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Effect of Foliar Supplementation of Water Soluble Fertilizer on Growth, Yield and Economics of Wheat Crop (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted during *rabi* season of 2015-16 at Agronomy Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, to evaluate the effects of foliar application of water soluble fertilizers on growth, yield attributes and yield of wheat. The soil of the experimental plot was sandy loam in texture, low in available nitrogen (131.3 kg ha^{-1}), medium in available phosphorus (17.2 kg ha^{-1}), and high in available potassium (335.4 kg ha^{-1}). The soil was alkaline in reaction (pH 7.8). The experiment was laid out in Randomized Block Design with 17 treatments having three replications. The treatments comprising two fertilizers level i.e., Recommended dose of fertilizer (RDF) (150 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1}) and 75% of RDF and supplemented with foliar application of water soluble fertilizers viz. Urea phosphate (17:44) @ 1.5%, NPK (18:18:18) @ 1.5%, $ZnSO_4$ @ 0.5% and Urea 2% at different stages. One treatment was control where no fertilizer applied. Growth parameters viz, plant height, dry matter accumulation, crop growth rate and leaf area index were increased with T_9 i.e., RDF along with foliar application of water soluble fertilizers NPK (18:18:18) @ 1.5% at 40 DAS followed by Urea phosphate (17:44) @ 1.5% at 65 DAS. Among treatments, application of RDF along with foliar application of water soluble fertilizers NPK (18:18:18) @ 1.5% at 40 DAS followed by Urea phosphate (17:44) @ 1.5% at 65 DAS exhibited the highest values of yield attributes, viz. effective tillers/meter row length (mrl), number of spikeletes/spike, number of grains/spike and 1000-grains weight which led to the highest grain yield (6220 kg ha^{-1}) However, alternate application of NPK (18:18:18) @ 1.5% and Urea phosphate (17:44) @ 1.5% or vice versa produced statistically similar grain yield of wheat at the same level of fertilizer application. RDF or 75% RDF along with foliar application of NPK (18:18:18) @ 1.5% was slightly superior as compared to RDF or 75% RDF along with foliar application of Urea phosphate (17:44) @ 1.5% irrespective of time of application.

Keywords Fixed level of fertilizers, Foliar application, Water soluble fertilizers, Growth, Wheat.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important staple food of about two million people (36% of the world population). Wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur 2008). In India, it is the second most important cereal food crop next to rice and contributes to the total food grain production of the country to the extent of about 25%. India is second largest producer of wheat in the world after China contributing about 12% share in total world wheat production. India's area, production and productivity in wheat is 30.2 mha, 92.5 mt and 3070 kg ha^{-1}, respectively (Indiastat.com). Haryana contributes about 13.5% wheat in central pool of India with area, production and productivity of 2540 thousand ha, 11399 thousand tonne and 4226 kg ha^{-1}, respectively (Indiastat. com). Among different elements required for plant growth N, P and K are very important. Foliar fertilization with nitrogen, phosphorus, and potassium (N-P-K) can be supplemented with soil applied fertilizers but cannot replace soil fertilization in the case of maize (Ling and Silberush 2002), because demand for P is 1/10 that of N hence, a foliar application might be beneficial. Therefore, correcting the plant's deficiency by foliar application seems plausible. Very little research has been conducted on the use of P as foliar spray at early stages of wheat and corn. However, recent work by Benbella and Paulsen (1998) showed that foliar applications after anthesis of 5 to 10 kg KH_2PO_4 ha^{-1} (1.1 to 2.2 kg P ha^{-1}) increased wheat grain yields by up to 1tonne ha^{-1}. Generally, availability of nitrogen, phosphorus and potassium in Indian soil is abundant but its availability to crop is very low. It is well known fact that with the introduction of high yielding, input responsive and pest resistant varieties, the grain yield increased not only in Haryana state but also at national level but from the last five years the grain yield of wheat has stagnated due to high soil fertilization which created toxicity to the soil as well as in the food chain. Urea a major source of nitrogen is generally being applied as basal and as top dressing at critical growth stages of the crop and under ideal conditions. The percent recovery of nitrogen is not more than 40%, meaning a loss of 60% of applied nitrogen in the form of urea (Prakash *et al*. 2018). The lower productivity could be attributed to the fact that under intense cereal cropping system and immense use of inorganic fertilizers, especially nitrogen, there has been great depletion of soil fertility (Prakash *et al.* 2019). So, the practice of foliar fertilization has the advantages of low cost and a quick plant response, and it is particularly important when soil problems occur and root growth is inadequate. Surve and Bhosale (2015) reported the foliar spray of NPK (19:19:19) at 0.5% improved grain yield of wheat. A favorable balance of macro and micronutrients is also required for optimum crop production. Research findings have shown that foliar feeding can increase yields from 12% to 25% when compared to conventional fertilization. Foliar application of nutrient at appropriate time may have an impact on the wheat quality. Gaballa *et al*. (2003) reported that applying 10 kg ha^{-1} of urea by spraying in earhead stage increased seed protein from 10.2 to 11.8%.

MATERIALS AND METHODS

The experiment was conducted during the *rabi* season of 2015 at the Agronomy Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental site is situated at an elevation of 215.2 m above mean sea level with latitude 29º10' N and longitude of 75º46' E in the sub-tropical zone. The net plot size was 14 m^2 using variety WH 1105. The soil of the experimental site was sandy loam with low electrical conductivity (0.28 dS m^{-1}), Organic carbon (0.31%) slightly alkaline in reaction (7.8), low in available nitrogen (131.3 kg ha^{-1}), medium in available phosphorus (17.2 kg ha^{-1}) and high in available potassium (335.4 kg ha^{-1}). The experiment was laid out in Randomized Block Design (RBD) with 17 treatments having three replications. The treatments comprising of two level of fertilizers i.e., RDF (150 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha) and 75% RDF as a basal doses and followed by foliar application of water soluble fertilizers viz. NPK (18:18:18) @ 1.5%, Urea phosphate (17:44) @ 1.5%, $ZnSO_4$ @ 0.5% and Urea 2.5% at different growth stages of wheat crop. Soil samples were taken from 0-15 cm depths randomly at five places from experimental field before sowing. The composite sample was prepared by mixing all the collected soil samples from experimental field. Soil samples were air dried, grinded and sieved through 2 mm sieve and analyzed to estimate soil

reaction (pH), electrical conductivity (EC), organic carbon (OC %), available soil N, available P, and available K by adopting standard procedures. The cost of various inputs used and the prices of outputs in the prevailing local markets were considered for cost of cultivation and net returns was worked out by subtracting the total cost of cultivation of each treatment from the gross income of respective treatment. The experimental data collected on various growth and yield components were subjected to Fisher's method of "Analysis of variance" (ANOVA) as outlined by Gomez and Gomez (1983) and data were compared with critical differences at a probability level of 5%.

RESULTS AND DISCUSSION

Growth studies: Growth in terms of plant height, dry matter accumulation and number of tillers at various crop growth stages significantly influenced by fertilizer levels and foliar application of water soluble fertilizers. The plant height and dry matter accumulation increased with advancement of crop age in all the treatments and highest values recorded at maturity. Plant height and dry matter accumulation were significantly higher in T_9 over all other treatments at maturity except T_8 because it had same level of fertilizer, but T_9 at 90 DAS was statistically at par with T_6, T_7 and T_8 (Table 1). Number of tillers was significantly higher in T_9 over all other treatments at 90 DAS except T_8 because it had same level of fertilizers. T_9 having RDF along with NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS which provide N, P and K nutrients in adequate proportion at vegetative log phase or grand growth phase and resulted in increased crop growth. It may be due to fact that N, P and K are major plant nutrients being the important constituent of chlorophyll, nucleotides, nucleic acid, enzymes, protein, phospholipids and osmotic and ionic regulation which take part in various metabolic processes of crop, is most needed to increase cell size and cell number by converting the carbohydrate into protoplasm during this stage so N, P and K application were able to cause considerable positive changes in growth. Surve and Bhosale (2015) also recorded the similar results of plant height and dry matter accumulation which were significantly higher with fertilizer level along with foliar applied treatments of NPK through 19:19:19 at 0.5 %.

Treatment having RDF along with foliar ap-

Table 1. Effect of fertilizer levels and foliar application of water soluble fertilizers on plant height dry matter accumulation and number of tillers at different stage of crop growth.

Treatments	Plant height (cm)		Dry mater accumulation (g/mrl)		No. of tillers/mrl
	90 DAS	At maturity	90 DAS	At maturity	90 DAS
T_1: Control	64.42	72.38	114.81	209.73	95.78
T_2: RDF	74.38	85.32	150.81	267.13	117.47
T_3: 75% RDF	70.76	81.99	142.23	245.63	110.53
T_4: RDF, UP* 40 DAS	75.11	87.36	151.89	278.53	118.76
T_5: RDF, NPK** 40 DAS	75.77	88.08	152.92	290.69	120.52
T_6: RDF, UP 65 DAS	76.78	88.38	155.41	313.68	121.83
T_7: RDF, NPK 65 DAS	77.51	88.39	156.35	331.47	122.69
T_8: RDF, UP 40 DAS, NPK 65 DAS	78.56	90.38	157.38	343.84	127.89
T_9: RDF, NPK 40 DAS, UP 65 DAS	79.63	91.77	158.78	349.65	129.15
T_{10}: RDF, $ZnSO_4$ + Urea 45 DAS	75.22	87.31	153.25	332.68	118.77
T_{11}: 75% RDF, UP 40 DAS	71.87	84.36	143.48	257.54	108.81
T_{12}: 75% RDF, NPK 40 DAS	72.14	84.69	144.55	262.82	110.56
T_{13}: 75% RDF, UP 65 DAS	72.41	85.35	147.15	273.42	111.86
T_{14}: 75% RDF, NPK 65 DAS	72.74	85.69	148.81	277.55	113.15
T_{15}: 75% RDF, UP 40 DAS, NPK 65 DAS	75.02	86.39	153.21	302.74	116.22
T_{16}: 75% RDF, NPK 40 DAS, UP 65 DAS	75.39	86.71	154.64	308.67	117.12
T_{17}: 75% RDF, $ZnSO_4$ + Urea 45 DAS	72.46	84.71	143.61	276.41	107.97
SEm+	1.38	1.29	1.13	1.67	1.90
CD (p=0.05)	4.00	3.60	3.27	4.84	5.52

*Water soluble Urea phosphate (UP, 17:44) @ 1.5 %, **Water soluble NPK (18:18:18) @ 1.5 % and Day after sowing (DAS).

Table 2. Effect of fertilizer levels and foliar application of water soluble fertilizers on crop growth rate and leaf area index of wheat.

Treatments	Crop growth rate (g/mrl/day)		Leaf area index	
	90-120 DAS	121-145 DAS	90 DAS	120 DAS
T_1: Control	2.78	0.45	3.81	1.18
T_2: RDF	3.44	0.56	5.04	2.07
T_3: 75% RDF	3.34	0.51	4.41	1.76
T_4: RDF, UP* 40 DAS	3.68	0.65	5.13	2.15
T_5: RDF, NPK** 40 DAS	4.01	0.69	5.18	2.18
T_6: RDF, UP 65 DAS	4.67	0.72	5.24	2.21
T_7: RDF, NPK 65 DAS	5.16	0.81	5.28	2.23
T_8: RDF, UP 40 DAS, NPK 65 DAS	5.47	0.89	5.47	2.32
T_9: RDF, NPK 40 DAS, UP 65 DAS	5.52	0.99	5.63	2.36
T_{10}: RDF, $ZnSO_4$ + Urea 45 DAS	5.43	0.65	5.15	2.15
T_{11}: 75% RDF, UP 40 DAS	3.36	0.53	4.49	1.82
T_{12}: 75% RDF, NPK 40 DAS	3.39	0.67	4.54	1.88
T_{13}: 75% RDF, UP 65 DAS	3.60	0.73	4.59	1.94
T_{14}: 75% RDF, NPK 65 DAS	3.69	0.73	4.67	1.98
T_{15}: 75% RDF, UP 40 DAS, NPK 65 DAS	4.31	0.81	5.12	2.15
T_{16}: 75% RDF, NPK 40 DAS, UP 65 DAS	4.32	0.92	5.19	2.21
T_{17}: 75% RDF, $ZnSO_4$ + Urea 45 DAS	3.92	0.61	4.52	1.86
SEm+	0.04	0.07	0.01	0.01
CD (p=0.05)	0.12	0.21	0.03	0.03

*Water soluble Urea phosphate (UP, 17:44) @ 1.5 %, **Water soluble NPK (18:18:18) @ 1.5 % and Day after sowing (DAS).

plication of NPK (18:18:18) at 40 DAS and Urea phosphate (17:44) at 65 DAS were also superior regarding to the crop growth rate and leaf area index. The maximum crop growth rate was recorded between 90-120 DAS and decreases after 120 DAS, the lowest being upto 30 DAS of wheat crop. The highest crop growth rate was obtained with treatment T_9 i.e., RDF supplemented with NPK (18:18:180) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS at all growth stages but it was statistically at par with T_8 and significantly higher over all other treatments (Table 2). The highest crop growth rate (5.52 g/mrl/day) obtained between 91-120 DAS in T_9 i.e., RDF supplemented with NPK (18:18:180) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS which was 60.46% higher over RDF alone (3.44 g/mrl/day). Leaf area index of wheat progressively increased with advancement of crop age and reached at a plateau at 90 DAS and later on it decreased in all the treatments. Leaf area index was maximum in T_9 i.e. RDF + foliarly applied fertilizers with NPK (18:18:18) at 40 DAS and Urea phosphate (17:44) at 65 DAS but it was statistically at par with T_8 from 90-120 DAS (Table 2). This treatment (T_9) indicates that two times foliar application of fertilizers (NPK (18:18:18) at 40 DAS and Urea phosphate (17:44) at 65 DAS) maintains the N, P and K availability during grand period of growth i.e., active tillering and elongation phase. Besides, application of foliar applied fertilizer at later stage also helps in more nutrient interception by plant leaves which in turn formation of chlorophyll pigment for longer time which leads to high photosynthetic rate even up to 120 DAS. Rahman *et al.* (2014) also recorded similar results of leaf area index (highest LAI at 90 DAS) when they applied fertilizer levels along with two times foliar applied of KH_2PO_4 solution @ 0.1% at 70 and 80 DAS. Nataraja *et al.* (2006) reported the physiological parameters with combined application of 100% P_2O_5 of RDF + soil application of $ZnS0_4$ @ 10 kg ha^{-1} recorded significantly higher leaf area (88.00 dm^2 m^{-1} row length), LAI (3.91) at 90 DAS and LAD (113.70 days) and CGR (0.207 g dm^{-2} day^{-1}) during 61-90 DAS.

Yield attributes and yield

Yield attributes: Foliar application of NPK (18:18:18) with RDF or 75% RDF produced higher effective tillers, number of spikelets/spike and 1000-grain weight as compared to foliar application of Urea phosphate (17:44) with RDF or 75% RDF

irrespective of time of application. The fertilizer levels either RDF or 75% RDF supplemented with single foliar application of either Urea phosphate (17:44) and NPK (18:18:18) at 65 DAS produced higher number of effective tillers, number of spikelets/spike and 1000-grain weight as compared to either RDF or 75% RDF supplemented with single foliar application of either Urea phosphate (17:44) and NPK (18:18:18) at 40 DAS (Table 3). Among different treatments the maximum number of effective tillers, number of spikelets/spike and 1000-grain weight were recorded in the treatment (T_9) i.e., RDF supplemented with NPK (18:18:18) at 40 DAS and Urea phosphate (17:44) at 65 DAS. However, number of effective tillers recorded in T_9 was statistically at par with T_8, number of spikelets/spike recorded in T_9 was statistically at par with T_6, T_7, T_8, T_{10}, T_{14}, T_{15} and T_{16} and 1000-grain weight recorded in T_9 was statistically at par with T_6, T_7 and T_8 but these were significantly higher over rest of the treatments. In general, yield attributing characters viz. number of effective tillers/mrl, grains/spike, spikeletes/spike and 1000-grain weight increased with level of fertilizer along with foliar applied fertilizers irrespective of time of application and doses (Table 3). With the supply of adequate amount of nutrients in T_9 i.e., RDF along with NPK (18:18:18) and Urea phosphate (17:44) at right time resulted into higher plant height, more dry matter accumulation, higher CGR and higher leaf area index which in turn increased yield attributing components with more photosynthates were produced at optimum nutrient supply which ultimately resulted in increase in yield. Jamal *et al.* (2006) also reported that yield attributes i.e., number of fertile tillers per plant, spike length, spike diameters, awn length, number of grains per spike and 1000-grain weight were higher value from foliar + soil applied N, P and K.

Yield: Recommended doses of fertilizer produced significantly higher grain yield as compared to 75% RDF to the tune of 5.09% (Table 3). RDF or 75% RDF along with foliar application of NPK (18:18:18) fertilizer produced higher grain yield as compared to RDF or 75% RDF along with foliar application of Urea phosphate (17:44) irrespective of time of application. RDF or 75% RDF supplemented with Urea phosphate (17:44) and NPK (18:18:18) at 65 DAS produced higher grain yield as compared to RDF or 75% RDF supplemented with Urea phosphate (17:44) and NPK (18:18:18) at 40 DAS. Among different treatments the

Table 3. Effect of fertilizer levels and foliar application of water soluble fertilizers on yield and harvest index of wheat.

Treatments	No. of effective tillers m^{-1} row length	No. of pikelets $spike^{-1}$	1000 grain weight (g)	Grain yield (kg ha^{-1})	Bio-yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)
T_1: Control	73.68	16.62	35.21	2521	6347	3826	40.03
T_2: RDF	90.36	22.30	39.55	5710	14186	8477	40.24
T_3: 75% RDF	85.02	20.00	38.36	5433	13470	8037	40.33
T_4: RDF, UP* 40 DAS	91.35	23.01	40.04	5851	14527	8677	40.27
T_5: RDF, NPK** 40 DAS	92.70	23.33	40.15	5867	14599	8732	40.18
T_6: RDF, UP 65 DAS	93.71	24.00	40.19	6035	14947	8912	40.37
T_7: RDF, NPK 65 DAS	94.37	24.28	40.21	6039	15007	8968	40.23
T_8: RDF, UP 40 DAS, NPK 65 DAS	98.38	26.00	41.03	6205	15452	9247	40.15
T_9: RDF, NPK 40 DAS, UP 65 DAS	99.34	26.69	41.28	6220	15473	9253	40.19
T_{10}: RDF, $ZnSO_4$ + Urea 45 DAS	91.36	24.66	40.02	6011	14938	8926	40.23
T_{11}: 75% RDF, UP 40 DAS	83.69	21.62	38.91	5548	13774	8227	40.27
T_{12}: 75% RDF, NPK 40 DAS	85.04	22.09	39.11	5569	13816	8247	40.30
T_{13}: 75% RDF, UP 65 DAS	86.04	23.67	39.35	5734	14264	8529	40.20
T_{14}: 75% RDF, NPK 65 DAS	87.04	24.32	39.41	5757	14294	8538	40.27
T_{15}: 75% RDF, UP 40 DAS, NPK 65 DAS	89.40	25.00	39.92	5851	14565	8713	40.17
T_{16}: 75% RDF, NPK 40 DAS, UP 65 DAS	90.09	25.29	40.03	5865	14605	8740	40.16
T_{17}: 75% RDF, ZnSO4 + Urea 45 DAS	83.05	24.00	39.60	5725	14255	8531	40.15
SEm+	1.46	0.79	0.36	88	93	131	0.90
CD (p=0.05)	4.25	2.29	1.06	256	268	378	NS

*Water soluble Urea phosphate (UP, 17:44) @ 1.5 %, **Water soluble NPK (18:18:18) @ 1.5 % and Day after sowing (DAS).

maximum grain yield was recorded in the treatment (T_9) i.e., RDF supplemented with NPK (18:18:18) at 40 DAS followed by Urea phosphate at 65 DAS, which was 14.48 and 8.7% higher than 75% RDF and RDF alone, respectively. The improvement of yield attributes i.e., number of effective tillers/mrl (9.93%), number of spikeletes/spike (19.69%), number of grains/spike (10.73%) and 1000-grain weight (4.37%) in T_9 i.e., RDF supplemented with NPK (18:18:18) at 40 DAS followed by Urea phosphate at 65 DAS, led to higher grain yield in this treatment as compared to RDF alone. Surve and Bhosale (2015) also reported that fertilizer level along with foliar applied NPK (19:19:19) @ 0.5% at tillering and flowering stages obtained higher grain yield (3755 kg ha^{-1}) along with yield attributing characters i.e., number of grain/spike, weight of grain/spike and 1000 grain weight at same level of foliar applied fertilizer. Ali *et al*. (2014) also recorded that the phosphite based product, Nutri-phite (3% N, 8.7% P and 5.8% K) increased the wheat grain yield by this treatment.

The highest straw yield was obtained where treatment T_9 i.e., RDF supplemented with NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS but it was statistically at par with T_6, T_7, T_8 and T_{10} and significantly higher over rest of the treatments (Table 3). This may be due to the fact that major plant nutrient N, P and K availability were more uniform throughout the vegetative growth of the crop plants as foliar spray. Same fertilizer levels (RDF or 75% RDF) and time of application along with different foliarly applied fertilizer (NPK (18:18:18) and Urea phosphate (17:44)) produced statistically similar grain, straw and biological yield separately but slightly higher with NPK (18:18:18). It is due to the fact that all three major nutrient (NPK) are supplied with this. Moreover, high values of yield attributes have also contributed to higher yield. Ahmad *et al.* (2012) also reported that both grain and straw yield and different yield contributing characters viz., spikes/plant, spike weight, grains/spike and test weight were significantly higher with soil application of 120 kg N ha^{-1} and supplemented with foliar spray of 2% DAP + 1% KCl + 100 ppm nutrient mixture.

Recommended dose of fertilizer produced significantly higher biological yield as compared to 75% RDF to the tune of 5.31%. RDF or 75% RDF along with foliar application of NPK (18:18:18) fertilizer produced higher biological yield as compared to RDF or 75% RDF along with foliar application of Urea phosphate (17:44) irrespective of time of application. Effects of RDF or 75% RDF supplemented with Urea phosphate (17:44) or NPK (18:18:18) at 65 DAS produced higher biological yield as compared to RDF or 75% RDF supplemented with Urea phosphate (17:44) or NPK (18:18:18) at 40 DAS. The highest biological yield was obtained where treatment T_9 i.e., RDF supplemented with NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS but it was statistically at par with T_8 and significantly higher over all other treatments, because in T_8 and T_9 used same fertilizer level along with alternate application of NPK (18:18:18) and Urea phosphate (17:44). The biological, grain and straw yields were higher by 9.07, 8.9 and 9.15%, respectively in T_9 i.e., RDF supplemented with NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS as compared to RDF alone (Table 3). The increase in biological yield was also due to the increase in dry matter accumulation which was due to high leaf area index in this treatment. Amanullah *et al.* (2015) reported that yield components and yield increased with soil applied along with 2% foliar spray of urea. The possible region in increased yield were adequate nutrient management by reducing leaching losses of N, P and K and nutrient availability to grand growth phase by foliar application of fertilizers. In the present investigation, harvest index was not influenced significantly with various treatments (Table 3) since harvest index of any crop is more controlled by genetic factor rather than management and environment factors.

ECONOMICS

The cost of cultivation was equal in T_8 and T_9 (Rs 58477 ha^{-1}) while control recorded the lowest cost of cultivation Rs 50848 ha^{-1}. Because in T_8 and T_9 applied RDF along with alternate application of NPK (18:18:18) and Urea phosphate (17:44). These two treatments also had higher cost of cultivation due to increased cost of fertilizers and its application. The highest gross returns were recorded in T_9 due to highest grain yield in it and as a result net returns

Table 4. Effect of fertilizer levels and foliar application of water soluble fertilizers on economics of wheat production.

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B : C ratio
T_1: Control	50848	52183	1335	1.03
T_2: RDF	57027	116732	59705	2.05
T_3: 75% RDF	55647	110983	55336	1.99
T_4: RDF, UP* 40 DAS	57652	119579	61926	2.07
T_5: RDF, NPK** 40 DAS	57851	120015	62164	2.07
T_6: RDF, UP 65 DAS	57652	123207	65554	2.13
T_7: RDF, NPK 65 DAS	57851	123467	65616	2.13
T_8: RDF, UP 40 DAS, NPK 65 DAS	58477	126987	68510	2.17
T_9: RDF, NPK 40 DAS, UP 65 DAS	58477	127240	68763	2.17
T_{10}: RDF, $ZnSO_4$ + Urea 45 DAS	57282	122909	65626	2.14
T_{11}: 75% RDF, UP 40 DAS	56272	113383	57110	2.01
T_{12}: 75% RDF, NPK 40 DAS	56471	113792	57321	2.01
T_{13}: 75% RDF, UP 65 DAS	56272	117295	61023	2.08
T_{14}: 75% RDF, NPK 65 DAS	56471	117674	61203	2.08
T_{15}: 75% RDF, UP 40 DAS, NPK 65 DAS	57097	119723	62626	2.09
T_{16}: 75% RDF, NPK 40 DAS, UP 65 DAS	57097	120031	62934	2.10
T_{17}: 75% RDF, $ZnSO_4$ + Urea 45 DAS	55902	117149	61247	2.09

*Water soluble Urea phosphate (UP, 17:44) @ 1.5 %, **Water soluble NPK (18:18:18) @ 1.5 % and Day after sowing (DAS).

and B:C ratio was also higher in this treatment. The net returns and B:C ratio were improved with the application of RDF along with alternate application of NPK (18:18:18) at 40 DAS and Urea phosphate (17:44) at 65 DAS (Table 4). But T_{15} and T_{16} were found more economical by reducing 25% of RDF and supplemented with two times foliarly applied NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS. In T_{16} i.e., 75% RDF along with foliar application of NPK (18:18:18) at 40 DAS followed by Urea phosphate (17:44) at 65 DAS, cost of cultivation is nearly equal to RDF alone but net returns were Rs. 3229 ha^{-1} higher. Saleem *et al*. (2013) also reported that soil application of urea along with 2 and 3% foliar application of urea gave maximum return by spending minimum. The foliar application of urea ((2% spray of urea (at two leaves, booting and tillering stage) or 3% spray of urea (at tillering and booting stage)) along with soil application was economical and can compensate the yield losses.

CONCLUSION

The treatment having RDF supplemented with foliar application of water soluble fertilizers NPK (18:18:18) @ 1.5% at 40 DAS followed by Urea phosphate (17:44) @ 1.5% at 65 DAS, was superior in terms of growth parameters, yield attributes and yield of wheat over all other treatments. However, alternate application of NPK (18:18:18) @ 1.5% and Urea phosphate (17:44) @1.5% or vice versa produced statistically similar grain yield of wheat at the same level of fertilizer application. RDF or 75% RDF along with foliar application of NPK (18:18:18) @ 1.5% was slightly superior as compared to RDF or 75% RDF along with foliar application of Urea phosphate (17:44) @ 1.5% irrespective of time of application. Single foliar application of water soluble fertilizer at 65 DAS had an edge over its application at 40 DAS along with same level of fertilizers. By reducing 25% of RDF and supplemented with alternate foliar application of water soluble fertilizers NPK (18:18:18) @ 1.5% at 40 DAS followed by Urea phosphate (17:44) @ 1.5% at 65 DAS was more economical.

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