



Cost-Benefit Analysis of Irrigation and Nitrogen Scheduling in Wheat (*Triticum aestivum* L.) Cultivation

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Abstract: Field experiment was conducted to study the effect of irrigation and nitrogen scheduling on cost of cultivation, net return and benefit cost ratio of wheat crop, at Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India, during *rabi* season of 2019-20. The gross return, net return and B: C ratio was maximum under the irrigation schedule I₄-irrigation at CRI, tillering, flowering and milking stage. Irrigation at CRI, tillering and late jointing stage and significantly superior to other treatments. Minimum gross return, net return and B: C ratio was in irrigation schedule I₁-irrigation at CRI. Among nitrogen splits, results revealed that the maximum gross return, net return and B: C ratio in N₃- Four splits of nitrogen vs N₂- three splits of nitrogen was significantly superior over N₁- two splits of nitrogen. Higher yield of crop with proper moisture and nutrient availability gave better economic returns of the crop as compared to the treatments where moisture was insufficient at critical stages.

Keywords: Economics, Irrigation, Nitrogen, Wheat, *Triticum aestivum*

Wheat cultivation has been symbolic of the green revolution and self sufficiency in food production (Sulochna et al 2018). Maximum yield of crop may not always be the ultimate goal. In modern farming profit is more important factor than the maximum yield. The response of yield to nitrogen supply is influenced by environmental conditions, especially the quantity and timing of water availability to the crop. In wheat, recovery of nitrogenous fertilizer can be significantly increased by applying nitrogen at critical growth stages of wheat (Abourached et al 2008). Proper irrigation scheduling is important practice for improving water use efficiency, utilization of energy and other production inputs. Major factors influencing irrigation schedule are water requirement of crop; availability of water for irrigation; and capacity of the root zone to store water. Water needs of crop are of great importance for determining the time of irrigation during the crop growing season. The different levels of irrigation and soil fertility have significant effect on economic of crop (Chakmas et al 2018). The four irrigations at crown root initiation, late tillering, flowering and milk stages produced maximum income over three irrigations production efficiency and net income were also higher (Jain et al 2018).

Availability of nitrogen at critical stages and its management plays an important role in improvement of crop growth, environmental safety and economics of crop production (Maqsood et al 2012). Nitrogen scheduling plays an important role in growth, productivity of wheat as well as on its use efficiency. Due to highly mobile it losses through various ways response of wheat to split application of nitrogen with reduced basal dose has been reported by several workers in India. Nitrogen is extremely mobile

nutrient; it suffers more losses due to leaching, runoff and volatilization etc. The nitrogen use efficiency varies from 30-50% (Zain et al 2021). Split nitrogen application improves utilization by crops while lowering fertilizer loss due to leaching and volatilization (Si et al 2020). Water and fertilizer application during important crop growth stages could improve the physiological and biochemical characteristics of the crop, and eventually improve yield (Li et al 2023). The present study was carried out to investigate the influence of different irrigation and nitrogen schedules on economics of wheat crop.

MATERIAL AND METHODS

Field experiment was conducted at research farm of Mata Gujri College, Shri Fatehgarh Sahib, Punjab, India. The location coordinates are 30°65'N latitude, 76°39' E longitudes. The crop was grown in *rabi* season of 2019-20. The experiment was laid out in split plot design with four irrigation schedules and three splits of nitrogen i.e. total twelve treatment combinations replicated thrice. The recommended dose of fertilizers for wheat crop was 120, 60 and 40 kg ha⁻¹ of N, P₂O₅ and K₂O respectively. The treatment details are as: Irrigation scheduling: I₁- Irrigation at CRI, I₂- irrigation at CRI and tillering, I₃- Irrigation at CRI, tillering and late jointing stage, I₄- Irrigation at CRI, tillering, flowering and at milking stage. Nitrogen scheduling: N₁- Nitrogen in two splits, N₂- Nitrogen in three splits, N₃- Nitrogen in four splits. Full doses of P and K fertilizers were applied at sowing time and nitrogen was applied as per the treatments in different sub plots. First dose of nitrogen was applied as basal dose; second dose was applied at CRI, third at late

jointing and fourth at flowering stage in different plots in combination with irrigation. Regular biometric observations were recorded at periodic intervals of 30, 60, 90 DAS and at harvest stage. Yield parameters were recorded just before the harvesting of crop. The grain yield of each plot was recorded and converted in hectare.

Statistical analysis: The statistical analysis was performed using Microsoft Excel. Statistical significance between treatments for various parameters was analyzed using critical differences at 0.05 probability level.

Economic analysis: Relative economics of different treatments were worked out on the basis of grain and straw yield per hectare. The cost of inputs and outputs were estimated on prevailing market rates. The Benefit: Cost ratio was calculated:

Benefit: Cost ratio = Net returns (₹/ha)/Cost of cultivation (₹/ha)

Total cost of cultivation was calculated by adding the cost of variables (involved in each operation/input) in the common cost. Gross return was estimated by converting the economics yield of wheat crop (grain and straw) into monetary terms on the basis of support price of wheat grain and prevailing local market price for straw and expressed as per hectare.

RESULTS AND DISCUSSION

Effect of irrigation scheduling: The different treatments significantly affected the economics of crop except the cost of cultivation (Table 1). The highest gross return, net return and benefit cost ratio was observed in I₄- Irrigation at CRI, tillering, flowering and milking stage which was at par with I₃- Irrigation at CRI, tillering and late jointing stage and significantly superior to remaining treatments. This might due to the proper availability of moisture at critical stages resulted in higher growth and yield parameters that gave better economic benefits as compared to other treatments.

Balkrishna et al (2023) reported that irrigation schedules significantly effect on economics of wheat. The higher return was observed when irrigation was applied at CRI stage and before flowering of wheat and was significantly superior over rest of treatments. Application of only one irrigation at crown root initiation stage resulted in lower nutrient uptake that gave poor yield of crop. The irrigations applied at crown root initiation, late tillering, flowering and milk stages produced higher income over three irrigations (Jain et al 2018). Kumar et al (2017) observed the increase in irrigation number from one to four increased the grain yield of wheat.

Effect of nitrogen scheduling: The different nitrogen schedule have significant effect on the economics of crop except cost of cultivation (Table 1). The highest gross return, net return and benefit cost ratio was observed in N₃- four splits of nitrogen which was at par with N₂- three splits of nitrogen at critical growth stages of the crop which was significantly superior over rest of treatments (Table 1). The higher net returns with four splits of nitrogen application was due to steady supply of nitrogen which synchronized with the peak period of nitrogen requirement that had resulted in higher yield which fetched higher prices. Mathukia et al (2014) also reported higher net returns and benefit: cost ratio with the application of nitrogen @ 120 kg/ha in 3 splits. The lowest cost of cultivation, gross return, net return and benefit cost ratio were in N₁- two splits of nitrogen. The lower return was after split application of nitrogen as most of the nitrogen is lost by leaching, when applied 50% as basal dose the crop cannot receive nitrogen at later stage for growth thus reduction in yield.

Economic benefits from split application of nitrogen can be observed by higher nutrient availability at critical stages of crop that increased vegetative growth as well as yield of the crop as compared to application of fertilizer at sowing time or in two splits. Applying all the fertilizer quantity of recommended fertilizer not only waste essential nutrients but

Table 1. Gross return, net return and benefit cost ratio as affected by irrigation and nitrogen scheduling

Treatments	Cost of cultivation	Gross return (₹)	Net return (₹)	B:C ratio
Main plot (Irrigation scheduling)				
I ₁ -Irrigation at CRI (Crown root initiation)	46289	85123	38834	0.84
I ₂ - Irrigations at CRI and tillering stage	46589	92356	45766	0.98
I ₃ - Irrigations CRI, tillering and late jointing stage	46889	99141	52251	1.11
I ₄ - Irrigations at CRI, tillering, flowering and milking stage	47189	105473	58284	1.23
CD (p= 0.05)	-	9443	9443	0.20
Sub plot (nitrogen scheduling)				
N ₁ - Two splits of nitrogen	46439	87482	41042	0.88
N ₂ - Three splits of nitrogen	46739	97988	51248	1.10
N ₃ - Four splits of nitrogen	47039	101100	54060	1.15
CD (p= 0.05)	-	8133	8133	0.17

also leads to environmental pollution by leaching in water resources and soil layers. Less availability of fertilizer nutrients results in poor grain yield as proved to be economically less beneficial to farmers as cost of fertilizer remain same in both cases. Verma et al (2018) observed that the split application of nitrogen (33%N at sowing + 33%N at 30 DAS +33% at 60 DAS) recorded significantly the highest gross returns .net return, and B:C. Akhter et al (2017) concluded, Kashmir 3 splits of nitrogen in the ratio of 25:50: 25 (basal + active tillering + booting) resulted in highest gross returns, net returns and benefit: cost ratio followed by the treatment where nitrogen was applied in the ratio of 50: 25: 25 (basal + jointing + booting).Agronomic use efficiency, nitrogen utilization efficiency and grain protein content in wheat were significantly affected by split application of nitrogen over control treatment revealed by (Hundal and Kang 2019). Irrigation water plays a crucial role in development of wheat plant during critical growth stages form germination of seed to maturation. Irrigation applied at critical growth stages would be valuable management practice for improving yield of wheat crop (Zain et al 2021). Deficiency of nitrogen has greater impact on grain yield and yield attributes by affecting the production of biomass and solar radiation use efficiency of the crop plant (Heinemann et al 2006). Soil and climatic variability and conditions associated with processes that affect nitrogen dynamics in the soil and their relationship with the plant may cause changes in nitrogen availability and its requirement of the plant.

CONCLUSION

The irrigation scheduling at CRI, tillering, flowering and milking stage with four nitrogen split have significant impacts on production economics of wheat. The highest gross return, net return and benefit cost ratio were recorded in these combinations ($I_4 N_3$). The benefits depend on the cost of irrigation and nitrogen inputs relative to the increase in yield and revenue. In general, efficient irrigation and precise nitrogen scheduling improve the benefit-cost ratio, but the exact impact can vary based on specific conditions such as local water availability, fertilizer costs and yield potential.

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