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Effect of Foliar Application of Water-Soluble Fertilizers on Growth and Yield of Wheat (*Triticum aestivum* L.)

A. R. Ninama [a++], G. S. Vala [b#], R. Choudhary [a++*], S. D. Chudasma [c†], J. P. Jadeja [a†] and K. V. Ram [a++]

[a] *Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India.*
[b] *Horti. Agriculture Research Station (Fruit Crops), Junagadh Agricultural University, Mahuva-364290, Gujarat, India.*
[c] *Department of Agronomy, Navasari Agricultural University, Navasari-396445, Gujarat, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Direct fertilizer application to leaves stimulates leaf activity, which directly affects the plant's water uptake and promotes root growth. Foliar fertilizers can therefore hasten the uptake of nutrients from the soil, which is advantageous for plants that need urgent nutrient intervention. A field experiment was carried out at Junagadh Agricultural University, Junagadh during rabi season of 2019-20 to evaluate effect of foliar spray of water-soluble fertilizers on wheat (*Triticum aestivum* L.) growth and yield. The experimental trial consists of 12 treatments with 3 replication and randomized block design. The results of the experiment revealed that the growth parameters viz., plant height and

[++] *Ph.D. Scholar;*
[#] *Research Scientist;*
[†] *M. Sc. Scholar;*
**Corresponding author: E-mail: raghuveerbajya63458@gmail.com;*

number of effective tillers metre^{-1} row length at harvest increased significantly with the application of T_2 + foliar spray of 19:19:19 @ 0.5% at 60 DAS & 90 days after sowing (DAS) whereas plant population were not affect significantly by application of different treatments. There was also significant improvement in grain and straw yields were observed with the application of T_8 over 75% recommended dose of fertilizer (RDF) and 100% RDF.

Keywords: Foliar spray; growth; RDF; water soluble fertilizer; wheat; yield.

1. INTRODUCTION

Foliar feeding is a strategy that is now widely used in modern crop management to ensure optimal crop performance. It does this by enhancing crop growth at specific growth stages, correcting nutrient deficiencies in the crop, and improving crop tolerance to unfavorable conditions for crop. Foliar feeding is a method of supplying nutrients to plants by sprinkling liquid fertilizer either in suspension or solution directly over the crop canopy. When used as a supplement with soil fertilization and utilized properly it can be more effective, affordable, environmentally friendly, and target-oriented. Foliar application gets around some of the drawbacks of soil fertilization, such as leaching, precipitation of insoluble fertilizer's, antagonistic relationships between specific nutrients, heterogeneous soils unsuited to low dosages, and fixation/absorption reactions, such as those involving phosphorus and potassium [1]. Not all fertilizers can be used as foliar sprays, but only those with a low salt index, high solubility, and high purity can be used in this way [2]. For foliar application, liquid fertilizers are a preferable source [3]. These fertilizers are extremely water soluble and have various N, P, and K ratios that make them suitable for foliar nutrition [4]. Specialty fertilizers are those fertilizer products that are used under unique soil or plant circumstances or to encourage unique plant behavior.

Its scope includes all water-soluble fertilizers (WSF), slow-release fertilizers, micronutrients, and bespoke fertilizers. Water soluble fertilizers come in a variety of formulas with varying amounts of nitrogen, phosphorus, and potassium (NPK), but they may also include other nutrients including micronutrients. To increase yield and enhance quality of a variety of crops, such as fruits, vegetables, oil seeds, pulses, cereals, cotton, coriander, tobacco, sugarcane, and tea, water soluble fertilizers are used as chemical fertilizers in sprinkler and drip irrigation systems as well as foliar sprays. Water soluble fertilizers applied topically to crops is reported to show positive effects on their growth, production, and quality [5]. Foliar nutrition is thus acknowledged as a significant fertilization technique in contemporary agriculture. When a crop is in need of a lot of nutrients, foliar fertilization can be a great way to alleviate nutrient shortages and provide essential nutrients. Crop foliage gains more nutrients as a result, and crop leftovers also gain more nutrients. In the late growing season, when plants are less able physiologically to absorb nutrients from the soil, it can feed nutrients effectively. Foliar fertilization has a significant potential to produce higher yield when utilized as a supplement to soil fertilization in intensive cropping systems.

2. MATERIALS AND METHODS

Field experiment was conducted at Instructional Farm, Junagadh Agricultural University, Gujarat, (21°51´ N latitude and 70°55´ E longitude), during *rabi* 2019-20 season. Soil was medium black clayey in texture (pH 7.8, EC 0.33 d S m^{-1}. RDF was applied as soil application through Urea, DAP and MOP. P_2O_5 and K_2O was applied as basal at sowing of crop, while nitrogen applied in three splits i.e. 25% at sowing, 50% at 25 DAS and 25% at 35 DAS). The experimental field was laid out in randomized block design comprising of 8 treatments and 3 replications i.e., $T_1$100 % RDF T_2 – 75 % RDF (control), T_3 – T_2 + foliar spray (FS) of Urea @ 2 % at 30 DAS, T_4 – T_2 + FS of Urea @ 2 % at 30 DAS & 60 DAS, T_5 – T_2 + FS of Urea @ 2 % at 30 DAS, 60 DAS & 90 DAS, T_6 - T_2 + FS of 19:19:19 @ 0.5 % at 30 DAS, T_7 – T_2 + FS of 19:19:19 @ 0.5 % at 30 DAS & 60 DAS, T_8 – T_2 + FS of 19:19:19 @ 0.5 % at 30 DAS, 60 DAS & 90 DAS, T_9- T_2 + FS of Urea @ 2 % at 30 DAS + FS of 19:19:19 @ 0.5 % at 60 DAS, T_{10}- T_2 + FS of Urea @ 2 % at 30 DAS + FS of 13:00:45 @ 0.5 % at 60 DAS, T_{11}- T_2 + FS of Urea @ 2 % at 30 DAS + FS of 19:19:19 @ 0.5 % at 60 DAS + FS of 13:00:45 @ 0.5 % at 90 DAS and T_{12}- T_2 + FS of 19:19:19 @ 0.5 % at 30 DAS + FS of 13:00:45 @ 0.5 % at 60 DAS. Wheat was grown under GW 463 variety. The initial plant population was noted at 60 days after sowing and at harvest This was accomplished by calculating the number of plants per hectare based on the no. of plants per 1 meter row length from three different spots within each net plot area. The original plant population was noted at harvest and 60 days after sowing. Each net plot's output was threshed and cleaned separately, and the grain yield was calculated in kilograms per net plot. On a hectare basis, the grain yield per net plot was changed to kilograms. Analysis of variance (ANOVA) was performed on the experiment's data in excel sheet accordance with Gomez and Gomez's [6].

3. RESULTS AND DISCUSSION

3.1 Plant Population

Table 1 provides information on the plant population per hectare at 60 days after sowing and at harvest as affected by various treatments. A review of the data revealed that the number of plants per hectare at 60 DAS and at harvest were not significantly impacted by the various treatments. The results clearly indicated that plant population per hectare were uniform. Hence, various growth, yield attributes and yield of wheat crop was not influenced due to variation in the plant population.

The data presented in Table1 revealed that 60 days after sowing and at harvest plant population were not significantly affected due to application of foliar spray of WSF. This indicated that foliar spray application of water soluble fertilizers had no influence on germination and emergence which tended to indicate that plant population was uniform in all the treatments and there was no ~~any~~ adverse effect on wheat crop.

3.2 Plant Height

The data recorded (Table 2) on plant height at 30, and 60 days after sowing and at harvest as affected by various treatments along with statistical inference.

A perusal of data indicated that height of plant at 30 DAS did not differ significantly due to different treatments.

Table 1. Plant population of wheat as influenced by different treatments

Treatment No.	Plant Population (ha^{-1})	
	At 60 DAS	at harvest
T_1	1481481	1475474
T_2	1452564	1446241
T_3	1358876	1356875
T_4	1457749	1455394
T_5	1561574	1557458
T_6	1560856	1558564
T_7	1563231	1560233
T_8	1661736	1659769
T_9	1665405	1661452
T10	1564536	1560261
T11	1560845	1558107
T12	1559956	1558214
S.Em.±	11760	12570
C.D. at 5%	NS	NS
C.V.%	6.14	6.67

Table 2. Plant height of wheat as influenced by different treatments

Tr. No.	Plant height (cm) at		
	30 DAS	60 DAS	Harvest
T_1	29.62	50.73	76.26
T_2	29.03	49.59	70.44
T_3	32.92	65.35	78.67
T_4	29.09	65.06	74.89
T_5	31.92	73.60	81.44
T_6	32.83	73.55	83.88
T_7	32.05	66.23	76.73
T_8	33.31	75.80	85.46
T_9	34.69	75.43	81.61
T10	31.68	52.95	73.26
T11	32.00	64.16	74.26
T12	31.29	65.38	80.17
S.Em.±	1.26	2.95	3.32
C.D. at 5%	NS	8.66	9.75
C.V.%	6.93	7.83	7.37

According to the data in Table 2, increasing the foliar application of water-soluble nutrients resulted in a significant rise in plant height. Application of T_2 + FS of 19:19:19 @ 0.5% at 30 DAS, 60 DAS & 90 DAS (T_8) recorded significantly higher plant height (75.80cm), but it was statistically at par with T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS (T_9), T_2 + FS of 19:19:19 @ 0.5% at 30 DAS (T_6), and T_2 + FS of Urea @ 2% at 30 DAS, 60 DAS & 90 DAS (T_5). While treatment 75% RDF (T_2) recorded significantly lower plant height (49.59 cm), which was at par with T_2 (100% RDF).

Data presented in Table 2—indicated that increasing foliar spray of WSF significantly increased plant height. Application of T_2 + FS of 19:19:19 @ 0.5% at 60 DAS & 90 DAS (T_8) recorded significantly higher plant height (85.46cm) at harvest, but it was statistically at par with T_2 + FS of 19:19:19 @ 0.5% at 30 DAS (T_6), T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS (T_9), T_2 + FS of 19:19:19 @ 0.5% at 30 DAS + FS of 13:00:45 @ 0.5% at 60 DAS (T_{12}), T_2 + FS of Urea @ 2% at 30, 60 & 90 DAS (T_5) and 100% RDF (T1). While treatment 75% RDF (T2) recorded significantly the lower plant height (70.44 cm) at 60 DAS and harvest.

At 30 DAS, the increasing application of foliar sprays of water-soluble fertilizers had non-significant impact on plant height. Nevertheless, foliar sprays of 19:19:19 @ 0.5% at 30, 60 and 90 DAS resulted in significantly greater plant heights of 75.80 cm and 85.46 cm at 60 days after sowing and harvest, respectively.

The significantly higher increase in plant height that was observed may be because the crop's responses to using nutrients throughout several growth phases have been stimulated by the foliar application of nutrients at different times of the crop's growth stages. The spraying of Nitrogen, Phosphorus, and Potassium in combination increased the mobilization of macronutrients as reported by Hatwar *et al*. [7].

3.3 Grains Yield (kg ha^{-1})

Table 3 presents data on grain yield as effected by different treatments together with statistical inference. A critical examination of data (Table 3) indicated that grain yield was significantly affected by increasing foliar spray of water-soluble fertilizer's. Significantly higher yield (4688 kg ha^{-1}) was obtained with the application of T_2 + FS of 19:19:19 @ 0.5% at 30 DAS, 60 DAS & 90 DAS (T_8), but it remained statistically at par with T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS (T_9), T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS + FS of 13:00:45 @ 0.5% at 90 DAS (T_{11}), T_2 + FS of 19:19:19 @ 0.5% at 30 DAS + FS of 13:00:45 @ 0.5% at 60 DAS (T_{12}), T_2 + FS of Urea @ 2% at 30 DAS + FS of 13:00:45 @ 0.5% at 60 DAS (T_{10}), and T_2 + FS of 19:19:19 @ 0.5% at 30 DAS & 60 DAS (T_7). While, treatment 75% RDF (T_2) recorded significantly lower grain yield (2868 kg ha^{-1}).

Table 3. Grain yield, straw yield and harvest index of wheat as influenced by different treatments

Treatment No.	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest index (%)
T_1	3426	4759	41.85
T_2	2868	4507	38.53
T_3	3126	4912	38.20
T_4	3246	4907	39.32
T_5	3241	4958	39.52
T_6	3918	5079	43.53
T_7	4069	5159	44.08
T_8	4688	5690	45.17
T_9	4369	5683	43.46
T_{10}	4092	5399	43.11
T_{11}	4228	5402	43.90
T_{12}	4102	5277	43.73
S.Em.±	232	238	1.60
C.D. at 5%	680	699	NS
C.V.%	10.67	8.02	6.64

3.4 Straw Yield (kg ha^{-1})

The data (Table 3) regarding straw yield as influenced by various treatments that with increasing foliar spray of water-soluble fertilizers significantly increasing straw yield. Higher straw yield (5690 kg ha^{-1}) were recorded with the application of T_2 + FS of 19:19:19 @ 0.5% at 30 DAS, 60 DAS & 90 DAS (T_8), which was significantly higher but remained at par with T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS (T_9), T_2 + FS of Urea @ 2% at 30 DAS + FS of 19:19:19 @ 0.5% at 60 DAS + FS of 13:00:45 @ 0.5% at 90 DAS (T_{11}), T_2 + FS of Urea @ 2% at 30 DAS + FS of 13:00:45 @ 0.5% at 60 DAS (T_{10}), T_2 + FS of 19:19:19 @ 0.5% at 30 DAS + FS of 13:00:45 @ 0.5% at 60 DAS (T_{12}) and T_2 + FS of 19:19:19 @ 0.5% at 30 DAS & 60 DAS (T_7). While, treatment 75% RDF (T_2) recorded significantly lower straw yield (4507 kg ha^{-1}). Banerjee *et al*. [8] also find similar results with the foliar application of fertilizers grass pea.

3.5 Harvest Index (%)

Table 3 presents data on harvest index as affected by various treatments along with statistical interpretation. The data concluded that the harvest index (HI) was not significantly impacted by the foliar application of water-soluble fertilizers.

The evaluation of yields is the practical method for determining if a technology is superior. Because of foliar feeding of major nutrients, significant variations in wheat grain and straw production were seen in the current study. Among different treatments, application of T_2 + FS of 19:19:19 @ 0.5% at 30 DAS, 60 DAS & 90 DAS (T_8) significantly influenced grain yield and straw yield (Table 3). Yield of wheat is the cumulative effect of growth and yield attributing characteristic's. Also, foliar fertilization has the capacity to increase the effectiveness and speed with which a nutrient is utilized by a plant that desperately needs it for maximum growth and yield [9].

The improvement in yield characteristics can be attributed to the production of dry matter and its accumulated in reproductive organs. This can be determined by analyzing the accumulation of dry matter in the leaves and leaf area, which affects the plant's ability to photosynthesize, yield and performance of any crop. Additionally, foliar application of WSF, which contains all three key nutrients, increases photosynthetic activity, increases the synthesis and storage of carbohydrates and auxins, which favors flower retention and increase the number of reproductive parts per plant. Additionally, an increase in nutrient absorption and enhanced growth factors may be the cause of a considerable rise in yield metrics. Foliar application of nutrients enhanced the availability of nutrients for absorption and use by the crops, which in turn produced more photosynthates and improved dry matter partitioning from source to sink. Foliar feeding primarily boosted photosynthesis, carbohydrates, soluble protein levels, and nucleic acid levels, which led to higher dry matter output and sink size. The improved grain development ~~are~~ associated with higher WSF concentrations may be attributable to enhanced photosynthetic activity, higher chlorophyll content and higher nutrient uptake, which together increase plant dry matter production and, ultimately, productivity. The management of soil Nitrogen, Phosphorus, Potassium, and other nutrients should be improved to increase crop yield and improve crop quality. For vegetative growth, a balanced fertilizer application is required [10]. Higher yield under more frequent application of water-soluble fertilizer (Polyfeed - 19:19:19) may be caused by sufficient availability of easily soluble nutrients. A favorable sink that might have provided more nutrients throughout critical development phases would have been generated if cytokinins could be synthesised at their highest levels at higher levels of nitrogen and phosphorous. Nitrogen availability is boosted by the foliar spray, which increases photosynthetic activity. The increased growth was attributed to better photosynthate utilization and better photosynthate distribution to the economically valuable regions. Spraying water-soluble nutrients may have raised yields because it increased nutrient and water intake, which in turn promoted photosynthesis and increased food buildup in edible sections. It is more reliable because of its quick plant responses, convenience, high efficacy, and reduction of toxic symptoms brought on by higher soil accumulation of specific nutrients as a result of foliar nutrition [11]. All these factors discussed above collectively boosting the yields under the influence of WSF (Polyfeed - 19:19:19) in wheat. These finding are corroborating with the results of [12-15].

4. CONCLUSION

On the basis of this experimental, it may be concluded that soil application of 75% RDF

$N-P_2O_5-K_2O$ ha^{-1} along with foliar spray of WSF (19:19:19) @ 0.5 per cent at 30, 60 and 90 DAS or foliar spray of urea @ 2% at 30 DAS + foliar spray of (19:19:19) @ 0.5 per cent at 60 DAS were for obtaining higher the yield and profitability of wheat under irrigated conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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