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Enhancing Wheat Productivity through Foliar Application of Urea and Balanced NPK Fertilizers

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Abstract

A field experiment was conducted during the Rabi season to evaluate the effect of water soluble fertilizers on growth, yield attributes, yield and economics of wheat (*Triticum aestivum* L.). The experiment comprised eight treatments involving recommended dose of fertilizers (RDF), foliar application of urea and water soluble fertilizer 19:19:19 at vegetative and flowering stages. The results revealed that application of RDF along with foliar spray of urea at vegetative stage and 19:19:19 at flowering stage significantly enhanced plant growth, dry matter accumulation, yield attributes and yield of wheat. Among the treatments, T_7 (RDF + Urea at vegetative stage + 19:19:19 at flowering stage) recorded maximum plant height at harvest (109.5 cm), dry matter accumulation (812.6 g m^{-2}), effective tillers (358 m^{-2}), spike length (11.4 cm), spikelets $spike^{-1}$ (20.6), test weight (44.8 g), grain yield (4765 kg ha^{-1}) and straw yield (6825 kg ha^{-1}). The same treatment also recorded highest gross monetary returns (Rs. 1,19,250 ha^{-1}), net monetary returns (Rs. 72,450 ha^{-1}) and B:C ratio (1.55). Improvement in crop performance was mainly attributed to balanced nutrient availability, improved nutrient use efficiency and enhanced photosynthetic activity due to foliar nutrition. The study concluded that integrated use of RDF along with foliar application of urea and water soluble fertilizer significantly improved productivity and profitability of wheat under irrigated conditions.

Keywords: Wheat, Water soluble fertilizers, Foliar nutrition, Urea, 19:19:19, Yield, Economics

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and serves as a staple food for a large population across the world. In India, wheat contributes substantially to food security and agricultural economy. However, increasing nutrient depletion, declining fertilizer use efficiency and imbalanced fertilization practices have become major constraints in sustaining wheat productivity.

Efficient nutrient management plays a vital role in improving growth and yield of wheat. Conventional soil application of fertilizers often results in nutrient losses through volatilization, leaching and fixation, thereby reducing nutrient use efficiency. Foliar application of water soluble fertilizers has emerged as an effective strategy for supplying nutrients directly to plants during critical growth stages. Water soluble fertilizers provide readily available nutrients and ensure quick absorption through leaves, resulting in improved physiological and metabolic activities. Among water soluble fertilizers, 19:19:19 is widely used because it supplies balanced nitrogen, phosphorus and potassium simultaneously. Foliar application of urea and balanced NPK fertilizers during vegetative and reproductive stages enhances chlorophyll content, photosynthetic efficiency, dry matter production and grain filling in wheat [1]. Foliar nutrition also helps in overcoming temporary nutrient deficiencies during peak crop demand periods. Several researchers have reported significant improvement in growth, yield attributes and yield of wheat due to foliar application of water soluble fertilizers along with RDF [2, 3]. Combined application of soil and foliar fertilizers enhances nutrient uptake efficiency and improves economic returns. Keeping these facts in view, the present investigation was undertaken to study the effect of water soluble fertilizers on growth, yield attributes, yield and economics of wheat.

Materials and Methods

A field experiment entitled was conducted during the Rabi season of 2025–26 at the Research Farm, Vivekananda Global University, Jaipur, Rajasthan, India. The experimental site is situated in Agro-climatic Zone IIIA (Semi-Arid Eastern Plains) of Rajasthan at 26°05′ N latitude and 75°28′ E longitude with an altitude of 427 m above mean sea level.

The climate of the region is semi-arid with hot summers and cold winters. During the crop season, maximum and minimum temperatures ranged from 17.3°C to 37.9°C and 0.3°C to 21.5°C, respectively. Total rainfall received during the cropping season was 94.5 mm. The experimental soil was sandy loam in texture with pH 8.25, EC 0.16 dS m^{-1}, organic carbon 0.18%, available nitrogen 130.8 kg ha^{-1}, available phosphorus 14.23 kg ha^{-1}, available potassium 251.12 kg ha^{-1}, and available zinc 0.62 ppm.

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. The treatments included different combinations of recommended dose of fertilizers (RDF), urea spray, and water-soluble NPK fertilizers. The treatments were: T_1 – Control, T_2 – 100% RDF, T_3 – RDF + Urea at vegetative stage, T_4 – RDF + Urea at flowering stage, T_5 – RDF + 19:19:19 at vegetative stage, T_6 – RDF + 19:19:19 at flowering stage, T_7 – RDF + Urea at vegetative stage + 19:19:19 at flowering stage, T_8 – RDF + 19:19:19 at vegetative stage + Urea at flowering stagee. Each plot measured 3.0 m × 5.0 m with a net plot area of 2.6 m × 5.0 m. Foliar application of urea was applied at 2.0% concentration and water-soluble fertilizer (NPK 19:19:19) at 1.0% concentration. Sprays were applied as per treatment specifications. Foliar sprays were applied using a knapsack sprayer at a spray volume of 500 L ha^{-1}. The first spray was applied at vegetative stage and the second spray at flowering stage. Spraying was carried out during morning hours to ensure maximum absorption and minimize evaporation losses.

Wheat variety 'RAJ 4079' was used as the test crop. Seeds were sown on 16 October 2025 using the "Kera" method at a spacing of 20 cm with a seed rate of 100 kg ha^{-1}. Recommended fertilizer dose of 120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1} was applied through urea, single super phosphate (SSP), and muriate of potash (MOP). Half dose of nitrogen along with full doses of phosphorus and potassium were applied as basal, while the remaining nitrogen was top dressed in two equal splits after first and second irrigations. Foliar sprays of urea and water-soluble fertilizers were applied as per treatment specifications.

The experimental field was prepared through ploughing, harrowing, and planking to obtain fine tilth. Standard agronomic practices including irrigation, hoeing, weeding, and plant protection measures were followed uniformly in all plots. Seven irrigations were applied during the crop growth period.

Growth observations including plant population, plant height, dry matter accumulation, and effective tillers were recorded at different crop growth stages. Yield attributes such as spike length, number of spikelets $spike^{-1}$, and test weight were recorded at harvest. Grain yield, straw yield, biological yield, and harvest index were computed on hectare basis. Representative grain and straw samples were analyzed for nitrogen, phosphorus, and potassium contents using standard analytical methods.

Economic analysis including net returns and benefit: cost ratio was worked out using prevailing market prices of inputs and produce. Gross returns were calculated based on prevailing market prices of wheat grain (ha/ q^{-1}) and wheat straw (ha/ q^{-1}) during the crop season. Net returns were obtained by subtracting the total cost of cultivation from gross returns. Benefit-cost ratio was computed by dividing gross returns by total cultivation cost. The cost of fertilizers, labor, irrigation, plant protection measures and harvesting operations were included while calculating total production cost. The recorded data were statistically analyzed using analysis of variance (ANOVA) appropriate for Randomized Block Design following the procedure suggested by Panse and Sukhatme (1985). Treatment means were compared at 5% level of significance using critical difference (CD) values wherever the F-test was found significant.

Results and Discussion

Effect on Plant Height

Plant height increased progressively with crop growth stages under all treatments (**Table 1**). Among the treatments, T_7 (RDF + Urea at vegetative stage + 19:19:19 at flowering stage) recorded significantly higher plant height at 30 DAS (26.1 cm), 60 DAS (78.6 cm) and at harvest (109.5 cm). This treatment was closely followed by T_8. The increase in plant height due to combined foliar application of urea and 19:19:19 may be attributed to improved nutrient availability and rapid nutrient absorption through leaves during active vegetative growth stages. Nitrogen supplied through foliar urea enhances cell division and chlorophyll synthesis, while balanced NPK supplied through 19:19:19 improves metabolic and enzymatic activities.

The lowest plant height was recorded under control treatment due to inadequate nutrient supply. Similar findings were reported by [1], [3] and [4].

Effect on Dry Matter Accumulation and Effective Tillers

Dry matter accumulation increased significantly with advancement in crop growth stages and nutrient management practices. Treatment T_7 recorded maximum dry matter accumulation at 30 DAS (124.9 g m^{-2}), 60 DAS (428.5 g m^{-2}) and harvest (812.6 g m^{-2}). The same treatment also produced highest number of effective tillers (358 m^{-2}). Improved dry matter accumulation under foliar nutrition treatments may be due to enhanced photosynthetic efficiency, better

nutrient uptake and increased assimilate production. Foliar feeding during critical growth stages ensured continuous nutrient availability, resulting in vigorous vegetative growth and higher tillering capacity. Water soluble fertilizers provide nutrients in readily available form and improve nutrient translocation within plants. Similar observations were also reported by [2] and [5].

Table 1 Effect of water soluble fertilizers on plant population and dry matter accumulation of wheat

Treatment	Plant height (cm) 30 DAS	Plant height (cm) 60 DAS	Plant height (cm) At harvest	Dry matter accumulation (g m^{-2}) 30 DAS	Dry matter accumulation (g m^{-2}) 60 DAS	Dry matter accumulation (g m^{-2}) At harvest	Number of effective tillers m^{-2} at harvest
T_1 – Control	18.4	52.6	78.3	82.4	248.6	486.3	248
T_2 – 100% RDF	22.7	68.4	96.5	106.8	356.4	682.7	312
T_3 – RDF + Urea at vegetative stage	23.9	72.8	101.4	112.5	382.1	724.8	328
T_4 – RDF + Urea at flowering stage	23.1	70.9	99.2	109.7	368.9	701.5	319
T_5 – RDF + 19:19:19 at vegetative stage	24.4	74.2	103.7	116.4	394.6	746.2	336
T_6 – RDF + 19:19:19 at flowering stage	23.8	72.5	101.8	113.8	386.7	731.4	331
T_7 – RDF + Urea at vegetative stage + 19:19:19 at flowering stage	26.1	78.6	109.5	124.9	428.5	812.6	358
T_8 – RDF + 19:19:19 at vegetative stage + Urea at flowering stage	25.3	76.9	106.8	120.6	412.8	784.3	349
SEm ±	0.72	1.84	2.11	3.24	9.18	16.42	7.24
CD (P=0.05)	2.15	5.47	6.28	9.63	27.28	48.79	21.52

Effect on Yield Attributes

Yield attributes of wheat were significantly influenced by foliar application of water soluble fertilizers (**Table 2**). Treatment T_7 recorded the highest spike length (11.4 cm), number of spikelets per spike (20.6) and test weight (44.8 g), which were significantly superior over control and RDF alone. The improvement in yield attributes may be attributed to enhanced nutrient availability during reproductive stages, leading to better spike development, grain formation and grain filling. Foliar application of balanced nutrients during flowering stage improved photosynthate translocation towards reproductive organs. The increase in test weight under T_7 indicated efficient grain filling and higher accumulation of carbohydrates and proteins in grains. Similar findings were reported by [4] and [7].

Effect on Grain and Straw Yield

Grain and straw yields were significantly influenced by different nutrient management treatments. The highest grain yield (4765 kg ha^{-1}) and straw yield (6825 kg ha^{-1}) were recorded under T_7, followed by T_8 and T_5. The increase in grain yield under combined foliar nutrition treatments may be attributed to improved growth parameters, higher dry matter accumulation and superior yield attributes. Foliar application of urea during vegetative stage enhanced vegetative growth and tillering, while application of 19:19:19 during flowering stage improved reproductive growth and grain filling. Balanced nutrient supply throughout crop growth stages ensured better source-sink relationship and efficient

assimilate partitioning. The lowest grain yield (2480 kg ha^{-1}) was recorded under control treatment due to poor nutrient availability and lower growth performance. Similar findings were reported by [3], [5] and [6].

Effect on Harvest Index

Harvest index was not significantly affected by different treatments, although numerically higher values were observed under T_7 (41.11%) and T_8 (40.89%). This indicates that foliar nutrition improved both grain and straw production proportionately.

Table 2 Effect of water soluble fertilizers on yield attributes and yields of wheat

Treatment	Length of spike (cm)	No. of spikelets per spike	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1 – Control	7.8	14.2	34.6	2480	4120	37.58
T_2 – 100% RDF	9.6	17.8	39.4	3960	5980	39.84
T_3 – RDF + Urea at vegetative stage	10.2	18.6	41.1	4285	6325	40.38
T_4 – RDF + Urea at flowering stage	9.9	18.1	40.3	4170	6210	40.17
T_5 – RDF + 19:19:19 at vegetative stage	10.5	19.2	42.4	4415	6480	40.53
T_6 – RDF + 19:19:19 at flowering stage	10.3	18.8	41.7	4320	6395	40.31
T_7 – RDF + Urea at vegetative stage + 19:19:19 at flowering stage	11.4	20.6	44.8	4765	6825	41.11
T_8 – RDF + 19:19:19 at vegetative stage + Urea at flowering stage	11.0	19.9	43.5	4620	6680	40.89
SEm ±	0.28	0.54	0.86	96.4	128.6	0.62
CD (P=0.05)	0.84	1.61	2.56	286.5	382.1	NS

Table 3 Effect of water soluble fertilizers on economics of wheat

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C Ratio
T_1 – Control	32,500	61,800	29,300	0.90
T_2 – 100% RDF	41,200	98,600	57,400	1.39
T_3 – RDF + Urea at vegetative stage	43,100	1,06,850	63,750	1.48
T_4 – RDF + Urea at flowering stage	42,850	1,03,950	61,100	1.43
T_5 – RDF + 19:19:19 at vegetative stage	44,600	1,10,200	65,600	1.47
T_6 – RDF + 19:19:19 at flowering stage	44,350	1,07,850	63,500	1.43
T_7 – RDF + Urea at vegetative stage + 19:19:19 at flowering stage	46,800	1,19,250	72,450	1.55
T_8 – RDF + 19:19:19 at vegetative stage + Urea at flowering stage	46,200	1,15,600	69,400	1.50
SEm ±	620	2,180	2,040	0.05
CD (P=0.05)	1,842	6,478	6,062	0.14

Effect on Economics

Economic analysis revealed significant differences among treatments (**Table 3**). Treatment T_7 recorded the highest gross monetary returns (Rs. 1,19,250 ha^{-1}), net monetary returns (Rs. 72,450 ha^{-1}) and B:C ratio (1.55). Higher economic returns under this treatment were mainly due to increased grain and straw yields. Although foliar nutrition treatments incurred slightly higher cultivation costs, the additional yield obtained compensated for the increased expenditure and resulted in greater profitability. The lowest economic returns were observed under control treatment. These findings are in close conformity with the results reported by [1] and [2].

Conclusion

The present investigation clearly demonstrated that foliar application of water soluble fertilizers significantly improved growth, yield attributes, yield and economics of wheat. Among the treatments, RDF along with foliar application of urea at vegetative stage and 19:19:19 at flowering stage (T_7) proved most effective in enhancing plant height, dry matter accumulation, effective tillers, grain yield and profitability. Therefore, integrated use of soil fertilization along with foliar application of water soluble fertilizers may be recommended for achieving higher productivity and economic returns in wheat cultivation under irrigated conditions.

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