



Response of Maize to Humic Acid and Foliar Salicylic Acid Application

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ABSTRACT

Humic acid to soil has positive effects on soil properties that result in improved soil fertility and maize yield. Maize growth and yield can also be enhanced by foliar application of salicylic acid. A field experiment was carried out at Agronomy Research Farm, The University of Agriculture Peshawar during summer season, 2021 to evaluate the response of maize to humic acid and foliar salicylic acid application. Results revealed that plots treated with humic acid at the rate of 15 kg ha⁻¹ significantly increased plant height (217.8 cm), grains ear-1 (507), thousand grains weight (302.3 g) and grain yield (5309 kg ha⁻¹). Salicylic acid with 750 mg L⁻¹ showed taller plants (221.1 cm), maximum grains ear-1(502), heavier thousand grains weight (299.1 g) and maximum grain yield (5171 kg ha⁻¹) which is statistically similar with the application of salicylic acid foliar spray at the rate of 500 mg L⁻¹. Interaction between humic acid and salicylic acid was found to be non-significant except in case of grains ear-1 and grain yield. It was concluded that humic acid at the rate of 15 kg ha⁻¹ and salicylic acid foliar spray of 750 mg L⁻¹ is recommended for higher grain yield of maize in Peshawar.

INTRODUCTION

Maize (*Zea mays* L.) is the highest yielding cereal crop worldwide. Botanically, maize belong to family poaceae/gramineae. Maize is tall, annual, cross pollinated crop with an extensive fibrous root system. Maize is a multipurpose crop used as food by human, fodder by animals and provides raw materials for industry. Its grain is a rich source of starch (72%), vitamins A and B (3%- 5%), proteins (1.6 %), (4.86 %) oil, (5.8%) fiber, (3.0%) sugar and (1.7%) ash. One hundred gram of fresh grain contains 361 calories of energy, 9.4 g protein, 4.3g fat, 74.4g carbohydrate, 1.8g fiber, 1.3g ash, 10.6% water, 140mg vitamins, 9mg calcium, 290mg phosphorus and 2.5mg iron .

Maize is a valuable feed grain because it is among the highest in net energy content and lowest in protein and fiber content. The demand for maize has considerably increased due to the expansion in the poultry and livestock industries [4]. In Khyber Pakhtunkhwa, maize is often grown as a dual-purpose crop, producing grain as well as fodder. Among cereal crops, maize ranked 3rd after wheat and rice in Pakistan . In Khyber Pakhtunkhwa it is on 2nd position after wheat. The overall production of maize in Pakistan was about 8.9 thousand tons and was cultivated on 1417.8 thousand hectares while in Khyber Pakhtunkhwa maize was cultivated on 468 thousand hectares with the production of about 3.5 thousand tons and average yield was 1933 kg ha⁻¹.

In agriculture, organic products such as compost, green manures, food scraps, and humic acids are used as soil conditioners or dietary supplements. Humic acid is highly successful at increasing soil fertility, improving crop quality and resistance, lowering soil toxicity, and enhancing the physiochemical characteristics of soil. Humic acid was advantageous to soil and plants when administered sparingly. While lowering salinity and dryness, it improves plant growth and development and seed germination. The findings demonstrated that humic acid addition has enormous potential to boost crop production and enhance the biological and physiochemical characteristics of soil. Aside from the claim that 1 kg of humic acid may replace 1 tonne of manure, humic material has a positive impact on crop progress, mineral nutrition, seed emergence, seedling growth, root induction and growth, shoot advancement, and macro and micronutrient absorption.

A grain crop called maize needs a lot of water to flourish. When compared to other grains, maize yield can be decreased by a lack of water. Water stress in maize during different growth phases results in shorter anthesis-silking periods, reduced chlorophyll content, less photosynthetic activity, and subsequently lower yield. Osmoprotectants like kinetin, salicylic acid, and glycine betaine help some species tolerate stress and drought. Nonetheless, there is some difference in increasing photosynthetic capacity, plant dry matter production, and leaf area of various crop species under water stress conditions.

Natural plant hormone salicylic acid (2-hydroxybenzoic acid) is essential for allowing plants to withstand a variety of environmental challenges, including heat, drought, and salt tolerance. Abiotic stress can be minimized by salicylic acid by altering a variety of physiological and metabolic processes in

different plant species. Salicylic acid supports crop resilience to water stress. By speeding up assimilation, which demonstrated a rise in chlorophyll content and the hill response in the leaf, foliar administration of salicylic acid altered various physiological and biochemical characteristics of plants.

Given the importance of humic acid and foliar salicylic acid application in increasing maize productivity, this study was conducted to determine the ideal level of humic acid and salicylic acid spray for improving maize grain production.

LITERATURE REVIEW

Prakoso et al. (2020) conducted a study to investigate the impact of humic acid on the growth and yield of two maize cultivars. The study included various treatments: a control group with no fertilizer or humic acid, NPK without humic acid, and NPK combined with humic acid at three different concentrations: 5%, 10%, and 15%. The humic acid was applied at a rate of 350 kg ha⁻¹, based on the amount of NPK 16:16:16 fertilizer used. Their findings revealed that the application of humic acid significantly enhanced the thousand seed weight, dry seed weight, harvest index, cob length, and overall productivity of the maize plants.

Khan et al. (2019) explored the role of humic acid and nitrogen levels in maize production. They employed four levels of humic acid (0, 0.6, 1.2, and 1.8 kg ha⁻¹) and two levels of nitrogen (0 and 120 kg ha⁻¹). The presence of nitrogen in combination with various levels of humic acid led to significant increases in corn yield. Nitrogen application alone also had a positive effect on maize production. The study found that higher concentrations of humic acid (1.8 kg ha⁻¹) in conjunction with 120 kg N ha⁻¹ were particularly effective for enhancing seed yield, making this combination a recommended practice for calcium-deficient, nitrogen-deficient soils.

Szczepanek and Wilczewski (2016) investigated the response of maize to soil-applied humic acid and potassium. Their results indicated that cob weight and grain yield improved with the application of humic acid. Furthermore, the combined application of humic acid and potassium led to increased seed production compared to the control group.

In a study by Ijaz and colleagues (2015), the effects of different concentrations of humic substances on maize were examined. They found that the application of 9 kg ha⁻¹ of humic acid resulted in delayed tasseling, silk initiation, and physiological maturity. However, this delay was associated with faster growth due to improved nutrient availability, ultimately leading to an increase in the number of grains per cob, 1000-kernel weight, biological yield, and seed yield.

Daur et al. (2013) focused on the use of powdered humic acid to enhance the growth and quality of maize fodder. They tested six levels of humic acid (5, 10, 15, 20, 25, and 30 kg ha⁻¹) and found that a rate of 20 kg ha⁻¹ significantly affected plant height, biological yield, grain yield, and harvest index.

Rao et al. (2012) explored the use of exogenous chemicals to improve maize growth under stress conditions. They applied salicylic acid and L-tryptophan at different concentrations through foliar spray. Results showed that 100 ppm of salicylic acid led to higher relative water content, leaf membrane stability index, chlorophyll content, and potassium content in maize plants, effectively mitigating moisture stress.

Purcarea and Cosma (2010) investigated the response of maize to salicylic acid under salinity stress. Salicylic acid was found to enhance the growth parameters of corn seedlings and reduce peroxidase activity in the roots, suggesting a potential role in alleviating salinity stress.

Hassan et al. (2019) conducted an experiment to assess the effect of humic acid and salicylic acid on maize growth. They applied three concentrations of humic acid (0, 2, and 4 g L⁻¹) and four concentrations of silicon (0, 7, 2, and 3 ml L⁻¹). The results showed significant improvements in plant height, leaf area, and ear length with an increase of 11.69%, 24.89%, and 3.49%, respectively, compared to the control treatment.

Sharif et al. (2004), the impact of synthetic fertilizer and organic manure, including humic acid, on maize production was assessed. When humic acid was used alone at a rate of 200 kg ha⁻¹, grain yield, total dry matter, and 1000-grain weight increased by 72%, 25%, and 28%, respectively. The combination of humic acid and phosphorus further enhanced seed yield, biomass yield, and 1000-kernel weight.

Desoky et al. (2015) conducted an experiment to evaluate the performance of wheat plants under salt stress conditions with the application of ascorbic acid and salicylic acid. Salt stress negatively impacted all parameters of wheat plants, including nutrient absorption. The highest values for straw and grain yield, 100-grain weight, protein content, and nutrient uptake were observed with the application of ascorbic acid and salicylic acid.

METHODOLOGY

Response of maize to humic acid and foliar salicylic acid application experiment was conducted at Agronomy Research Farm, The University of Agriculture Peshawar. Randomised complete block design (RCBD) was used to conduct the experiment with three replications. The plot measured 5 m by 4.5 m and had six rows. The distances between plants and rows were kept at 25 and 75 cm, respectively. With the use of urea, SSP, and MOP, nitrogen, phosphorus, and potassium were provided at rates of 160, 90, and 60 kg ha⁻¹, respectively. The experiment consists of four humic acid levels (0, 05, 10 and 15 kg ha⁻¹) and four foliar salicylic acid foliar sprays (0, 250, 500 and 750 mg L⁻¹). At the time of seeding, various humic acid applications had been applied. Salicylic acid foliar sprays required a certain amount of water per plot, which was first calculated. Suggested salicylic acid levels were then prepared and applied using a backpack sprayer at the crop's V8 stage. The CS-200 maize hybrid was sown at a rate of 30 kg ha⁻¹. To maintain the recommended plant population, thinning was done when the crop had four leaves. Manual weed control was used. The recommended irrigation schedule was followed, however adjustments were made based on the weather.

Data was recorded on following parameters:

Plant height (cm)

Plant height was determined at physiological maturity by randomly selecting five plants in each experimental unit. Total vertical height from the base of the plant to tassel tip was measured with the help of a measuring rod and taken the averages of all measured plants for a single mean.

Number of grains ear⁻¹

Ten ears were randomly chosen from each plot, and after each cob was shelled, the amount of grains was counted separately, and an average was taken.

Thousand grains weight (g)

Thousand grains from the seed lot of each plot were counted, weighed and averaged.

Grain yield (kg ha⁻¹)

Each plot's four core rows were picked with a sickle. Dehusked, dried, shelled and weighed using an electronic balance were the corn cobs. The data was then translated to kilogrammes per a⁻¹.

Statistical analysis

According to Steel et al., [17] the data was analyzed statistically using analysis of variance procedures applicable for randomized complete block with split plot arrangement. Average was compared by means of LSD test at 5% level of probability when the F-value is significant.

RESEARCH RESULT

Plant height (cm)

Data regarding plant height of maize as affected by different levels of humic acid and salicylic application is given in table 1. Statistical analysis of the data revealed that Salicylic acid (SA) and Humic acid (HA) significantly affected plant height of maize. SA and HA interaction was found non-significant. Taller plant height (217.8 cm) was found with application of humic acid at the rate of 15 kg ha⁻¹ followed by application of humic acid of 10 kg ha⁻¹ (215.2 cm) while shorter plant height (210.6 cm) was noted in control plots. This may be as a result of HA's ability to stimulate plant growth and improve the soil, which makes plants grow higher Turkmen et al. Our results are also in agreement with Moraditochae they found that humic acid use boosted plant height and other growth indices. In case of salicylic acid foliar spray taller plants (221.1 cm) were observed in plots that received salicylic foliar application of 750 mg L⁻¹ while shorter height was noted in control plots (209.2) which is statistically similar to that of salicylic foliar spray of 250 mg L⁻¹ (211.3). The hybrid's thick, strong stems that are short in height and resistant to logging may

be the likely cause. These results are in agreement with Pakar et al. who looked into the possibility that salicylic acid could have an impact on plant height.

Table 1. Plant height (cm) of maize as affected by humic acid and foliar salicylic acid application

Salicylic acid (mg L ⁻¹)	Humic acid (kg ha ⁻¹)				Means
	0	5	10	15	
0	206.3	206.7	211.0	212.7	209.2 c
250	207.3	211.0	212.7	214.3	211.3 c
500	211.3	213.7	215.7	217.3	214.5 b
750	217.3	218.7	221.3	227.0	221.1 a
Means	210.6 c	212.5 b	215.2 ab	217.8 a	

LSD value ($P \leq 0.05$) for humic acid (HA) = 3.8

LSD value ($P \leq 0.05$) for Salicylic acid (SA) = 3.8

Interaction of HA X SA = NS

Number of grains ear⁻¹

Data concerning number of grains ear⁻¹ is presented in table 2. Statistically analyzed data revealed that Humic acid (HA) and Salicylic acid (SA) application significantly affected number of grains ear⁻¹ of maize. HA and SA interaction was found significant. More number of grains ear⁻¹ (508) was found with application of 15 kg ha⁻¹ of humic acid while less number (471) of grains was recorded in control plots. These results are also corroborated by Ali et al., who found that humic acid spraying greatly increased yield components. This may be because more nutrients were available and supplied to the plants, which may explain the findings. Because of its capacity to break down wastes and gradually make nitrogen available to the plant and soil, humic acid, according to Sharif et al. increased grains ear⁻¹. In case of salicylic acid application higher number of grains (502) was observed with salicylic application of 750 mg L⁻¹ while lower number of grains (468) was noted in control plots. The outcomes are consistent with Ashraf et al. findings that foliar salicylic acid spray improves grains ear⁻¹ which may be attributable to an increase in photosynthetic capacity and rubisco activity.

Table 2. Number of grains ear-1 of maize as affected by humic acid and foliar salicylic acid application.

Salicylic acid(mg L ⁻¹)	Humic acid (kg ha ⁻¹)				Mean
	0	5	10	15	
0	455	465	472	479	468 d
250	463	476	484	498	480 c
500	479	488	496	523	497 b
750	485	494	500	528	502 a
Mean	471 d	481 c	488 b	507 a	

LSD value ($P \leq 0.05$) for humic acid (HA) = 4

LSD value ($P \leq 0.05$) for Salicylic acid (SA) = 4

Interaction of HA X SA = 8

Thousand grains weight (g)

Table 3 shows data concerning thousand grain weight of maize as affected by humic acid and salicylic acid application. Statistical analysis of the data revealed that Humic acid (HA) and Salicylic acid (SA) significantly affected thousand grain weight of maize, while the interaction was found non-significant. In case of humic acid heavier thousand grains weight was recorded with application of 15 kg ha⁻¹ (302.3 g) while minimum (288.9 g) thousand grains weight was recorded in control plot which is statistically at par with humic acid application of 5 kg ha⁻¹ (291.3 g). It may be because humic acid boosts soil drive, which strengthens the physical structure and organic environment of soil, which improves plant growth and ultimately increases grain weight, according to Waqas et al., [24]. Salicylic application of 750 mg L⁻¹ produced heavier grains (299.1 g) followed by 500 mg L⁻¹ (297 g) while shriveled grains were observed in control plots (290.3 g) where no application was done. The findings are consistent with those of Barsa et al. and Hussain et al. who observed that salicylic acid administration increased seed vigour and ultimately produced heavier and larger seeds.

Table 3. Thousand grains weight (g) of maize as affected by humic acid and foliar salicylic acid application.

Salicylic acid (mg L ⁻¹)	Humic acid (kg ha ⁻¹)				Means
	0	5	10	15	
0	285.3	286.0	291.7	298.0	290.3 c
250	288.3	289.3	295.0	303.0	293.9 bc
500	290.0	293.3	302.7	302.0	297.0 ab
750	292.0	296.7	301.3	306.3	299.1 a
Means	288.9 c	291.3 c	297.7 b	302.3 a	

LSD value ($P \leq 0.05$) for humic acid (HA) = 3.9
 LSD value ($P \leq 0.05$) for Salicylic acid (SA) = 3.9
 Interaction of HA X SA = NS

Grain yield (kg ha⁻¹)

Data regarding grain yield of maize as affected by humic acid and salicylic acid application is given in table 4. Statistical analysis of the data revealed that Humic acid (HA) and Salicylic acid (SA) significantly affected grain yield of maize. Interaction of HA and SA was also found significant. Humic acid applied at the rate of 15 kg ha⁻¹ produced higher grain yield (5309 kg ha⁻¹) while lowest grain yield (4668 kg ha⁻¹) was recorded in control plots. In the presence of high doses of humic acid plant use other nutrients more efficiently Dawood et al. revealed that although gradual release of nitrogen and decomposition of organic matter and agricultural wastes to make nitrogen available for improved plant growth owing to application of humic acid. With application of salicylic acid of 750 mg L⁻¹ maximum grain yield (5171 kg ha⁻¹) which is at par with salicylic application of 500 mg L⁻¹ (5109 kg ha⁻¹) minimum grain yield (4714 kg ha⁻¹) was recorded in control plot. According to Nabi et al., salicylic acid concentration increased grain production in comparison to untreated treatments. Salicylic acid spray on maize crop considerably enhanced grain output, according to Rehman et al.

Table 4. Grain yield (kg ha⁻¹) of maize as affected by humic acid and foliar salicylic acid application

Salicylic acid (mg L ⁻¹) 1)	Humic acid (kg ha ⁻¹)				Means
	0	5	10	15	
0	4456	4673	4791	4935	4714 c
250	4653	4725	4837	5116	4833 b
500	4758	4911	5183	5583	5109 a
750	4804	4963	5316	5603	5171 a
Means	4668 d	4818 c	5032 b	5309 a	

LSD value ($P \leq 0.05$) for humic acid (HA) = 99
 LSD value ($P \leq 0.05$) for Salicylic acid (SA) = 99
 Interaction of HA X SA = 198

CONCLUSIONS AND RECOMMENDATIONS

It is concluded from the results that humic acid application of 15 kg ha⁻¹ increased yield of maize as compared to control. In case of salicylic acid foliar application, 500 mg L⁻¹ enhanced the overall growth, yield and yield traits of maize over others. It is recommended that humic acid application of 15 kg ha⁻¹ and salicylic acid foliar spray at the rate of 750 mg L⁻¹ is recommended for higher productivity of maize in agro climatic condition of studied area.

ADVANCED RESEARCH

By conducting advanced research, you can deepen our understanding of how humic acid and salicylic acid influence nutrient dynamics and uptake in maize. This knowledge can provide more precise recommendations for optimizing nutrient management practices and improving maize productivity under diverse agro-climatic conditions.

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