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PERFORMANCE OF WHEAT (*Triticum aestivum* L.) UNDER SOIL AND FOLIAR NUTRITION

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ABSTRACT

A field study was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat) during *rabi* season of 2019-20 to study the performance of wheat (*Triticum aestivum* L.) under soil and foliar nutrition by using Randomized Complete Block Design with nine treatments and four replications. The study revealed that soil application of 50% RDF + 2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS recorded significantly higher protein content in grains, N, P and K uptake by crop, length of spike, number of grains spike^{-1}, 1000 grain weight, grain yield and straw yield of wheat which remained at par with 50% RDF through soil application + 2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS. The study also indicated that there was positive correlation between, N, P and K content (%), N, P and K uptake of crop, length of spike, number of grains spike^{-1}, 1000 grain weight with the grain and straw yield of wheat crop.

(Key words: Wheat, RDF, soil application, foliar nutrition, uptake, yield, correlation)

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important staple food grains of human race. It is the second most widely cultivated cereal after maize (Houshyar *et al*., 2010). It is India's second most important cereal crop, after rice, covering around 29 million hectares and accounting for 37% of the country's food grain production (Anonymous, 2012). Wheat is an important food grain that transformed India from paucity of food grains at the time of independence to the surplus mode. When India got independence in the year 1947, the production of wheat was quite low at around 6.5 million tonnes. In the present scenario, India is second largest producer of wheat in the world with a production touch to all time record of 106.21 million tonnes for the year 2019-20 and is higher by 11.60 million tonnes over average wheat production of 94.61 million tonnes. Wheat, after rice, is India's second most common cereal crop, covering 29.5 million hectares. In 2017-18, India's total annual wheat production was 99.51 Mt, with a productivity of 3.37 t ha^{-1}. India is the world's largest producer and ranks as the second largest producer of wheat in world (Anonymous, 2021).In addition, India exports over 0.6 million tonnes of wheat to Bangladesh, Nepal, the United Arab Emirates, and other nations.Apart from being used as food, wheat grains also have industrial importance including manufacturing of paste, alcohol, gluten *etc*. Residues obtained after milling wheat grains ***i.e.,*** bran is used as cattle feed. Wheat straw is utilized as a fodder for feeding the livestock and also used in manufacturing mattresses, straw hats, papers and art purposes. Wheat is quite sensitive to nutrient management; therefore it needs proper care in terms of nutrients. As we look for new ways to boost production, it becomes clear that there is still a significant yield gap between wheat-growing regions across the world, as well as between on-station and on-farm yields (Majumdar *et al.,*2013). To realize the yield potentiality of any crops/ cropping system, optimum nutrient supply is an essential and foremost important practice (Hatti *et al*., 2018). Soil fertility and other agronomic practices play an indispensable role in determining the economic yield and quality of wheat. Fertilizers have been and will continue to be the key inputs for achieving the estimated food grain production goals of the country. The importance of nitrogen, phosphorus and potassium application to wheat crop has been recognized since long and is the backbone of any fertilizer management programme. Nitrogen (N), phosphorus (P) and potassium (K) requirements are depend on the type of soil, climate, production practices, available moisture and cropping pattern. Appropriate nutrient management can maintain the soil nutrient balance besides supplying nutrients to plants in sufficient amount. The nutrient management options influences the growth, yield and yield attributing characters of wheat (Mishra and Singh, 2014). Hence, the balanced nutrition (right dose, right time, right method, right source and right proportion) of nutrients is the key to sustain its productivity on a long-term basis (Vijayakumar *et al.,* 2019).

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The basic requirement for stabilizing the crop productivity lies in the improvement of soil fertility (Ezung *et al*., 2020). Foliar fertilization can complement soil fertilization. Crop responses to foliar application of nutrients can be seen in 3 to 4 days. Foliar fertilization can complement soil fertilization.

Use of chemical fertilizers cannot be avoided wholly as they are potential sources of high amount of nutrients in easily available form (Yadav *et al.,* 2017). The nitrogen is subjected to various types of losses. The nitrogen left over in soil is lost through denitrification, volatilization and leaching processes in the soil. As a result of inefficient and partial use of nitrogen, crop yields are reduced. Furthermore, fertilizers need a lot of energy to manufacture and are very costly (Wagan *et al*., 2017). In general, foliar N application and uptake during anthesis is preferred over soil urea applications because it allows for faster (50 per cent absorption in 6 hours) and more effective N transport to the crop (Wagan *et al*., 2017). Foliar fertilization through leaves is an efficient technique of fertilization which enhances the availability of nutrients. It has been notices that utilization of fertilizers especially urea applied through soil is not as effective as whenit is supplied to the plant through foliage along with soil application (Mosluh *et al*., 1978). Foliar fertilization also improves the availability of nutrients to crops for obtaining higher yield (Arif *et al*., 2006). Foliar application has advantages of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation as well as regulating the uptake of nutrients by plant. Foliar nutrition is designed to eliminate the problems like fixation and immobilization of nutrients. Hence, foliar nutrition is recognized as an important method of fertilization in modern agriculture (Chaurasia *et al*., 2005).

MATERIALS AND METHODS

A field experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of 2019-20 and is located in the North Gujarat Agro-climatic Zone of the Gujarat State. The geographical coordinates of the location at 24° 19' North latitude and 72° 19' East longitude with an elevation of 154.52 meters above the mean sea level. The zone is characterized by arid and semi-arid climate with fairly cold winter and hot and dry windy summer. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.22%) and available nitrogen (165.8 kg ha^{-1}), medium in available phosphorus (43.8 kg ha^{-1}) and high in available potassium (330.9 kg ha^{-1}) with soil pH of 7.6. The experiment was set up with nine treatments of different soil and foliar sprays and four replications. The treatments were T_1: 100% RDF soil application, T_2: 75% RDF soil application +1% foliar sprays of urea, urea phosphate and MOP at 30 and 45 DAS , T_3: 75% RDF soil application +1% foliar sprays of urea, urea phosphate and MOP at 30, 45 and 60 DAS, T_4: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS, T_5: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS, T_6: 50% RDF soil application + 2% foliar spray of urea, urea phosphate and MOP at 30 and 45 DAS, T_7: 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS, T_8: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS and T_9: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS. The previous crop grown on the experimental site was cowpea in *kharif* 2019-20. Land preparation was done by tractor drawn cultivator. Full quantity of recommended dose of phosphorus, potassium and half dose of nitrogen in form of DAP, MOP and urea, respectively were manually applied before sowing of wheat crop in the furrows as per the treatments and properly covered with soil. The remaining half dose of nitrogen was applied in the form of urea in two equal splits (25% at CRI and 25% at flag leaf stage) after 2nd and 5th irrigation in each treatment plots. Whereas, foliar spay was applied as per the treatments. A pre-emergence application of pendimethalin @ 0.75 kg ha^{-1} on next day of sowing using Knapsack sprayer and one hand weeding at 40 DAS was done to manage the weeds. Total nine irrigations were given to wheat crop depending on soil and environmental conditions. Wheat variety 'Gujarat Wheat 451' was sown. The seeds were treated with Fipronil 5 SC @ 6 ml kg^{-1} seed and were sown with the seed rate of 120 kg ha^{-1} with inters row spacing of 22.5 cm and at a uniformly depth of 4 - 4.5 cm deep in a previously opened furrows on 17th Nov, 2019. Five previously tagged plants from each net plot were selected for recording yield attributes *viz.,* length of spike, number of grains spike^{-1}, 1000 grain weight. Grain and straw yield were computed from the plants harvested from net plot in each treatment. N content in grains and straw was estimated as per the method suggested by Waranke and Barber (1974). P and K content in grains and straw were estimated as per the method suggested by Jackson (1973). NPK nutrient uptake of grains and straw was calculated by following formula as below;

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x yield (kg ha}^{-1})}{100}$$

The percentage of protein of grain was worked out by multiplying the nitrogen percentage values with a factor of 5.70. All the observations were made using standard procedures.The statistical analysis of the experimental data was done by following the procedure described by Gomez and Gomez (1984). The different sources of variation in ANOVA were tested by "F-test" and compared with the value of Table F at 5% level of significance. S.Em.±, critical differences and co-efficient of variance (C.V. %) were also worked out. Correlation and regression studies were done as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Nutrient concentration, uptake and protein content

The nutrient concentration, nutrient uptake and protein content of wheat were significantly influenced by different soil and foliar nutrition treatments (Fig. 1). The data revealed that 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS recorded significantly higher N, P and K contents in grain (2.20, 0.390 and 0.344 %, respectively) and straw (0.738, 0.290 and 1.075 %, respectively) which was found on par with 50% RDF soil application + 2% foliar sprays of soluble NPK (19:19:19) at 30, 45 and 60 DAS [N, P and K contents in grain (2.14, 0.378 and 0.334 %, respectively) and straw (0.698, 0.276 and 1.073 %, respectively)]. Whereas, significantly lower N, P and K contents in grain (1.87, 0.300 and 0.295 %, respectively) and straw (0.580, 0.214 and 0.965 %, respectively) were observed in 100% RDF soil application treatment. The higher content of N, P and K content in grain and straw is attributed to frequent application of fertilizers which resulted into increased availability of N along with P and K throughout grand growth period when it was most needed. Yassen *et al*.(2010) also reported the same results wherein additional nitrogen as a foliar spray increased nitrogen concentration in both grain and straw when compared with the control. Similar conclusion were drawn by Maitlo *et al.* (2006), who observed improvement in growth, yield, nutrient uptake and quality of wheat under foliar fertilization of N through 2-2.5% urea solution. The higher content of phosphorus might be due to increase in the initial seedling growth of plant due to soil application of phosphorus fertilizers along with the foliar application of phosphorus leading to more assimilation of phosphorus by the wheat plant. Soil and foliar application of all three major nutrients in ample quantity might have enhanced the availability of potash which enhanced the assimilation of potash which resulted in increased content of potash in grain and straw. Similar conclusions were drawn by Abdul *et al.* (2014),who witnessed significant effect on plant P and K due to foliar application of phosphorus.

Correspondingly, 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS treatment recorded significantly higher uptake of N,P and K (140.66, 33.69 and 75.15 kgha^{-1}, respectively) followed by 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS(131.64, 31.48 and 72.43 kg ha^{-1}, respectively) (Table 1). Increase in nutrient uptake might be due to combined application through soil as well as foliar application of fertilizers which improved the N, P and K content in grain and straw which increased uptake N, P and K in grain and straw of wheat.These results are in line with Jankowski *et al.* (2016), who stated that intensified foliar fertilization increased the phosphorus, potassium, calcium and sulphur content of wheat grains.

Protein content in grains was significantly influenced by different soil and foliar nutrition treatments. Among different treatments, significantly higher protein content in grain was registered with the application of 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS (12.54%) which was statistically at par with 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS (12.17%). Whereas, significantly lower protein content in grain was noticed in 100% RDF soil application (10.66%). The higher protein content in soil and foliar nutrition treatments was attributed to increase nitrogen concentration in grain and straw (Fig. 1) as evidenced by correlation and regression studies (Table 2) indicated positive correlation coefficient value between protein content (%) in grains and N content (%) in wheat grains. Further, the regression studies indicated that one per cent increase in N content (%) in wheat grains increased protein content of wheat grains by 4.54%. The higher protein content may be due to the fact that application of major plant nutrient N, P and K fertilizer at later stage of crop growth or even grain formation, utilized in grain than other plant parts. That is why protein content in grain was more with later stage of foliar application of nutrient N, P and K fertilizers.More or less similar results were also found by Curt *et al*.(2002),who demonstrated that foliar N applications just before and following flowering significantly enhanced grain N content and, thus, percent protein in winter wheat.

Yield attributes and yield

A perusal of the data (Table 1) revealed that different treatments caused significant variation on various yield parameters and yields of wheat.The results revealed that application of 50% RDF through soil +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS produced significantly higher length of spike, number of grains spike^{-1}, 1000 grain weight, grain and straw yield (11.42 cm, 41.86, 41.84 g, 4543 kg ha^{-1} and 5527 kg ha^{-1}, respectively) which was statistically established on par with 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS (10.22 cm, 40.39, 40.49 g, 4405 kg ha^{-1} and 5383 kg ha^{-1}, respectively). Whereas, significantly lower length of spike, number of grains spike^{-1}, 1000 grain weight, grain and straw yield were observed in100% RDF soil application (8.76 cm, 36.76, 36.53 g, 3598 kg ha^{-1} and 4353 kg ha^{-1}, respectively). The magnitude of increase in grain yield of wheat due to former two treatments over latter(100 % RDF) was the extent of 26.87 and 22.45 per cent, respectively. The higher grain yield with 50% RDF through soil +2% foliar spray of either urea, urea phosphate and MOP or soluble NPK (19:19:19) at 30, 45 and 60 DAS might be attributed to increase in nutrient uptake leading to more accumulation of dry matter in grains due to foliar application of nutrients at different vegetative stages of wheat which lead to improvement in yield attributes like length of spike, number of grains spike^{-1} and 1000-grain weight (Table 1). The reasons are further supported by correlation values and regression equations (Table 2) which indicated positive correlation between content (%) of N, P, K in grain, uptake (kg ha^{-1}) of N, P and K by grains with the grain yield (0.957,

Table 1.Nutrient uptake, yield parameters and yield of wheat as influenced by different nutrient management treatments

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			Length of spike (cm)	No. of grains spike^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total					
T_1: 100% RDF soil application	67.38	25.26	92.64	10.84	9.30	20.14	10.59	42.01	52.60	8.76	36.76	36.53	3598	4353
T_2: 75% RDF soil application +1% foliar spray of urea, urea phosphate and MOP at 30 and 45DAS	74.58	30.47	105.06	12.47	10.92	23.39	11.85	47.53	59.38	9.10	37.09	38.16	3896	4765
T_3: 75% RDF soil application +1% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS	79.93	31.51	111.43	13.99	11.58	25.56	12.68	48.60	61.28	9.39	38.00	39.51	3993	4827
T_4: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS	72.48	28.68	101.16	11.82	10.25	22.07	11.43	45.39	56.82	8.97	36.98	37.99	3812	4610
T_5: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS	77.58	30.80	108.38	13.38	11.61	25.00	12.07	47.67	59.74	9.24	37.87	38.63	3904	4763
T_6: 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30 and 45DAS	83.59	33.68	117.26	14.54	12.66	27.20	13.20	51.18	64.38	10.04	39.81	39.78	4044	4861
T_7: 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS	100.05	40.60	140.66	17.75	15.94	33.69	15.65	59.50	75.15	11.42	41.86	41.84	4543	5527
T_8: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS	81.22	32.40	113.61	13.95	12.08	26.03	12.87	50.78	63.65	9.93	39.23	39.42	3986	4829
T_9: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS	94.09	37.55	131.64	16.64	14.84	31.48	14.72	57.70	72.43	10.22	40.39	40.49	4405	5383
SEm.±	4.02	1.37	4.56	0.73	0.57	0.98	0.65	2.20	2.48	0.44	1.14	0.96	169	226
CD (P=0.05)	11.73	4.00	13.30	2.14	1.66	2.86	1.89	6.43	7.24	1.29	3.31	2.79	493	660
CV%	9.89	8.48	8.03	10.53	9.37	7.51	10.15	8.80	7.90	9.11	5.87	4.89	8.41	9.26

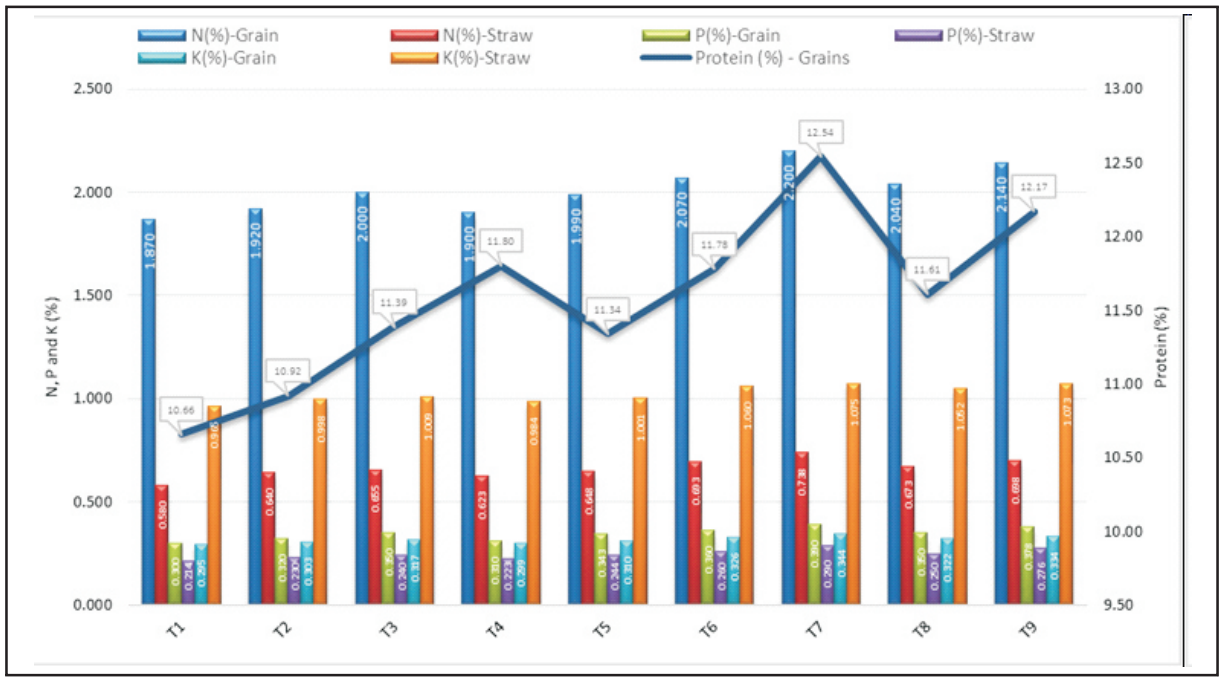

Figure1. Nutrient concentration (N, P and K %) in grain, straw and protein content (%) of wheat grains as influenced by different nutrient management treatments **Legend:**

T_1: 100% RDF soil application
T_2: 75% RDF soil application +1% foliar spray of urea, urea phosphate and MOP at 30 and 45DAS
T_3: 75% RDF soil application +1% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS
T_4: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS
T_5: 75% RDF soil application +1% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS
T_6: 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30 and 45DAS
T_7: 50% RDF soil application +2% foliar spray of urea, urea phosphate and MOP at 30, 45 and 60 DAS
T_8: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30 and 45 DAS
T_9: 50% RDF soil application +2% foliar spray of soluble NPK (19:19:19) at 30, 45 and 60 DAS

Table 2. Correlation and regression relationship between various parameters and yield as influenced by different nutrient management treatments

Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equation	R^2
Grain yield (kg ha^{-1})	N % in grain	0.957	Y= -1046.75+2515.26x	0.916
	P % in grain	0.941	Y= 895.33+9069.01x	0.886
	K % in grain	0.947	Y= -1260.82+16676.62x	0.897
	N uptake by grains (kg ha^{-1})	0.992	Y= 1753.67+27.91x	0.985
	P uptake by grains (kg ha^{-1})	0.986	Y= 2207.57+130.11x	0.973
	K uptake by grains (kg ha^{-1})	0.992	Y= 1701.52+181.36x	0.984
Straw yield (kg ha^{-1})	N % in straw	0.926	Y= 76.24+7268.31x	0.857
	P % in straw	0.956	Y= 1402.88+14053.66x	0.913
	K % in straw	0.868	Y= -2948.32+7643.79x	0.753
	N uptake by straw (kg ha^{-1})	0.986	Y= 2348.65+78.30x	0.972
	P uptake by straw (kg ha^{-1})	0.985	Y= 2825.72+169.32x	0.971
	K uptake by straw (kg ha^{-1})	0.988	Y= 1669.85+64.15x	0.976
Protein content (%) in grains	N % in grain	0.857	Y= 2.44+4.54x	0.734
Grain yield (kg ha^{-1}) 866.73+325.95x	Length of spike (cm) 0.863		0.929	Y=
	No. of grains $spike^{-1}$	0.929	Y= -1900.67+153.13x	0.864
	1000 grain weight (g)	0.961	Y= -3052.53+180.65x	0.924

0.941, 0.947, 0.992, 0.986 and 0.992, respectively). Similarly, the study indicated positive correlation between content (%) of N, P, K in straw, uptake (kg ha^{-1}) of N, P and K by straw with the straw yield (0.926, 0.956, 0.868, 0.986, 0.985 and 0.988, respectively).The quantification of relationship between nutrient uptake and yields have shown that each kg increase in uptake of N, P and K by grains resulted in increase in grain yield of wheat by 27.91, 130.11 and 181.36 kg ha^{-1}, respectively. Likewise, each kg increase in uptake of N, P and K by straw resulted in increase in straw yield of wheat by 78.30,169.32 and 64.15 kg ha^{-1}, respectively.

In addition, the correlation and regression studies implied that there was positive correlation between yield attributes and grain yield which showed that each cm increase in length of spike, each one increase in number of grains $spike^{-1}$ and each one gram increase in 1000-grain weight resulted in enhancement in grain yield by 325.95, 153.13 and 180.65 kg ha^{-1}, respectively.Similar results were noticed under three foliar applications of nutrients which lead to maximum number of spikes m^{-2}, grains $spike^{-1}$, thousand grains weight and biological yield (Arif *et al*., 2006). Gul *et al.* (2011) also witnessed parallel results *i. e.,* significant response of wheat yield components and wheat yield for foliar sprays of nitrogen, potassium and zinc.

In view of the results obtained from the investigation, it is concluded that improved quality of grains, higher grain and straw yields of wheat under loamy sand soils of North Gujarat Agro-climatic Zone conditions can be obtained by nourishing the crop with 50% RDF (120:60:40 kg N: P_2O_5: K_2O kg ha^{-1}) through soil application along with 2% foliar spray of either urea, urea phosphate and MOP or soluble NPK (19:19:19) at 30, 45 and 60 DAS.

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