), the quantity of organic manure as vermicompost was applied one week before sowing. The quantity of organic manure (vermicompost with 1.6 % N on dry weight basis) was applied on equivalent N basis i.e. 100% recommended dose of nitrogen in wheat (120 kg ha^{-1}). Wheat (Variety GW 273) was sown on 2nd December 2014 and harvested on 7th April 2015. The details of the tillage management treatments were:

i) Conventional Tillage (TM_1): Fields was prepared by running two pass of tractor driven cultivator followed by two disc harrowing and then one levelling with the help of planker. After this, sowing of seeds was done with tractor driven normal seed drill by using 100kg seeds ha^{-1}.

ii) Minimum tillage with BBF (TM_2): The respective plots were prepared with the help of one pass cultivator followed by one levelling. After this, tractor driven broad bed from furrow (BBF) was used for sowing 100 kg seeds ha^{-1}.

iii) Minimum tillage with roto-seed drill (TM_3): Field was prepared by one pass cultivator followed by one levelling. Then after, tractor driven roto-seed drill was used for sowing of 100 kg seeds ha^{-1} under this method.

iv) Zero tillage (TM_4): Direct sowing of seeds with seed rate of 100 kg ha^{-1} was done without tilling the land with the help of tractor driven specially designed zero seed cum fertilizer drill at optimum soil moisture under this method. The plots were lightly irrigated after harvest of *kharif* rice.

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Result and Discussion

Effect of tillage and nutrient management on productivity of wheat

Grain yield of wheat: Different tillage management treatments had significant effect on grain yield of wheat. The grain yield ranged from 35.95 to 38.31q/ha [Table-1] under different treatments. Significantly higher grain yield (38.31q/ha) was registered under conventional tillage and proved significantly superior over all other tillage packages next highest grain yield of 37.58 q/ha was obtained in zero tillage, which was significantly superior to minimum tillage with BBF (36.54 q/ha) and minimum tillage with Roto-seed drill (35.95 q/ha). However, both the minimum tillage remained statistically at par in relation to grain yield. The grain yield was higher under conventional tillage followed by zero tillage. This might be due to the better conducive rhizosphere environment for higher uptake of nutrients and in turn boost up the growth, leading to the development of higher yield attributes through supply of more photosynthates towards the sink. The results are in close conformity with the finding of [6].

Grain yield of wheat increased significantly with the application of chemical fertilizers, organic manures and integrated use of both the sources over control. The results showed that the wheat grain yield ranged between 12.37 to 46.50 q/ha [Table-1] under different nutrient management treatments. Maximum grain yield (46.50 q/ha) was recorded in plots where 75% recommended inorganic fertilizer was applied along with + 25% organic manure (NM_2) and proved significantly superior over 25% RDF inorganic +75% organic manure (NM_4), 100% organically treated plots (NM_5) and Control (NM_6) which had 20.31, 24.87 and 275.91% lower grain yields over (NM_2) but found at par with 100% RDF through inorganic fertilizer (44.33 q/ha) and 50% RDF inorganic+50% organic manure (43.48 q/ha). Grain yield in control plots was significantly lower than the treatments where inorganic fertilizers or organic manure was used alone or integrated use of both organic and inorganic sources of nutrients was made. Thus, wheat crop responded significantly to combine the application of organic manure and inorganic fertilizers as compared to control and resulted in savings of more than 25% chemical fertilizers. The increase in grain yield might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period, resulting in a favorable increase in yield attributing characters, which ultimately led towards an increase in economic yield. The organic manures besides providing essential nutrients to crop also improve the soil properties and inorganic fertilizers supply nutrients to synchronize with crop nutrient demand. Application of recommended fertilizer produced significantly higher grain yields than plots receiving organic manure alone. It may be because of the fact that organic sources are not able to release the nutrients synchronizing with the peak crop requirement because of their slow mineralization rate at low temperature during winter. Similar results were observed by [7,8].

Straw yield of wheat: Wheat straw yield more or less followed the same trends as the wheat grain yield. Among the various tillage management treatments, straw yield recorded under minimum tillage with BBF (44.71 q/ha) and minimum tillage with roto-seed drill (44.61q/ha) was statistically at par [Table-1], whereas conventional tillage recorded significantly higher straw yield (46.01q/ha) than the zero tillage (45.40 q/ha) and both of the minimum tillage. Also zero tillage proved significantly superior over later treatments in terms of straw yield.

The straw yield ranged from 22.96 to 53.25 q/ha under different nutrient management treatments, being highest (53.25 q/ha) in plots where application of 75% RDF in combination with 25% organic manure was made. It had significantly higher straw yield than NM_4 (46.79 q/ha), NM_5 (45.66 q/ha) and Control (22.96 q/ha) but showed a non-significant differences with NM_1 (51.41q/ha) and NM_3 (51.03q/ha). Significantly, higher straw yield was found in the 100% RDF treatments than plots receiving 100% organic manure alone. Straw yield is a function of vegetative growth. The increase in growth and yield owing to the application of inorganic fertilizer may be attributed to the fact that this nutrient being important constituents of nucleotides, proteins, chlorophyll and enzymes, involves in various metabolic processes which have direct impact on vegetative and reproductive phase of plants. These findings confirmed by the result [7,9].

Harvest index: Harvest index of wheat was varied significantly due to different tillage management treatments. Conventional tillage (44.38 %) registered highest harvest index and found at par with zero tillage (44.26 %) but differed significantly over minimum tillage with BBF (43.87%) and minimum tillage with roto-seed drill (43.55 %) however, harvest index of former minimum tillage was similar to later and zero tillage too.

The varying nutrient management practice *i.e.* Chemical fertilizers or organic

manures alone and integrated use of both the sources brought about marked variation on harvest index of wheat. Harvest index range from 35.01 to 46.61% [Table-1]. Significantly higher harvest index of wheat was obtained with the application of 75% RDF in combination with 25% organic manure (46.61 %) and proved significantly superior over NM_4, NM_5 and Control. However, NM_1 and NM_3 were statistically similar in terms of harvest index as they did not exert significant effect on harvest index. The results are in close agreement with the findings of [9,10].

Production efficiency: Among tillage management treatments, maximum production efficiency (30.16 kg/ha/day) was obtained under conventional tillage which was significantly higher by 1.89, 4.60 and 6.13% over zero tillage, minimum tillage with BBF and minimum tillage with roto-seed drill respectively. However, both of the minimum tillage treatments were significantly lower than zero tillage in terms of Production efficiency.

Similarly, under nutrient management practice, 75% RDF inorganic +25% organic manure (NM_2) also showed higher production efficiency (36.61 kg/ha/day) which was statistically at par with 100% RDF through inorganic fertilizer (34.90 kg/ha/day) and 50% RDF inorganic +50% organic manure (34.24 kg/ha/day) but proved significantly superior over 25% RDF inorganic +75% organic manure, 100% organically treated plots and control which had 20.27, 24.86 and 275.87% lower production efficiency over (NM_2). Hence, production efficiency was decreased with supplementation of recommended dose of fertilizer with increased rate of organic manures. This might be owing to higher yields obtained under former treatment compared to subsequently later treatments. These results are in conformity with findings of [11].

Table-1 *Grain and straw yield, harvest index and Production efficiency of wheat as influenced by tillage and nutrient management*

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Production efficiency (kg/ha/day)
Tillage management (Main Plots)				
Conventional tillage (TM_1)	38.31	46.01	44.38	30.16
Minimum tillage with BBF (TM_2)	36.54	44.71	43.87	28.77
Minimum tillage with roto-seed drill (TM_3)	35.95	44.61	43.55	28.31
Zero tillage (TM_4)	37.58	45.40	44.26	29.59
SEm ±	0.20	0.08	0.13	0.16
CD (p= 0.05)	0.69	0.27	0.45	0.54
Nutrient management (sub plots)				
100 % RDF through inorganic fertilizer (NM_1)	44.33	51.41	46.29	34.90
75 % RDF inorganic + 25 % organic manure (NM_2)	46.50	53.25	46.61	36.61
50 % RDF inorganic + 50% organic (NM_3)	43.48	51.03	46.02	34.24
25% RDF inorganic + 75% organic manure (NM_4)	38.65	46.79	45.23	30.44
100% RDF through organic manure (NM_5)	37.24	45.66	44.92	29.32
Control (NM_6)	12.37	22.96	35.01	9.74
SEm ±	1.10	1.37	0.21	0.87
CD (p= 0.05)	3.15	3.92	0.60	2.48

Effect of tillage and nutrient management on profitability of wheat

Cost of cultivation: The cost of cultivation of wheat was varied due to different tillage and nutrient management treatments. Among the tillage management treatments, the cost of cultivation of wheat was the lowest (Rs. 29546 /ha) under zero tillage and the highest (Rs. 33196 /ha) under conventional tillage due to more number of tillage operation. An equal cost of cultivation of Rs. 30646 /ha was found under both minimum tillage with BBF and minimum tillage with roto-seed drill. The least cost of cultivation of wheat was recorded under zero tillage due to saving in cost for land preparation than other tillage packages. Earlier worker also reported the lower cost of cultivation under zero tillage than conventional tillage in wheat [12].

The cost of cultivation of wheat under different nutrient management treatments varied from Rs. 19027 to 42607/ha [Table-2]. Higher cost of cultivation was observed with the treatment, which received the maximum amount of recommended dose of fertilizer through organic manures. Hence, cost of cultivation of wheat was increased with supplementation of recommended dose of fertilizer with increased rate of organic manures. Maximum cost of cultivation of Rs 42607 /ha was observed in the 100% organically treated plots (NM_5) followed by NM_4 (Rs.37825/ha), NM3 (Rs. 33446/ha), NM_2 (Rs. 28865/ha), NM_1 (Rs. 24285/ha) being the lowest (Rs.19027/ha) under Control where neither chemical fertilizers nor organic manures were applied. The quantity of organic manures requirement to replace inorganic fertilizer is very high and hence the cost of cultivation is higher compared to chemical fertilizers. This confirms the findings of [13].

Gross monetary returns: The Gross monetary returns (GMR) of wheat were significantly influenced due to different tillage and nutrient management treatments. Among the tillage packages, the highest GMR (Rs. 72220.49 /ha) was recorded under conventional tillage and proved significantly superior over all other tillage packages. Zero tillage treatment fetched next highest GMR value of Rs. 70933.92/ha which was significantly superior to minimum tillage with BBF (Rs. 69143.43/ha) and minimum tillage with roto-seed drill (Rs. 68205.40/ha). However, the significant differences among the both minimum tillage packages in terms of GMR did not reach to the level of significance.

The Gross monetary returns of wheat among the various nutrient management treatments varied significantly. The highest gross monetary returns was found at 75% RDF inorganic+25% organic manure (Rs. 86883.94/ha) and proved significantly superior over 25% RDF inorganic +75% organic manure (Rs. 72983.33/ha), 100% organically treated plots (Rs. 70493.31 /ha) and control (Rs. 25750.75/ha) but at par to 100% RDF through inorganic fertilizer (Rs. 83021.69 /ha) and 50% RDF inorganic +50% organic manure (Rs. 81621.83 /ha) as the statistical differences did not reach to the level of significance. It might be because of more grain and straw yield. This confirms the findings of [13].

Net monetary returns: Different tillage management treatments caused marked variation on net monetary returns (NMR). Zero tillage gave the highest net monetary returns (Rs. 41387.75/ha) which showed significantly superior over all other tillage packages. Zero tillage practice exhibited 5.71, 6.98 and 9.25% higher net returns over conventional tillage, minimum tillage with BBF and minimum tillage with roto-seed drill treatments respectively. Next highest NMR value of Rs 39024.32/ha was fetched under conventional tillage followed by minimum tillage with BBF (Rs. 38497.26 /ha) which were at par to each other and proved significantly superior over minimum tillage with roto-seed drill (Rs. 37559.24/ha). The NMR was higher under zero tillage due to lower cost of cultivation, however, under conventional tillage, it was due to more grain and straw yields.

The lowest NMR was recorded under control (Rs. 6724.25/ha) among the nutrient management treatments. However, application of 100% RDF through inorganic fertilizer gave significantly the higher net monetary returns (Rs. 58737.19/ha) followed by 75% RDF inorganic +25% organic manure (Rs. 58019.44/ha) which were at par among themselves and proved significantly superior over 50% RDF inorganic+50% organic manure (Rs. 48176.33 /ha), 25% RDF inorganic +75% organic manure (Rs. 35158.83 /ha), 100% organically treated plots (Rs. 27886.81/ha). The higher NMR under 100% chemical fertilizers alone and 75% RDF inorganic +25% organic manure was due to lower cost of cultivation and

more grain and straw yields.

Benefit: Cost ratio: It refers to the monetary gain over each rupee of investment. Among the tillage packages, the highest benefit: cost ratio of wheat (2.45) was recorded under zero tillage and proved significantly superior over all other tillage packages. Treatment having minimum tillage with BBF fetched next highest B:C ratio of 2.30 which showed non-significant differences to minimum tillage with roto-seed drill (2.27). Both the minimum tillage packages had significantly higher profitability over conventional tillage (2.21). The highest benefit: cost ratio in zero tillage is attributed to reduced cost of the tillage operation over the minimum and conventional tillage and thereby saving in operational cost, diesel and time under zero tillage. This confirms the results of [14].

The benefit: cost ratio of wheat was decreased with supplementation of recommended dose of fertilizer with increased rate of organic manures. The quantity of organic manures requirement to replace inorganic fertilizer is very high and hence, the B: C ratio is lower compared to chemical fertilizers. But owing to the beneficial effect of organic manures on soil health, the farmers need to apply the organic manures. Significantly the higher benefit: cost ratio (3.43) was obtained with the application of 100% RDF through inorganic fertilizer, followed by the treatment which received 75% RDF + 25% organic manure (3.01). The nutrient management treatments *viz.* chemical fertilizers or organic manures alone and integrated use of both the sources had significantly higher profitability over control (1.36).The profitability was minimum under control treatment obviously due to the lowest grain and straw yields. These results are in accordance with the work of [8].

It was concluded that due to shortage of time between sowing of wheat and harvesting of rice, wheat can be grown under zero tillage condition with combined application of nutrient sources 75% RDF inorganic fertilizer + 25% organic manure for getting higher production and net returns considering the soil health.

Table-2 *profitability of wheat as influenced by tillage and nutrient management*

Treatments	Cost of cultivation (Rs/ha)	Gross monetary returns (Rs/ha)	Net monetary returns(Rs/ha)	B:C ratio
Tillage management (Main Plots)				
Conventional tillage (TM_1)	33196.00	72220.49	39024.32	2.21
Minimum tillage with BBF (TM_2)	30646.00	69143.43	38497.26	2.30
Minimum tillage with roto-seed drill (TM_3)	30646.00	68205.40	37559.24	2.27
Zero tillage (TM_4)	29546.00	70933.92	41387.75	2.45
SEm ±	-	298.66	298.66	0.009
CD (p= 0.05)	-	1033.51	1033.51	0.032
Nutrient management (sub plots)				
100 % RDF through inorganic fertilizer (NM_1)	24285.00	83021.69	58737.19	3.43
75 % RDF inorganic + 25 % organic manure (NM_2)	28865.00	86883.94	58019.44	3.01
50 % RDF inorganic + 50% organic (NM_3)	33446.00	81621.83	48176.33	2.44
25% RDF inorganic + 75% organic manure (NM_4)	37825.00	72983.33	35158.83	1.93
100% RDF through organic manure (NM_5)	42607.00	70493.31	27886.81	1.66
Control (NM6)	19027.00	25750.75	6724.25	1.36
SEm ±	-	2079.51	2079.51	0.071
CD (p= 0.05)	-	5943.71	5943.71	0.203

Conflict of Interest: None declared

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