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IMPACT OF SOWING METHODS AND NITROGEN MANAGEMENT ON GROWTH, YIELD AND ECONOMICS OF WHEAT

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ABSTRACT

Shifting from conventional flat-bed sowing to the Furrow Irrigated Raised Bed (FIRB) technique is a highly effective, modern agronomic approach to maximize wheat yield. When paired with strategic nitrogen (N) management that integrates granular urea with nano urea plus can improve nutrient use efficiency (NUE) while reducing fertilizers costs and environmental runoff. Hence, to evaluate the effect of sowing methods and nitrogen management on growth, yield and economics of wheat, a field experiment was conducted during *Rabi* season 2024-25 at the Research Farm of School of Agriculture, Abhilashi University, Chailchowk, Mandi (H.P.). The experiment was laid out in a split-plot design with three replications. Main plots with two sowing methods and sub plots with three nitrogen management practices. Among the main plots, Furrow Irrigated Raised Bed (FIRB) method of sowing resulted in significantly higher values of crop growth (plant height, number of tiillers and dry matter accumulation), yield attributes (effective tillers and number of grains per spike) and yield (grain and straw) than conventional sowing. Among the sub plots, 100 per cent recommended dose of nitrogen and 75 per cent recommended dose of nitrogen + one spray of nano urea plus (40 DAS) behaving alike resulted in better crop growth, yield attributes, grain and straw yields of wheat compared to treatment comprised of 50 per cent recommended dose of nitrogen + two sprays of nano urea plus (40 and 60 DAS). Highest net returns and net returns per rupee invested were obtained from the FIRB sowing and with the application of 100 per cent recommended dose of nitrogen.

Keywords: sowing methods, FIRB sowing, nano urea plus, wheat, economics.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most widely cultivated food crops of the world. Wheat is an important source of dietary proteins, minerals and vitamins. In India accounts for the second largest share of wheat acreage after rice, occupying nearly 32.8 million hectares, and recorded a production of 117.9 million tonnes with an average productivity of 1903 kg/ha during 2023-24. In Himachal Pradesh, wheat was cultivated over 320 thousand hectares during 2023-24, yielding 609 thousand metric tonnes with a productivity of 1903 kg/ha. (Indiastat.c om, 2024). The productivity of wheat depends upon several factors like sowing methods, water management, weed management and nutrient management. The method of sowing is significant as it determines the proper crop stand establishment and facilitates plants to utilize land and other resources more proficiently. The beneficial effect of line sowing has been very well documented by several researchers. Recently, furrow irrigated raised bed (FIRB) system has proven to be an excellent option in increasing the resource use efficiency. In FIRB, the application of irrigation water is restricted to furrows only, made between two parallel beds. The moisture to crop root zone is made available through lateral movement of water. Apart from this, such configurations have also been found useful in trapping

the rainwater for soil moisture augmentation (Sagar *et al.,* 2017). The piling up of fertile topsoil in the form of bed also helps in vigorous root system enabling the plant to explore more soil volume and resistance against lodging (Rana *et al.,* 2019). Bed planting facilitate better placement of fertilizers including top-dressing and mechanical weed control in wheat crop. Wheat cultivation on FIRB system can results in saving of seed, water and nutrients by 25-40 per cent without affecting the grain yield (Singh *et al.,* 2023). In bed planting, some area may remain unsown in the form of furrows and crop is planted on the top of the beds only. The yield compensation or advantage is assumed due to border effect. On raised bed, border effects allow the canopy to intercept more solar radiation (Tripathi and Das, 2017).

Nitrogen management is another most important factor affecting the productivity of wheat. Nitrogen plays a very crucial role in plant growth and development (Rehman *et al.,* 2008). Nitrogen is one such nutrient that most often limits crop production (Sharma *et al.,* 2016). But the excessive use of N fertilizer leads to low nitrogen use efficiency and economic loss. Therefore, the optimizations of N nutrition for crops as well as the rational use of N fertilizers are important (Singh *et al.,* 2022). Wheat cultivation heavily relies on urea as a nitrogen source, but its application often results in significant nitrogen losses due to leaching, volatilization and de-nitrification which are growing concerns for environmental pollution. Under the situation, nanotechnology has been emerging as a promising tool in agriculture and recently developed nano-fertilizers like nano-urea provides greater nutrient use efficiency to plants with minimal environment pollution. Nano urea with its small particle size increases surface area and facilitates better penetration into plant cells, leading to improved nitrogen assimilation and physiological growth (Biswas et al. 2024). Two foliar sprays of nano urea and 75 per cent of the recommended nitrogen dose through soil applied urea can match or surpass yields achieved with 100 per cent conventional urea, while also improving nitrogen use efficiency and reducing greenhouse gas emissions (Rani et al. 2024). Considering all the above facts, therefore, the present investigation was undertaken to evaluate the impact of sowing methods and nitrogen management on growth, yield and economics of wheat.

Materials and Methods

Experimental site and weather conditions

The experiment was carried out at Research Farm, School of Agriculture of Abhilashi University, Chailchowk, Mandi (H.P.) during Rabi season of 2024-25. The experimental site was situated at 31°33' N latitude and 77°00' E longitudes with the elevation of 1411 m above mean sea level. The soil of experimental field was slightly acidic in reaction (5.6), medium in organic carbon (0.75%), low in available nitrogen (231 kg/ha), medium in available phosphorus (18.91 kg/ha) and potassium (191 kg/ha). Agro-climatically, Mandi represents the mid hill-sub humid zone and high hill temperate wet agro climatic zone of Himachal Pradesh which is characterized by cool winters (October to November) and mild summers (March to April). Mean weekly meteorological data were recorded during crop season from November to May during 2024-25.The maximum weekly temperature ranged between 15.0 to 31.9°C and minimum weekly temperature ranged between 2.4 to 19.1°C. The total rainfall was recorded to be 300.2 mm during the crop season.

Experimental design and field implementation

This experiment was laid out in a split plot design with two sowing methods in main plots (M_1 - Conventional sowing, M_2 – Furrow Irrigated Raised bed (FIRB) sowing) and three nitrogen management practices (S_1 – 100% RDN, S_2 - 75% RDN + 1 spray of nano urea plus at 40 DAS and S_3 - 50% RDN + 2 sprays of nano urea plus at 40 and 60 DAS) in sub plots. The six treatments were comprised with a gross plot size of 4.5 m × 3.0 m and three replications for each treatment. The total gross plot area was 13.5 m^2. The net plot size was decreased to 7.2 m^2 (3.6 m × 2.0 m) for observational purposes. Field was prepared with the help of a tractor drawn disc plough followed by two harrowing and planking. The layout of the field was done manually and plots were prepared and leveled. In FIRB plots, raised beds of 90 cm width alternated by furrows of 30 cm width and 20 cm depth were prepared. Wheat seeds of variety 'HPW 368' were used for sowing. In conventional sowing method, wheat seeds were sown on flat beds at a row spacing of 22.5 cm using a seed rate of 100 kg/ha. In FIRB system, four rows of wheat were sown on raised beds at a row spacing of 22.5 cm using a seed rate of 80 kg/ha. The crop was fertilized with recommended dose of nitrogen, phosphorus and potassium *i.e.* 120, 60 and 40 kg/ha through urea, SSP and MOP at the time of sowing. 50 per cent of recommended N (60 kg/ha in M_1S_1, 45 kg/ha in M_1S_2, 30 kg/ha in M_1S_3, 48 kg/ha in M_2S_1, 36 kg/ha in M_2S_2 and 24 kg/ha in M_2S_3) and whole of recommended P (60 and 48 kg/ha in treatments comprised of M_1 and M_2, respectively) and K (40 and 32 kg/ha in treatments comprised of M_1 and M_2, respectively) in all respective treatments was applied at the time of sowing.

Remaining 50 per cent of recommended N (60 kg/ha in M_1S_1, 45 kg/ha in M_1S_2, 30 kg/ha in M_1S_3, 48 kg/ha in M_2S_1, 36 kg/ha in M_2S_2 and 24 kg/ha in M_2S_3) was top dressed at 30 DAS in all the treatments. The dilutions of 0.4% nano urea plus was prepared (4 ml nano urea plus/litre of water) and used at the rate of 500 l/ha in respective treatments. One foliar spray of nano urea plus was done at 40 DAS in S_2 treatment combinations and two foliar sprays of nano urea plus were done at 40 and 60 DAS in S_3 treatment combinations. Weeds were managed manually with first weeding at 40 days after sowing and second weeding at 70 days after sowing. Two irrigations were applied as per crop needs during dry weather conditions. Harvesting was done manually, later followed by sun drying in the field for 4 to 5 days. Subsequent to this, threshing was done plot by plot.

Observations Recorded

The data gathered included growth [plant height (cm), number of tillers (per m^2) and dry matter accumulation (g/m^2)] and yield traits [number of effective tillers (per m^2), number of grains per spike, grain yield (kg/ha) and straw yield (kg/ha)]. Plant height was measured in centimeters (cm) with the help of scale from the base to tip of the plant. Fresh plant samples from 0.50 m row length were cut from the ground level. The dry matter (g/m^2) was worked out after drying the plants in oven to constant weight at 70°C. The number of tillers and effective tillers were counted from a row length of one meter using a measuring rod. Randomly selected spikes from each plot were counted, and the number of grains per spike was noted. Grain and biological yield per plot was noted and then converted to kilograms per hectare (kg/ha). Straw yield per plot was obtained by subtracting grain weight from biological yield from individual plot produce. Economics per treatment was obtained by calculating the gross returns and net returns both in terms of Rs. per hectare. The net returns per rupee invested were calculated by dividing the net returns by the cost of cultivation.

Statistical analysis

The collected data were analyzed using the analysis of variance (ANOVA) technique as outlined by Gomez and Gomez (1984) under the context of a split plot design. A least significance test was used to analyze the treatment effects at a 5% level of significance.

Results and Discussion

Effect of sowing methods and nitrogen management on growth attributes: The study found that the impact of sowing methods and nitrogen management on growth attributes of crop at harvest was statistically significant (Table 1). Growth parameters of wheat *viz.*, plant height, number of tillers and dry matter accumulation were significantly increased with FIRB sowing as compared to conventional sowing. FIRB arrangement allows for better sunlight interception, which encourages upward vegetative growth (Abhishek *et al.*, 2021). Raised beds facilitate better aeration and reduced soil compaction compared to compacted flatbeds, which induces better root systems and encourages more tillering and higher accumulation of dry matter in plants (Hossain *et al.*, 2006). Among nitrogen management treatments, plant height, number of tillers and dry matter accumulation of wheat increased significantly with the application of 100 per cent recommended dose of nitrogen, which remained at par with the application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus (40 DAS). The significant increment in growth attributes might be due to the increased availability of nitrogen with the application of 100 per cent recommended dose of nitrogen as well as the application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus (40 DAS). Application of 75 per cent recommended dose of nitrogen in combination with one foliar spray of nano urea plus resulted in 25 per cent reduction in conventional soil-applied nitrogen without sacrificing plant growth. Nano urea plus contain ultra-small nitrogen particles (20-50 nm) that are easily absorbed by plants through stomata and promote cell division, cell elongation, and vigorous vegetative growth (Kharche *et al*., 2013).

Effect of sowing methods and nitrogen management on yield attributes: The various yield contributing characters of wheat *viz.* number of effective tillers per square meter and number of grains per spike were significantly higher due to FIRB sowing over conventional sowing (Table 2). FIRB sowing facilitates optimum moisture, better fertilizers placement and reduced crop lodging which increases the growth and development of plants, enhanced photosynthetic efficiency and improved source-sink relationship of the plants reflected by higher yield attributes of plants. Similar results were reported by Sagar *et al.* (2017), Raghuvanshi *et al.* (2021), and Singh *et al.* (2023). Among nitrogen management, yield attributes *viz.*, number of effective tillers per square meter and number of grains per spike were significantly higher with the application of 100 per cent recommended dose of nitrogen, which remained statistically at par with the application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus (40 DAS). The increase in yield attributes of wheat with 100 per cent recommended dose of nitrogen and 75 per cent

recommended dose of nitrogen + replacing remaining 25 per cent recommended dose of nitrogen with one spray of nano urea plus might be due to increased and optimum availability of nitrogen at crucial stage of development of crop which increased the photosynthetic activities and translocated more photosynthates in reproductive stages of the crop (Subramani *et al.*, 2023).

Effect of sowing methods and nitrogen management on yield: FIRB sowing significantly increased the grain and straw yields by 6.34 and 7.50 per cent over conventional sowing (Table 2). It might be due to the fact that FIRB planting gives better crop stand, better interception of solar radiation, reduced lodging and insect pest incidence owing to reduced canopy humidity resulting in significant improvement in yield attributing characters which finally contributed towards enhanced crop yield. However, land area was sacrificed for furrows under FIRB; otherwise per cent increase in wheat grain yield would be more than flat planting. These results are also supported by Chaudhary *et al.* (2016), Debbarma *et al.* (2018) and Abhishek *et al.* (2021). Among nitrogen management treatments, significantly higher grain and straw yields of wheat was recorded with the application of 100 per cent recommended dose of nitrogen, however, it was statistically at par with the application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus (40 DAS). The per cent increase in grain yield due to the application of 100 per cent recommended dose of nitrogen was 5.41 and 20.20 per cent over application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus and 50 per cent recommended dose of nitrogen + two sprays of nano urea plus, respectively. Better availability of nitrogen leads to more synthesis of carbohydrates and their translocation resulted in better growth and yield of the crop (Loura *et al.,* 2020). The combined application of nano and non-nano urea presents a synergistic strategy that capitalizes on the rapid absorption of nano urea while ensuring the sustained availability offered by conventional urea. In the present study, 25 per cent substitution of the conventional nitrogen (75% RDN) with nano urea plus foliar spray resulted in comparable yield to 100 per cent recommended dose of nitrogen than 50 per cent recommended dose of nitrogen substitution which led to yield gap. This might be due to the reason that despite high efficiency of nano urea plus, 50 per cent recommended dose of nitrogen is generally inadequate to meet the massive total nitrogen requirement of wheat crop (Kumar *et al.*, 2025).

Effect of sowing methods and nitrogen management on economics: FIRB sowing gave higher gross returns (Rs. 106610 per ha), net returns (Rs. 65414 per ha) and net returns per rupee invested (1.60) as compared to conventional sowing (Rs. 99670 per ha, Rs. 59261 per ha and 1.47, respectively) (Table 3). Among nitrogen management treatments, maximum gross returns (Rs. 112769 per ha), net returns (Rs. 73237 per ha) and net returns per rupee invested (1.85) were obtained with the application of 100 per cent recommended dose of nitrogen followed by the application of 75 per cent recommended dose of nitrogen + one spray of nano urea plus (Rs. 106754 per ha, Rs. 66039 per ha and 1.62, respectively). The effect of treatments on economic returns is in accordance with the higher yield of wheat with lower cost of cultivation.

Conclusion

Furrow Irrigated Raised Bed (FIRB) method of sowing and application of 100 per cent recommended dose of nitrogen to wheat proved best in increasing crop growth attributes, yield attributes, yield and economic returns. However, application of 75 recommended dose of nitrogen combined with one foliar spray of nano urea plus at 40 DAS recorded wheat yield and economic returns comparable to full 100 per cent recommended dose of nitrogen application. This reduced conventional nitrogen fertilizer requirement by **25 per cent** and made it a sustainable nitrogen management practice.

Table 1: Effect of sowing methods and nitrogen management on growth attributes of wheat

Treatment	Plant height (cm) at harvest	Number of tillers (per m^2) at harvest	Dry matter accumulation (g/m^2) at harvest
Sowing methods			
Conventional sowing	107.8	258	686.9
Furrow Irrigated Raised Bed (FIRB) sowing	112.2	272	747.1
SEm±	1.4	3	19.4
CD (P=0.05)	4.3	10	58.4
Nitrogen management			
100% RDN	115.8	284	777.0

75% RDN + 1 spray of nano urea plus at 40 DAS	112.8	273	741.3
50% RDN + 2 sprays of nano urea plus at 40 and 60 DAS	101.4	238	632.8
SEm±	1.7	5	25.8
CD (P=0.05)	5.1	14	77.4

Table 2: Effect of sowing methods and nitrogen management on yield attributes and yield of wheat

Treatment	Number of effective tillers (per m^2)	Number of grains per spike	Grain yield (kg/ha)	Straw yield (kg/ha)
Sowing methods				
Conventional sowing	236	50.93	3205	5257
Furrow Irrigated Raised Bed (FIRB) sowing	247	53.96	3422	5683
SEm±	3	0.98	69	134
CD (P=0.05)	10	2.95	207	403
Nitrogen management				
100% RDN	259	56.03	3623	5979
75% RDN + 1 spray of nano urea plus at 40 DAS	249	54.95	3427	5690
50% RDN + 2 sprays of nano urea plus at 40 and 60 DAS	219	46.36	2891	4741
SEm±	4	0.88	66	128
CD (P=0.05)	12	2.65	198	385

Table 2: Effect of sowing methods and nitrogen management on economics of wheat

Treatment	Gross returns (Rs./ha)	Net returns (Rs./ha)	Net returns per rupee invested
Sowing methods			
Conventional sowing	99670	59261	1.47
Furrow Irrigated Raised Bed (FIRB) sowing	106610	65414	1.60
Nitrogen management			
100% RDN	112769	73237	1.85
75% RDN + 1 spray of nano urea plus at 40 DAS	106754	66039	1.62
50% RDN + 2 sprays of nano urea plus at 40 and 60 DAS	89897	47736	1.14

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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