**Effect of fulvic acid on different growth and yield parameters of wheat (*Triticum aestivum*)**

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**Abstract:**

To fulfill the rising demand for wheat output caused by a growing population, plant growth must improve. For improved plant growth, organic nutrients and fertilizers are essential.Fulvic acid (FA) is the major component of soil organic matter, which improves soil structure and fertility. FA has been observed positively on plant growth and ultimately enhances crop production. A field experiment of randomized complete block designed was formed to characterize the influence of fulvic acid (FA) application on wheat development and productivity. A 10% treatment of fulvic acid was given in the form irrigation and foliar spray. The foliar treatment section of the plot was split in half. One foliar subplot received the entire dose of fulvic acid during the vegetative stage, whereas the other received a divided dose of the nutrient just before and after flowering. Then, data on vegetative and reproductive phases were collected to document the effect of fulvic acid treatments (Control, Foliar Full, Foliar Split and Irrigation) on chosen wheat cultivars. The finding revealed that the irrigated and foliar full treatment of fulvic acid significantly improved the parameters of wheat. The application of irrigated treatment showed the highest significant result in following parameters of leaf length (28.07 ± 1.45), leaf width (1.99 ± 0.10), leaf area (42.54 ± 2.26), number of leaves (27.45 ± 0.28), number of tillers (4.91 ± 0.06), plant dry weight (31.99 ± 1.10), plant height (88.28 ± 0.63), 1000 grains weight (562.9 ± 12.09), total yield (323.87 ± 15.98), spikelets per spike (18.44 ± 0.26) and grain weight per plant(17.99 ± 1.33). On the harvest index, however, we discovered no statistically significant effects of FA at irrigated treatment (51.44 ± 3.14) rather than of foliar full dose (56.64 ± 1.29). We can conclude that the irrigation treatment of fulvic acid is most successfully in improving the wheat growth and yield as compared to spraying of fulvic acid.

**Keywords:** *Triticum aestivum*; humic and fulvic acid (FA); randomized complete block design (RCBD); plant growth.

1. **Introduction**

Wheat is the most often consumed type of cereal in Pakistan, which produced 24.23 million tonnes on 8.69 million hectares and placed among the top 10 countries worldwide in terms of total yield output [1;2]. In Pakistan's agricultural sector, wheat holds a central place. Pakistani people rely heavily on wheat as a staple meal [3], because it is one of the main sources of carbohydrates, starch, protein, fats and vitamins for human and animal diet [4]. It contains 60 to 90% starch, 11 to 16% protein, 1.5 to 2% fats, 1.2 to 2% inorganic ions and also contains vitamin B and E [5]. In addition, the straw of wheat crop plays an important dual role as livestock feed for livestock production [6]. Incorporating new cultivars with increased yield potential and implementing better crop management procedures can increase wheat grain output and improve wheat grain quality [7]. Providing people with food without harming the environment has become one of the greatest current challenges facing agricultural sciences. So, new technologies are needed to promote the sustainable intensification of agricultural production. One the ways to bring plant growing technologies up to date is to use natural biostimulants, such as humic and fulvic acids, bacterial and fungal preparations [8;9].

Organic components play a vital function in enhancing nutrient availability and contributing to a higher-quality yield increase [10]. Micronutrients and organic compounds have significant effects on wheat's dry matter, yield, and other metrics [11]. The organic component consists of humic acid, fulvic acid, and bio-composts, which are utilized as a cost-effective source of plant nutrients. In addition to organic fertilizers, micronutrients are employed to improve wheat yield [12]. According to research, combining fulvic acid with chemical fertilizer reduced the output expenses of farmers [13]. Because of its low molecular weight and penetrative nature, fulvic acid is an organic complex that is often overlooked [14]. Microbial breakdown of humic compounds yields fulvic acid [15].

Fulvic acid is a miraculous discovery and a component of the humic molecule found in soil. Beneficial microorganisms acting on decomposing plant matter produce fulvic acid in the presence of sufficient oxygen [16]. Consequently, fulvic acid contains almost 60% trace elements [17]. Metals and minerals are dissolved by fulvic acid, which also becomes biochemically reactive. Fulvic acid is a natural method for making nutrients accessible to plants [18]. It improves the enzymes' activity [19]. It appears to improve the growth characteristics of plants by enhancing their oxygen absorption [20]. It immediately enters the plant's roots, rapidly moves to the stems and leaves, and boosts the immune system [21]. Application of Fulvic acid to the foliage increases root length [22] and expanded leaf area [23]. It boosted growth indices such as chlorophyll concentration, photosynthetic pigments, and plant biomass [24]. Also decreased the need for fertilizers and increased the output of numerous crops, and improved the physical, chemical, and biological characteristics of plants [25]. Researchers [26] found that plants produced more yield after receiving a foliar spray of humic acid during the fifth and sixth leaf stages. Humic acid and fulvic acid, used as a foliar spray, increased the K and nutrient uptake of various crops [27-30]. As a result, the primary objective of this investigation was to assess the effects of fulvic on *Triticum aestivum* development in terms of a variety of growth characteristics. We analyzed which application of applying foliar acid is most beneficial in the development of the wheat crop.

1. **Methodology**

The field experiment was conducted by using two wheat cultivars (Punjab11 and Faisalabad 08) grown in silty clay, sandy loam, and clay loam textural soils, respectively, and treated with combination of NPK fertilizers and 10% fulvic acid [31]. The soil texture was 24.5% sand, 48% clay, 27% silt. The seeds were collected from Punjab seed corporation center Lahore.

**2.1 Experiment strategy**

The experiment used a randomized complete block design. The total area of the (14.30) ft2 experiment was split into two blocks, and inside each block, nine smaller "subplots" were created. Each plot was 8 ft2 in size. Every block is replicated three times. Each replication was assigned one of four treatments control, irrigated, full foliar dose (Foliar F), and foliar split dose (Foliar S). The basal dose of N:P:K was applied as a ratio of (160:110:60) kg/ hectares. This 420ft2 experimental area was fertilized with 1kg of DAP, 1.86kg of urea, and 1kg of potash (0.73 Kg). Wheat was planted at a rate of 85 Kg/acre, with 15.5 grams of seeds per subplot (8ft2). The application rate of fulvic acid was determined to be 150litre/acre. To prepare this experimental area for the irrigation procedure, 30ml of fulvic acid with a concentration of 10% was dissolved in a total volume of 1500 ml of water. For the foliar subplots, 5ml of fulvic acid with a concentration of 10% was dissolved in water to bring the total volume to 1500ml. The foliar subplot was then divided into two parts, the first of which received the full dose of fulvic acid, and the second of which received a split dose. In the case of split doses, two split doses of fulvic acid were administered. The first split dose of FA foliar was administered during the vegetative stage, while the second dose was administered during the reproductive stage.

**2.2 Growth parameters**

Data for each metric was gathered at the vegetative and reproductive stages, for each treatment respectively. Leaf length was measured from node to tip. The leaf breadth was measured in the centre of the leaf. As a result, the leaf area for each leaf was calculated by multiplying the length and breadth values by a correction factor of 0.75. The total number of tillers was gathered simply by counting the number of tillers. Then, information about the total number of leaves was compiled. Having collected information on the aforementioned variables, disruptive sampling was performed by uprooting the plants. The entire plant, including its roots, leaves, stems, and tillers, was dried out in a lab before being weighed. The height of the plants was also recorded by measuring their entire length, from the very tip of the spikes to the very bottom of the soil.

Counting the number of spikelets on each spike yielded the statistics for spikelets per spike. Then, the thousand grains weight (g) was determined by weighing 1000 wheat grains for each treatment and replication. The amount of grain produced by each plant was calculated by weighing its total yield. Data on plant yields overall were gathered after each subplot's wheat was threshed. The following formula was then used to determine the harvest index.

Grain weight per plant/ Total plant weight=X100

**2.3 Statistical Analysis**

The data were analyzed by PROC MIXED and PRO GLM in SAA statistical software package 9.3.1 (SAS Institute Inc., CaryNC). We used analysis of variance to determine the fulvic acid treatment that resulted in the lowest mean (ANOVA). The means were compared using Duncan's multiple range test at a significance threshold of *P < 0.05* [32].

1. **Results**

The effect of fulvic acid on plant growth and yield improvement of wheat crop was monitored. The different parameter of wheat crop was analyzed and we have found the significant growth improvement in *Triticum aestivum.*

**Leaf length, leaf width and leaf Area of the wheat**

During the vegetative stage, there was a large rise in the mean value of leaf, leaf width, and leaf area. These parameters' mean values are displayed in (Table 5). At the irrigated fulvic acid treatment, the maximum mean value for leaf length was 29.01cm, leaf width was 1.98cm, and leaf area was 42.14cm. At the vegetative stage of wheat, the minimal mean values were 23.92, 1.75, and 32.48 cm for leaf length, leaf breadth, and leaf area, respectively. The irrigation and foliar complete treatments were noticeably different. The foliar split did not differ significantly from the control.

**Number of leaves**

The number of leaves grew dramatically in both the irrigated and foliar full fulvic acid treatments. The mean number of leaves was highest in irrigated plants, at 28.41. The lowest mean value was recorded at the control level, 21.08 (Table 6). The FA irrigation and foliar complete treatments were distinct from the control and foliar split conditions but not from one another. There was no statistically significant difference between the control and foliar split groups.

**Number of tillers**

The number of tillers considerably increased when fulvic acid was applied to irrigated plants. The highest mean number of tillers was recorded at 4.84 for the watered treatment. Control exhibited the lowest mean value of 3.84 (Table 7). It was determined that irrigated, foliar complete, and foliar split treatments were significantly superior to the control and significantly distinct from one another.

**Plant dry weight**

The number of leaves, tillers, spikelets per spike, and grain weight per plant were all significantly greater in the irrigated condition, as was the plant dry weight. The highest mean plant dry weight was recorded in the irrigated treatment at 32.54. The minimum mean value of 18.34 was observed in control (Table 7). It revealed that the irrigated treatment was significantly greater and distinct from the control and foliar split treatments, but not from the foliar completes treatment.

**Plant height**

Significantly greater plant height was seen in the irrigated treatment. The highest mean value for plant height was reported at the watered treatment, whereas the lowest mean value was observed at the control (Table 6). The irrigated, foliar full, and foliar split treatments were significantly different from the control and foliar split, but not from each other.

**Thousand grains weight**

In the case of irrigation treatment, it was noticeably greater. Irrigated plants produced more spikelets per spike and more grain per plant, leading to a greater total yield per hectare. The irrigated fulvic acid treatment had the highest mean thousand grains weight (564.54). The foliar split treatment resulted in the lowest mean value (489.79) (Table 6). According to Duncan's multiple range tests, the irrigation treatment greatly enhanced the weight of the thousand grains. The irrigation treatment greatly outperformed the foliar full and split treatments but did not differ from the control.

**Total Yield**

It was greatly improved under the irrigated treatment, followed by spikelet per spike, thousand grains weight, and grain weight per plant characteristics, all of which were also significantly higher. At irrigated, the highest mean value, 325.97, was noted. 252.47 was the lowest mean value at foliar split treatment (Table 5). The foliar full and foliar split treatments considerably increased the overall yield at the irrigated treatment. Foliar full and irrigation did not differ from one another appreciably.

**Spikelets per spike**

At the irrigated treatment, there was a substantial 18.31 increase in the number of spikelets per spike. The Duncan multiple range test showed that irrigated was much greater than foliar split and control. There was no statistically significant difference between the irrigation and foliar full treatments; however foliar full did differ from both the foliar split and control treatments (Table 7).

**Grain weight per plant**

The number of spikelets per spike also increased in the watered treatment, which resulted in a considerable increase in grain weight per plant. At the irrigated treatment, the mean grain weight per plant reached a maximum of 18.74. At the control, the mean value dropped to 8.36 (Table 8). The grain weight per plant at the irrigation treatment was much higher than at any other treatment. Foliar split and full were not substantially different from one another; however, they were much greater than in the control group.

**Harvest index**

This was followed by a considerable rise in plant dry weight and grain weight per plant in the irrigated treatment. The average harvest index was 51.64 in the irrigated group, 49.48 in the control group, and everywhere in between. As shown by Duncan's multiple range tests, there was no statistical difference between the irrigated treatment and the control group in terms of foliar fullness and foliar split. Irrigated yielded not much higher harvest index than the control group but the foliar full treatment is higher than irrigated 52.56 (Table 8).

**Table 1. Means and their standard error for leaf length (cm), leaf width (cm), leaf area (cm2), and plant height (cm) at different fulvic acid treatments.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Means ± Standard error** | | | |
| Treatment | LL | LW LA | PH |
| Control | 22.99 ± 0.93 | 1.73 ± 0.13 30.48 ± 1.92 | 80.55 ± 1.12 |
| Foliar F | 26.92 ± 0.46 | 1.94 ± 0.15 40.34 ± 2.59 | 85.69 ± 1.31 |
| Foliar S | 25.87 ± 0.51 | 1.75 ± 0.11 36.76 ± 2.71 | 84.66 ± 0.44 |
| Irrigated | 28.07 ± 1.45 | 1.99 ± 0.10 42.54 ± 2.26 | 88.28 ± 0.63 |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: LL: Leaf length (cm), LW: Leaf width (cm), LA: Leaf area (cm2), PH: Plant Height (cm).

**Table 2. Means and their standard error for total yield (g), thousand grains weight (g), and number of leaves at different fulvic acid treatments.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Means ± Standard error** | | | |
| Treatment | TY | TGW | TNL |
| Control | 289.49 ± 20.93 | 532.70 ± 9.23 | 22.06 ± 0.42 |
| Foliar F | 296.03 ± 11.86 | 529. 61 ± 0.15 | 26.21 ± 0.59 |
| Foliar S | 253.51 ± 10.61 | 489.3 ± 15.11 | 24.16 ± 0.49 |
| Irrigated | 323.87 ± 15.98 | 562.9 ± 12.09 | 27.45 ± 0.28 |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: TY: Total yield (g),

TWG: Thousand grains weight (g), LA: TNL: Number of leaves.

**Table 3. Means and their standard error for the number of tillers, plant dry weight (g), and Spikelets per spike at different fulvic acid treatments.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Means ± Standard error** | | | |
| Treatment | TILRS | PDW | SPS |
| Control | 3.81 ± 0.04 | 18.26 ± 1.53 | 15.48 ± 0.22 |
| Foliar F | 4.38 ± 0.16 | 29.54 ± 2.18 | 16.64 ± 0.59 |
| Foliar S | 4.07 ± 0.08 | 25.31 ± 1.71 | 16.56 ± 0.31 |
| Irrigated | 4.91 ± 0.06 | 31.99 ± 1.10 | 18.44 ± 0.26 |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: Tilrs: Number of Tillers, PDW: Plant Dry weight (g), SPS: Spikelet per spike.

**Table 4. Means and their standard error for grain weight per plant (g) and harvest index at different fulvic acid treatments.**

|  |  |  |
| --- | --- | --- |
|  | **Means ± Standard error** |  |
| Treatment | GWP | HI |
| Control | 8.36 ± 0.59 | 49.48 ± 1. 12 |
| Foliar F | 13.74 ± 1.08 | 56.64 ± 1.29 |
| Foliar S | 11.91 ± 0.92 | 52.56 ± 1.11 |
| Irrigated | 17.99 ± 1.33 | 51.44 ± 3.14 |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: GWP: Grain weight per plant (g), HI: Harvest index.

**Table 5. Treatments ranks based on the Duncan Multiple Range test for leaf length (cm), leaf width (cm) and leaf area (cm2), and total yield at different fulvic acid treatments.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LL | |  | LW |  | LA |  | TY |  |
| Treatment | Mean | Grouping | Mean | Grouping | Mean | Grouping | Mean | Grouping |
| Control | 23.92 | B | 1.75 | B | 32.48 | B | 289.49 | AB |
| Irrigated | 29.01 | A | 1.98 | A | 42.14 | A | 325.97 | A |
| Foliar F | 28.91 | A | 1.92 | A | 40 .36 | A | 280.02 | B |
| Foliar S | 27.87 | A | 1.79 | B | 36.34 | B | 252.47 | B |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: LL: Leaf length (cm), LW: Leaf width (cm), LA: Leaf area (cm2), TY: Total yield (g).

**Table 6. Treatments ranks based on the Duncan Multiple Range test for plant height (cm), thousand grains weight (cm), and the total number of leaves at different fulvic acid.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | PH |  | TGW |  | TNL |  |
| Treatment | Mean | Grouping | Mean | Grouping | Mean | Grouping |
| Control | 80.78 | C | 531.73 | AB | 21.08 | B |
| Irrigated | 89.01 | A | 564.54 | A | 28.41 | A |
| Foliar F | 87.69 | A | 531.49 | B | 27 .26 | A |
| Foliar S | 85.02 | B | 489.79 | C | 23.14 | B |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: PH: Plant height (cm), TGW: Thousand grains weight (g), TNL: Total no. of leaves.

**Table 7. Treatments ranks based on the Duncan Multiple Range test for the total number of tillers, plant dry weight (g), and spikelets per spike at different fulvic acid treatments.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | TILRS |  | PDW |  | SPS |  |
| Treatment | Mean | Grouping | Mean | Grouping | Mean | Grouping |
| Control | 3.84 | C | 18.34 | C | 15.54 | B |
| Irrigated | 4.84 | A | 32.54 | A | 18.31 | A |
| Foliar F | 4.59 | A | 27.49 | AB | 17.63 | A |
| Foliar S | 4.09 | B | 24.39 | B | 16.32 | B |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: Tilrs: Total no. of tillers, PDW: Plant dry weight (g), SPS: Spikelets per spike.

**Table 8. Treatments ranks based on Duncan's multiple range test for grain per plant (g) and harvest index at different fulvic acid treatments.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **GWP** |  | **HI** |  |
| Treatment | Mean | Grouping | Mean | Grouping |
| Control | 8.36 | C | 49.48 | B |
| Irrigated | 18.74 | A | 51.64 | A |
| Foliar F | 15.91 | B | 52.56 | AB |
| Foliar S | 13.99 | B | 51.44 | AB |

Note: Foliar F: Foliar Full dose, Foliar S: Foliar Split dose, Foliar S: GWP: Grain weight per plant (g), HI: Harvest index.

**4. Discussion**

Fulvic acid is the most significant natural organic fertilizer that is responsible for enhancing wheat's growth properties [33]. It improved plant growth characteristics [34]. This experiment was conducted utilizing one of the natural organic fertilizers FA in the form of split foliar, watered, and control treatments. In this experiment, fulvic acid dramatically increased leaf length (cm), leaf breadth (cm), and leaf area (cm2). It was discovered that fulvic acid has a significant function in the vegetative development of plants. According to research conducted by Abdel-Baky *et al*. [36] foliar fulvic acid spray increased the leaf area index and promoted leaf length, which is consistent with our work.

In this study, irrigation treatment significantly increased plant height, thousand grains weight (g), total yield (g), grain weight per plant (g), and harvest index merely by enhancing the intake of nutrients that promote healthy plant growth. According to research by [37], fulvic acid dramatically increased plant biomass. According to Suh *et al*. [38], fulvic acid treatment improves the fresh and dry weight, plant height, and plant growth in plants. Fulvic acid greatly boosted plant height, as per [39]. Fulvic acids (FAs) are essential for boosting crop output and enhancing the structure and fertility of soils with various textures [40]. Samavat *et al*. [41] revealed that fulvic acid greatly boosted the qualitative and quantitative yield, nutrient uptake, shoot growth, and yield of plants. It was discovered that fulvic acid influences growth metrics, as it drastically decreased the vegetative phase of wheat yet increased yield parameters. From the results of this study, it was determined that fulvic acid contributed significantly to the enhancement of growth parameters by increasing the mobility of nutrients and making them available to plant roots and absorbable by the cell wall. Ali *et al*. [24] found that fulvic acid increased growth parameters, such as chlorophyll content, photosynthetic pigments, and plant biomass while decreasing the accumulation of chromium in plants, which influenced the growth activity of plants. Yang *et al*. [42] observed that the application of fulvic acid greatly improved chlorophyll content and photosynthesis compared to the control.

In the recent study, foliar fulvic acid significantly enhanced the total number of leaves, spikelets, and tillers in the irrigated, foliar full treatments compared to the control. Although fulvic acid greatly boosted the growth characteristics of wheat during its reproductive phase, it was discovered in the current investigation that the wheat's reproductive phase growth parameters were not significantly affected by fulvic acid. Ahmad *et al*. [43] found that fulvic acid greatly increased biological yield (grains per spike), which is consistent with our findings. Elrys *et al*. [32] discovered that FA treatment considerably enhanced the antioxidant defense system of the plants, consequently decreasing ROS levels and enhancing wheat growth and yield under saline circumstances. In this study, irrigated treatment considerably outperformed control in terms of thousand grains weight, total yield grain weight per plant, and harvest index. The effects of foliar application of fulvic acid on wheat production and growth were examined by Khan *et al*. [43]. The outcome showed that the most feasible rate to obtain the highest yield of wheat was to apply humic acid alone or in conjunction with NP manures. At the irrigation treatment with fulvic acid, plant dry weight was greater. Following the upward trend in spikelet weight per spike, grain weight, leaves, and tillers were an increase in plant dry weight. Sootahar *et al*. [45] reported these characteristics, and they also looked into whether fulvic acid improved crop output and production. All of these characteristics significantly improve when fulvic acid is applied topically and to the leaves. This research complied with ongoing research.

Thousand grains weight, total yield, grain weight per plant, and harvest index were all considerably greater in the irrigated treatment compared to the control in this study. FA greatly increased yield simply by enhancing the absorption of nutrients that promote healthy plant growth. Abbas *et al*. [46] evaluated the effect of foliar spray of humic acid on wheat's grain yield and reported these parameters. At the tillering, flag leaf, and grain-filling stages, NP in combination with humic acid achieved the highest grain yield, resulting in an increase of almost 30% in yield over the control. Wheat (*Triticum aestivum* L*.*) under sandy soil conditions was sprayed with fulvic acid (FA) via foliar application, as described by Bughdady and Shoman [48]. All of the measured wheat characteristics improved dramatically in both growing seasons as FA concentrations rose from 0 to 6 g L-1. With 4 g L-1 and control treatment of FA in both seasons, the maximum yield and its constituent parts were attained. According to the research conducted by Rafie *et al*. [49], FA significantly enhanced both the quantitative and qualitative features of wheat.

According to Aminifard *et al*. [50], the application of fulvic acid has a substantial effect on the quality of fruits as well as the activity of antioxidants. Farmers' production costs were decreased with fulvic acid. According to Haroon *et al*. [51], the usage of fulvic acid in conjunction with chemical fertilizer reduced farmers' production expenses. Fulvic acid lowered the requirement for fertilizers Clapp *et al*., [52] tested if fulvic acid lowered fertilizer requirements while increasing crop yields in a variety of crops [53].

Fulvic acids (FAs) are beneficial for soil structure and fertility, and they also contribute to higher crop yields. In a recent pot experiment, wheat was grown on soils that were treated with FAs obtained from both plant and mineral sources. Results showed that the application of FAs increased nutrient uptake and wheat production. Moreover, FAs had a positive effect on soil organic carbon fractions and growth characteristics of wheat [40]. A combined application of humic and fulvic acid fertilizers significantly impact the growth, yield, and grain biochemical composition of wheat plants. The best results were seen by [54] with a combination of biofertilizers and humic acid, with increased plant height, growth rate, yield, and biochemical composition.

A mixture of humic acid, nitrogen, phosphorus, potassium,, zinc, sulfur, and manganese was combined with a liquid foliar fertilizer containing fulvic acid and gibberellic acids to create an organic-mineral liquid fertigation fertilizer. This fertilizer was utilized on wheat crops, alongside 50 kg of urea per acre. The application of this combination yielded the most favorable results in terms of biological yield [43]. Regarding the effect of organic acids as foliar spray on rice yield and its components, results show that the foliar application of humic and fulvic together increased significantly such parameters. Meanwhile, the foliar spray of humic acid alone gave the highest significant values of all parameters (plant height, no. of tillers, 1000 grains weigh and grains yield) in second season only with no significant differences between them [55]. Similar findings were achieved by Zhang and Ervin [56] who reported that humic acid contains cytokinins and their application resulted in increasing endogenous cytokinins and auxin levels which possibly leading to improve yield. This may explain the increment in the filled grains weight/panicle and grain yield observed in this study. El-Ghamry et al. [57] found that the growth parameters, morphological characteristics and chemical contents’ of faba bean plants records significant increases. Nikbakht et al. [58] and Baldotto and Baldotto [59] investigated that humic acid enhanced the floral yield and yield of gerbera, bean and gladiolus when used at greater concentrations. The increase in number of tillers and spike might be due to action of humic and fulvic acid which enhanced the uptake of nutrients thereby increasing the production of tillers and spike as compared to all other treatments. These results are in agreement with the previously reported results of El-Kouny [60] and Ragab et al. [60]. Current research is consistent with the work of the aforementioned researchers. They do, however, use different fulvic acid treatments at different time intervals and different cultivars. Fulvic acid had a positive impact on the growth metrics. Fulvic acid also demonstrated favorable benefits and a large boost in wheat growth indices. The purpose of this research was to examine how fulvic acid influences wheat yields. Fulvic acid as an organic fertilizer is critical for meeting the increasing demand for wheat due to the rising population because it reduces the need for fertilizers.

**5. Conclusion**

Wheat is the most widely used staple crop in the world, and it is critical to satisfying human hunger and the country's economy. Fulvic acid is a natural organic fertilizer that is used to boost plant development characteristics. It showed significant improvements in the wheat development. The results revealed that Wheat cultivars grew faster in irrigated and foliar full treatments condition, indicating that they are suitable for higher wheat growth. When compared to the control and foliar split treatments, fulvic acid irrigation and foliar complete treatments were highly significant. It was discovered that fulvic acid plays a substantial influence in improving all of the selected wheat metrics, implying that fulvic acid is mainly accountable for wheat growth.

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