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Effect of tillage and nitrogen management on growth, yield and economics of wheat (*Triticum aestivum* L.)

Anshul Shrama[1], Rohitashv Nagar[2], Deepak Nagar[3], Narendra Kumar Bhinda[4], P. C. Choudhary[5]

School of Agricultural Sciences, Career Point University, Kota

[1]M.Sc. Agronomy Student, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: anshulsharma0741@gmail.com

[2,3,4,5] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstracts:

During the Rabi season of 2023, a field experiment was conducted at the School of Agricultural Sciences, CPU, Kota (Rajasthan), aiming to evaluate wheat productivity under different tillage systems coupled with efficient nitrogen management practices. The experiment utilized a split-plot design with three replications, where the main plots included four tillage systems (zero tillage, minimum tillage, FIRB, and conventional tillage), and sub-plots consisted of four nitrogen levels (control, RDN, SPAD, and targeted yield of 5 t/ha), resulting in a total of 16 treatment combinations.

Among the tillage systems, conventional tillage showed significant improvements in various parameters such as plant height (95.13 cm), number of tillers per meter row length (372.26), dry matter accumulation per ₹meter row length (109.7 g), tillers per square meter (73.4), seeds per ear (40.4), test weight (39.6 g), seed yield (4220 kg/ha), straw yield (6380 kg/ha), biological yield (10600 kg/ha), net return (60595 /ha), and benefit-cost ratio (1.95) compared to zero tillage and minimum tillage. Moreover, the application of recommended doses of nitrogen (RDN) at 120:80:55 kg/ha NPK significantly enhanced₹ plant height (95.47 cm), number of tillers per meter row length (370.56), dry matter accumulation per meter row length (107.5 g), tillers per square meter (73.6), seeds per ear (40.7), test weight (41.4 g), seed yield (4185 kg/ha), straw yield (6326 kg/ha), biological yield (10511 kg/ha), net return (60715 /ha), and benefit-cost ratio (1.93) compared to control and SPAD

(80:60:50 kg/ha NPK). Overall, the findings underscore the importance of conventional tillage and efficient nitrogen management, particularly through recommended doses, in optimizing wheat productivity and economic returns. These results provide valuable insights for wheat cultivation practices aimed at enhancing yield and profitability in agricultural systems.

Key words: Wheat, Tillage, Nitrogen, Economics.

I Introduction:

Wheat (Triticum aestivum L.) is one of the most important staple crops globally, serving as a primary food source for a significant portion of the world's population. The optimization of wheat production is crucial to ensuring food security and meeting the increasing demands of a growing population. Among the various agronomic practices that influence wheat production, tillage and nitrogen management play pivotal roles. Tillage is a fundamental agricultural practice that involves the mechanical manipulation of soil to prepare seedbeds, control weeds, and incorporate crop residues. Different tillage methods, ranging from conventional plowing to reduced or no-tillage systems, can significantly impact soil structure, moisture retention, and ultimately, crop performance. Understanding the effects of various tillage practices on wheat growth and yield is essential for developing sustainable and efficient farming systems.

Nitrogen is a critical nutrient for wheat, influencing its growth, development, and yield. Effective nitrogen management involves the appropriate application of nitrogen fertilizers to meet the crop's nutritional requirements while minimizing environmental impacts. The rate, timing, and method of nitrogen application can greatly affect wheat productivity and economic returns. Therefore, integrating optimized nitrogen management with suitable tillage practices is key to achieving high yields and maintaining soil health. This study aims to investigate the combined effects of different tillage practices and nitrogen management strategies on the growth, yield, and economic performance of wheat. By evaluating various tillage and nitrogen treatments, the research seeks to identify the most effective combinations that enhance wheat production while promoting sustainable agricultural practices. The findings of this study will provide valuable insights for farmers, agronomists, and policymakers to develop and implement better management practices for wheat cultivation.

II Literature Review:

Wheat (*Triticum aestivum* L.) is a crucial cereal crop belonging to the Poaceae family, pivotal in meeting around 60 percent of the world's human energy requirements. In India, wheat holds a significant position as one of the primary staple food grains, with the country ranking second globally in wheat production, following China (Usadadiya and Patel, 2013). Covering 30 million hectares of land, India's wheat cultivation yields approximately 107 million tons annually, with an average yield of 3400 kg/ha (IASRI, 2019). This crop is a vital source of protein and calories worldwide, contributing significantly to human dietary needs, with projections indicating a continued rise in demand, especially in developing nations, by 2050 (FAO STAT, 2015; Wageningen FSC, 2016).

Enhancing wheat yield and quality relies heavily on adopting optimal agronomic practices, including efficient tillage methods. Optimum tillage practices are integral in achieving high yields as they facilitate better soil structure, root penetration, and moisture retention. Tillage operations encompass physical soil manipulations aimed at weed control, residue incorporation, improved infiltration, reduced evaporation, seedbed preparation, and soil compaction alleviation. Various forms of tillage such as zero tillage, reduced tillage, and conventional tillage have been utilized, with a recent surge in popularity for zero and reduced tillage techniques. These practices not only conserve moisture but also enhance soil organic matter, reduce CO2 emissions, and address environmental concerns linked to modern agriculture.

Nitrogen stands out as a crucial element for plant growth and productivity, primarily supplied through fertilizers due to widespread soil nitrogen deficiencies. Improving nitrogen use efficiency is vital, achieved by understanding crop peak nitrogen requirement periods and uptake patterns. Efficient nitrogen application during these critical periods optimizes fertilizer utilization, minimizing environmental losses. Nitrogen plays a pivotal role in amino acid and protein synthesis, essential for normal growth and yield. Incorporating nitrogenous fertilizers as starter doses significantly boosts crop growth and productivity.

III Methodology:

The field experiment was conducted at the Research Farm of the School of Agricultural Sciences, CPU, Kota (Rajasthan), specifically during the Rabi season of 2023-24. This section details the experimental techniques, materials, and methods employed for

evaluating treatments throughout the investigation.

The experimental soil was characterized as clay loam (vertisols) with a texture consisting of 22.6% silt, 37.1% sand, and 39.9% clay. It exhibited alkaline pH levels at 7.8, medium organic carbon content at 0.56%, and medium available nitrogen (314 kg/ha) and phosphorus (22.1 kg/ha) levels. However, the available potassium content was relatively higher at 298 kg/ha.

The experimental design utilized a split-plot arrangement with three replications. The main plots were divided into four tillage levels: zero tillage, minimum tillage, FIRB (Furrow Irrigated Raised Bed), and conventional tillage. Sub-plots consisted of four nitrogen levels: control, Recommended Dose of Nitrogen (RDN), Soil Plant Analysis Development (SPAD), and targeted yield of 5 t/ha. This design resulted in a total of 16 treatment combinations. Wheat was sown with an inter-row spacing of 22.5 cm and an intra-row spacing of 10 cm, using a seed rate of 100 kg/ha. Seeding was performed using a seed drill in the second week of November, and harvesting took place during the last week of March.

During harvest, data on various growth and yield attributes were collected, including plant height, number of tillers per meter row length, dry matter accumulation per meter row length, tillers per square meter, seeds per ear, test weight, seed yield, straw yield, biological yield, net return, and benefit-cost ratio (BC ratio). To collect data, five randomly selected plants were examined from each plot. Seed and straw yields were measured within the net plot and extrapolated to kg/ha.

Economic analysis involved calculating the costs and returns associated with each treatment. This included assessing input and output costs such as fertilizers, seeds, and labor for crop cultivation. Net income per hectare was determined using the formula: Net income (Rs/ha) = Gross income (Rs/ha) - Cost of cultivation. The benefit-cost ratio was calculated by dividing the net return by the cost of cultivation for each treatment combination.

Statistical analysis of the collected data was conducted using the analysis of variance (ANOVA) method, with significant differences evaluated at a 5% level of significance. This rigorous methodology ensured accurate evaluation and comparison of the different treatments and their impact on wheat productivity and economics.

IV Results and Discussion:

Growth and Yield Attributes:

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Upon analyzing the data presented in Table 1, it is evident that different tillage practices significantly influenced various growth and yield attributes of wheat. Conventional tillage exhibited a notable increase in plant height at 90 days after sowing (DAS), recording 95.13 cm, followed by the furrow irrigated raised bed (FIRB) system over zero tillage (73.51 cm) and minimum tillage. Similarly, the number of tillers per meter row length at 90 DAS was maximized with conventional tillage (372.26), followed by FIRB over zero tillage (258.14 cm) and minimum tillage. Dry matter accumulation per meter row length was higher with conventional tillage (109.7 g), followed by FIRB over zero tillage (79.3 g) and minimum tillage. The tillers per square meter were significantly higher in conventional tillage (73.4 tillers/m2), followed by FIRB over zero tillage (53.3 tillers/m2) and minimum tillage. Furthermore, seeds per ear were notably higher in conventional tillage (40.4), followed by FIRB over zero tillage (34.8 cm) and minimum tillage. Similarly, test weight showed higher values in conventional tillage (39.6 g), followed by FIRB over zero tillage (38.1 g) and minimum tillage.

This observed trend can be attributed to the better utilization of nitrogen and other nutrients, facilitating plant height growth and development, as supported by Gupta et al. (2011). The higher dry matter accumulation is likely due to better nutrient availability, higher moisture content, improved plant growth and development resulting from better soil physical conditions, and reduced weed infestation, as confirmed by Kumar et al. (2013).

Similarly, data from Table 1 regarding different nitrogen management practices revealed significant effects on plant height at 90 DAS under the application of Recommended Dose of Nitrogen (RDN) (95.47 cm) treatments, which were statistically comparable with targeted yield 5 t/ha, outperforming the control (72.16 cm) and Soil Plant Analysis Development (SPAD). Similar trends were observed for other parameters like the number of tillers per square meter, dry matter accumulation, seeds per ear, and test weight, where RDN treatments showed promising results compared to other nitrogen management practices.

This improvement in growth attributes under RDN treatments can be attributed to overall enhancement in vigor and crop growth due to the adequate supply of nitrogen during critical growth stages, essential for promoting rapid vegetative growth and biomass, in line with Singh et al. (2017).

Yield and Economics:

The data presented in Table 2 sheds light on the yield and economic aspects of different

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tillage practices and nitrogen management practices. Among the various tillage practices, conventional tillage resulted in significantly higher seed yield (4220 kg/ha) compared to FIRB over zero tillage (2935 kg/ha) and minimum tillage, with conventional tillage exhibiting a 45.8% increase over zero tillage. Similarly, straw yield and biological yield were significantly higher in conventional tillage (6380 kg/ha and 10600 kg/ha, respectively) compared to other tillage practices.

The increase in seed and straw yield under conventional tillage can be attributed to the optimized source-sink relationship, where conventional tillage allows for better dry matter accumulation and partitions a larger proportion to seed, ultimately enhancing seed yield. This finding is supported by Idnani and Kumar (2012) and Soma et al. (2020). Additionally, the biological yield, being a function of grain and straw yields, also showed a significant increase under conventional tillage, indicating improved vegetative growth leading to higher yield attributing characters.

Furthermore, data from Table 2 regarding different nitrogen management practices demonstrated a significant increase in seed yield, straw yield, biological yield, net returns, and benefit-cost ratio under RDN treatments compared to control and SPAD. This improvement in yield and economics can be attributed to the increased utilization of nitrogen, resulting in enhanced growth and yield, as indicated by Maurya et al. (2014) and Singh et al. (2021).

Table 1 Effect of tillage and nitrogen management practices on growth and yield attributes of wheat

Treatments	Plant height (cm)	No. of tiller/m^2	Plant dry weight (g/m row length)	Effective tillers/m^2	No. of seeds/ear	Test weight (g)
Tillage practices						
Zero tillage	73.51	258.14	79.3	53.3	34.8	38.1
Minimum tillage	88.74	272.32	92.4	60.6	37.5	38.8
FIRB	9324	359.17	106.8	68.2	39.2	39.2
Conventional tillage	95.13	372.26	109.7	73.4	40.4	39.6
SEm±	1.69	4.55	2.87	2.07	0.53	0.21

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CD (P=0.05)	5.07	13.64	8.62	6.22	1.6	0.62
Nitrogen management practices						
Control	72.16	256.21	78.4	51.2	34.3	38.2
RND (120:80:55 kg/ha NPK)	95.47	370.56	107.5	73.6	40.7	41.4
SPAD (80:60:50 kg/ha NPK)	87.14	342.13	91.7	59.3	37.1	40.7
Targeted yield 5t/ha (150:80:65 kg/ha)	94.29	364.10	103.9	68.8	38.6	40.9
SEm±	**1.68**	**4.47**	**2.62**	**1.91**	**0.47**	**0.19**
CD (P=0.05)	**4.87**	**13.42**	**7.87**	**5.74**	**1.4**	**0.56**

Table 2 Effect of tillage and nitrogen management practices on yield and economics of wheat

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Net return (ha.)	B:C ratio
Tillage practices					
Zero tillage	2935	4660	7595	41929	1.94
Minimum tillage	3520	5525	9045	53857	1.83
FIRB	3907	5995	9902	57275	1.91
Conventional tillage	4220	6380	10600	60595	1.95
SEm±	**101.7**	**143.3**	**245**	**1121.7**	**0.09**
CD (P=0.05)	**305**	**430**	**735.1**	**3365**	**0.27**
Nitrogen management practices					
Control	2920	4630	7568	50160	1.63
RND (120:80:55 kg/ha NPK)	4185	6326	10511	60715	1.93
SPAD (80:60:50 kg/ha NPK)	3480	5465	8945	53834	1.81
Targeted yield 5t/ha (150:80:65 kg/ha)	3890	5975	9865	57630	1.89
SEm±	**99.3**	**138.7**	**237.9**	**1091.7**	**0.08**

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CD (P=0.05)	**298**	**416**	**713.9**	**3275**	**0.24**

V Conclusion:

The study highlights the importance of optimal agronomic practices like tillage methods and nitrogen management in boosting wheat productivity and profitability. Conventional tillage, especially when coupled with Recommended Dose of Nitrogen (RDN), proved superior in terms of growth attributes, seed yield, and economic returns compared to zero tillage and minimum tillage. This emphasizes the need for farmers to adopt these practices to maximize crop resilience, resource use efficiency, and overall sustainability in wheat cultivation. The results suggest that combining conventional tillage with RDN can be particularly effective in vertisol soils of South-Eastern Rajasthan, leading to higher seed yield, net returns, and Benefit-Cost Ratio (B:C ratio).

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