Research Article

Optimizing Maize Production: Effects of Humic Acid, Nitrogen, and Zinc on Agronomic Traits, Yield, and Economics

Syed Muhammad Saqib Raza[1], Sheheryar[1], Rabia Khalid[1], Muhammad Mansoor[2], Sonia Sumreen[3] and Muhammad Muzammil Bin Khalil[1]

[1]Pulses, Crop Sciences Institute, National Agriculture Research Centre, Islamabad, Pakistan; [2]Plant Sciences Division, Pakistan Agricultural Research Council, Islamabad, Pakistan; [3]Land Resource Research Institute, National Agriculture Research Centre, Islamabad, Pakistan.

Abstract | To figure out the best combinations of humic acid and zinc with basic NPK doses on Maize cultivar "Azam White", a study was executed at the Agriculture Research Institute, D.I. Khan, K.P.K., Pakistan during the Kharif season, 2022. Randomized Complete Block Design was used for the field experiment wherein seven treatments were replicated thrice to get the average results. The treatments included; Untreated control, Humic acid (25 kgha^{-1}), NPK (120:60:60 kgha^{-1}), zinc (5 kgha^{-1}), Humic Acid + NPK, Zinc + NPK and Humic Acid + NPK + Zinc. Among all the nutrient treatments studied, it was found that the combined application of Humic Acid + NPK + Zinc proved to be the most efficient and effective treatment which not only boosted the agronomic parameters like germination percentage (94.65%), plant height (222.20 cm), number of cobs (2.65 plant^{-1}), number of grains (347.23 cob^{-1}), 100 grains weight (28.25 g) and grain yield (6.87 t ha^{-1}), but also gave maximum net returns (2.40). Since this treatment can be the most productive for farmers of the target locality, therefore it was recommended for general use in maize crop.

Received | August 21, 2024; **Accepted** | December 16, 2024; **Published** | December 26, 2024
***Correspondence** | Sheheryar, Pulses, Crop Sciences Institute, National Agriculture Research Centre, Islamabad, Pakistan; **Email:** drsheheryar2023@gmail.com
Citation | Raza, S.M.S., Sheheryar, R. Khalid, M. Mansoor, S. Sumreen and M.M.B. Khalil. 2024. Optimizing maize production: Effects of humic acid, nitrogen, and zinc on agronomic traits, yield, and economics. *Pakistan Journal of Agricultural Research*, 37(4): 421-425.
DOI | https://dx.doi.org/10.17582/journal.pjar/2024/37.4.421.425
Keywords | Maize, NPK, Humic acid, Zinc, Agronomic traits, Economics

Introduction

Maize (*Zea mays* L.), also known as the King of Cereals, is a short duration crop and an important staple food in Pakistan after wheat and rice (Broudly and Hammond, 2007). It is a highly nutritive crop containing proteins (1.9 g), fats (0.2 g), carbohydrates (8.2 mg), phosphorus (86 mg), calcium (28 mg) and other important dietary constituents (Kumar *et al*., 2018). Maize crop manifested 10.183 million tons production on an area of 1720 thousand hectares showcasing an average yield of 5.90 t ha^{-1} (GoP, 2023).

In Pakistan, the average maize yield is low relative to the biological potential of existing cultivars, largely due to management constraints, with plant nutrition being a major factor (Asif *et al*., 2013).

Humic acid is an essential component of soil organic matter that enhances soil fertility and productivity. Humic substances have been experimentally proved to have a two-fold effect; they combat with various abiotic stresses, such as, sub-optimal temperature, pH and moisture levels, while enhancing the uptake of nutrients and mitigating the absorption of toxic elements (Daur and Bakhashwain, 2013). It ameliorates the availability of NPK in calcium-containing soil due to the presence of potassium humate (Tahir *et al*., 2011).

Nitrogen is one of the important macronutrients found in plants which is integral part of many proteins, enzymes and chlorophylls. It has 1 to 4% contribution in dry matter production in plants (Asif *et al*., 2013). Nitrogen deficient soils pose negative impacts on the plants including stunted growth, delay in maturity and chlorotic spots on the leaves (Haque *et al*., 2001).

Similarly, zinc occupies central importance among the essential elements needed for better growth and production in maize crop (Shahaney et al., 2019). It has a paramount role in boosting productivity in a number of crops (Prasad et al., 2014). It is of significant importance in plant physiology and is an important constituent of many enzymes (Broadley *et al*., 2012). Stunted crop growth and reduced yields in crops have been reported due to insufficient zinc concentrations in plants (Prasad et al., 2014).

The current study focusses on an attempt to boost maize growth and yield through identification of sole and combined applications of humic acid, zinc and nitrogen.

Materials and Methods

An experiment was carried out using an open pollinated maize variety named "Azam White" in order to evaluate the impact of various sole and combined doses of nitrogen zinc and humic acid at the Agriculture Research Station, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan during Kharif, 2022. The treatments were checked in a Randomized Complete Block Design consisting of three replications. The plot size was 3 m × 4 m with a row-row and plant-plant distance of 75 × 25 cm. Dibbler planter was used for sowing purpose so as to maintain proper plant to plant distance.

Seed bed was prepared by using cultivator and rotavator twice in order to make the soil powdery and porous for better gaseous exchange and crop stand. The experiment included seven different treatments including T_0: Control (no nutrients applied), T_1: Humic Acid @ 25 kg ha^{-1}, T_3: NPK basic dose @ 120: 60: 60 kg ha^{-1}, T_4: Zinc 83.33 @ 5 kg ha^{-1}, T_5: Humic Acid + NPK, T_6: Humic Acid + Zinc and T_7: Humic Acid + NPK+ Zinc. Nitrogen was split applied with first split at the time of sowing while the second one at the knee height stage i.e. 35-45 days after sowing.

All the other agronomic and preventive measures were followed as per the recommendations of previous studies. Germination percentage was figured out by dividing the number of germinated seeds over the total number of seeds sown in each plot and multiplying the obtained value by 100. Plant height was measured by means of a meter rod in centimeters from base to the apex of plant, number of cobs and seeds per cob were counted from ten randomly selected plants and then mean value for both the parameters was calculated. Maize grain and biological yields were calculated by converting the per plot yields in to kg ha^{-1}. Moreover, economic analysis was done by calculating the ratio of net profit to total cost incurred for various inputs. The data were statistically analyzed by means of Statistix 8.1 while the differences in mean values were computed via Least Significant Difference (LSD) test.

Results and Discussion

Germination percentage, plant height (cm), number of cobs and grains cob^{-1}

Table 1 showed that the germination percentage significantly enhanced in plots treated with different nutrient sources whether applied separately or in combination with each other. The control treatment had the least percentage of germination (88.85), while rest of the treatments gave statistically similar values for the said parameter. Tall plants were produced in humic acid, NPK basic dose, Zinc applied plots and their different combinations. Humic acid produced the least tall plants (200.33 cm) among the nutrient treatments, however, the results in this treatment were still significantly higher than that of the control (187.27 cm). Combination of Humic Acid with basic doses of NPK and Zinc produced maximum number of cobs plant^{-1} (2.65) and grains cob^{-1} (347.3). Nevertheless, other nutrient treatments

also had significantly higher results for both the parameters in comparison with the untreated control which had 1.81 and 315.9 number of cobs^{-1} and grains cob^{-1}, respectively. This might be attributed to the effectiveness of certain nutrients which actively contributed to the enhancement of these parameters as compared to the untreated control. Better growth of the crop plants requires optimal availability of the essential nutrients among which nitrogen, phosphorus and potash play a leading role (Prajapati *et al*., 2018). Nitrogen synthesizes plant's protoplasm and hastens rapid cell division to increase plant size (Ramasay *et al*., 2011). Phosphorus is a metabolically active compound which takes part in cell elongation and cell division; it is also a structural component of cell constituents (Ahmad et al., 2004). Potash is responsible for maintaining turgor pressure and water balance in plant cells (Singh et al., 2003). Similarly, in a study conducted by Humtsoe *et al*. (2018), nitrogen, zinc, and boron were observed to enhance maize growth and development by increasing the number of cobs, grains and kernel yield. These results are in line with that of the current study's results.

100 grain weight (g), grain and biological yield (t ha^{-1}) and economic analysis

The 100-kernel weight in maize did get significantly affected by different nutrient sources as compared to the untreated control (Table 2). It was inferred from the values that 100 seeds in control had the lightest weight i.e., 19.35 g, while rest of the nutrient treated plots showed statistically at par values for the same. On the other hand, combination of humic acid + NPK + Zinc produced the maximum kernel yield of 6.87 t ha^{-1} and succeeded in giving maximum net return (2.40) as well. This was followed by the basic NPK dose which gave 6.13 t ha^{-1} grain yield with a net return of 1.67. The analysis concluded that although all the other nutrient treatments performed better than the untreated check, however, only the combination of Humic Acid, NPK and Zinc was the most productive and profitable treatment. Prajapati *et al*. (2018) investigated the use of vermicompost in combination with basic NPK dose in maize cultivar MM2255 and reported better growth, enhanced yield and more net returns than any other treatment. They concluded that combination of organic and inorganic

Table 1: *Germination percentage, plant height (cm), number of cobs and grains cob^{-1} under the impact of different nutrient sources.*

Treatments	Germination (%age)	Plant height (cm)	Number of cobs plant^{-1}	No. of grains cob^{-1}
Untreated Control	88.85b	187.27c	1.81e	315.9d
Humic acid (25kg ha^{-1})	91.65ab	200.33b	2.15d	326.7c
NPK (120:60:60 kg ha^{-1})	94.98ab	213.07a	2.35c	327.23c
Zinc (5kg ha^{-1})	91.31ab	218.93a	2.15d	321.1cd
Humic acid + NPK	94.98ab	219.67a	2.35c	337.3b
Zinc + NPK	96.31a	222.53a	2.48b	347.3a
Humic Acid + NPK + Zinc	94.65ab	222.20a	2.65a	347.23a
$LSD_{0.05}$	5.54	11.61	0.11	9.32

Different alphabets with mean values exhibit significant differences at P 0.05

Table 2: *100 grain weight (g), grain and biological yield (t ha^{-1}) and economics in maize crop under the impact of different nutrient sources.*

Treatments	100 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Economic analysis (BCR)
Untreated Control	19.35b	4.15d	12.17^{NS}	1.10e
Humic acid (25kg ha^{-1})	23.63ab	5.05cd	11.69	1.07c
NPK (120:60:60 kg ha^{-1})	24.23ab	6.13b	12.93	1.67b
Zinc (5kg ha^{-1})	28.19a	5.95bc	11.93	1.20d
Humic acid + NPK	27.91a	5.65c	11.01	1.07c
Zinc + NPK	24.62ab	5.97bc	12.39	1.37bc
Humic Acid + NPK + Zinc	28.25a	6.87a	12.02	2.40a
$LSD_{0.05}$	8.28	2.19	---	0.41

Different alphabets with mean values exhibit significant differences at P 0.05

nutrients can significantly enhance the overall attributes of maize crop ultimately increasing the final yield. Arif *et al.* (2010), Cheema *et al.* (2010), Broadley *et al.* (2012), Aslam *et al.* (2014) and Begum *et al.* (2018) studied different nutrient treatments in their respective experiments and found that combination of NPK with other micronutrients. Their results are in accordance with results of the present study.

Conclusions and Recommendations

The results of the present study concluded that among different nutrient treatments, the combination of Humic Acid @ (25kg ha^{-1}) + NPK (120:60:60 kg ha^{-1}) + Zinc (5kg ha^{-1}) ensured maximum plant growth and grain yield in maize cultivar "Azam White" in comparison with all the other treatments, including the untreated check. This treatment also gave the maximum net returns; therefore, it is recommended that Humic Acid and Zinc may be used as supplementary fertilizers along with the basic doses of NPK to get maximum monetary and yield benefits in maize in D.I. Khan and areas with alike environmental attributes.

Acknowledgement

The contribution of all the authors is hereby cordially acknowledged

Novelty Statement

This research is novel in evaluating the combined effect of Humic Acid, NPK, and Zinc on maize cultivar "Azam White" in D.I. Khan, Pakistan, offering a localized approach to optimize both agronomic traits and economic returns.

Author's Contribution

Mr. Syed Muhmmad Saqib Raza conducted the experiment and collected the data. Mr. Sheheryar wrote the manuscript, Miss Rabia Khalid did data analysis, Dr. Muhammad Mansoor gave technical inputs and did proof-reading of the manuscript, Dr. Sonia Sumreen refined the manuscript and Mr. Muzammil Bin Khalil helped in compilation of the data.

Conflict of interest

The authors have declared no conflict of interest.

References

Ahmad Alias, M.U., E. Ullah and E.A. Warraich. 2003. Effects of different phosphorus levels on the growth and yield of two cultivars of maize (*Zea mays* L.). Int. J. Agric. Biol., 4: 632-634.

Ahmad, Z., Kavanová, M., Lattanzi, F.A. Grimoldi, A.A., and Schnyder, H. (2004). Phosphorus deficiency decreases cell division and elongation in grass leaves. Plant Physiol., 141(2): 766–775.

Arif, M., M.T. Jan, N.U. Khan, H. Akbar, S.A. Khan, M.J. Khan, A. Khan, I. Munir, M. Saeed and A. Iqbal. 2010. Impact of plant populations and nitrogen levels on maize. Pak. J. Bot., 42(6): 3907-3913.

Anonymous, 2022-23. Economic survey of Pakistan, Finance Division, Government of Pakistan, pp. 21-22.

Asif, M., M.F. Saleem, S.A. Anjum, M.A. Wahid and M.F. Bilal. 2013. Effect of nitrogen and zinc sulphate on growth and yield of maize (Zea mays L.). J. Agric. Res., 51(4): 204-213.

Aslam, M., K. Ahmad, M.A. Maqbool, S. Bano, Q.U. Zaman and G.M. Talha. 2014. Assessment of adoptability in genetically adverse chickpea genotypes (*Cicer arietinum* L.) based on different physio-morphological standards under ascochyta blight inoculation. Int. J. Adv. Res., 2(2): 245-255.

Begum, F., F. Hossain, M. Islam, M. Mondal and R. Islam. 2018. Effect of naphthalene acetic acid (NAA) on oil content and quality of the mustard plant (Brassica campestris L.) Pertanika. J. Trop. Agric. Sci., 41(1): 133-139.

Broadley, M.R., P. Brown, I. Cakmak, Z. Rengel and F. Zhao. 2012. Function of nutrients: Micronutrients. In: Marschner's mineral nutrition of higher plants, 3rd edition. P. Marschner (ed). Academic press, London, UK. Pp. 208-265. https://doi.org/10.1016/B978-0-12-384905-2.00007-8

Broadley, M. R., and Hammond, J. P. (2007). Zinc in plants. New Phytologist, 173(4), 677–702.

Cheema, M.A., W. Farhad, M.F. Saleem, H.Z. Khan, A. Munir, M.A. Wahid, F. Rasul and H.M. Hammad. 2010. Nirtogen management strategies for sustainable maize production. Crop Environ., 1: 49-52.

Daur, I., and A.A. Bakhashwain. 2013. Effect of humic acid on growth and quality of maize fodder production. Pak. J. Bot., 45(S1): 21-25.

Government of Pakistan. (2023). Pakistan Economic Survey 2022-23. Ministry of Finance. p. 10.

Haque, M.M., A. Hamid and N.I. Bhuiyan. 2001. Nutrient uptake and productivity as affected by nitrogen and potassium application levels in maize/sweet potato intercropping system. Korean J. Crop Sci., 46(1): 1-5.

Humtsoe, B.M., J. Dawson and P. Rajana. 2018. Effect of nitrogen, boron and zinc as basal and foliar application on growth and yield of maize (*Zea mays* L.). J. Pharmacogn. Phytochem., 7(6): 1-4.

Kumar, R., J.S. Bohra, N.P. Kumawat, K. Upadhyay and A.K. Singh. 2018. Effect of balanced fertilization on production, quality, energy use efficiency of baby corn (*Zea mays*) and soil health. Indian J. Agric. Sci., 88(1): 28–34. https://doi.org/10.56093/ijas.v88i1.79547

Shahaney, J., Mumtaz, M. Z. Ahmad, M., Jamil, M., and Hussain, T. (2019). Zinc solubilizing *Bacillus spp.*: potential candidates for biofortification in maize. Microbiol. Res., 210: 51–58.

Prasad, K.S., Das, S. and Green, A. (2014). Zinc in Crops and Human Health. In U. Singh, C. Praharaj, S. Singh, and N. Singh (Eds.), Biofortification of Food Crops. (pp. 31–40). Springer.

Prajapati, V.K., N. Swaroop, A. Masih and R. Lakra. 2018. Effect of different dose of NPK and vermicompost on growth and yield attributes of maize (*Zea mays* L.) Cv. MM2255. J. Pharmacogn. Phytochem., 7(1): 2830-2832.

Ramasamy, P.K., K. Baskar and S. Ignacimuthu. 2011. Influence of vermicompost on kernel yield of Maize (*Zea mays* L.). Elixir Agric., 36(3): 119-3121.

Singh, M.S., Hasanuzzaman, M. Bhuyan, M.H. M.B., Nahar, K., Hossain, M.S., Mahmud, J.A., Hossen, M.S., Masud, A.A.C., Moumita, and Fujita, M. (2003). Potassium: A Vital Regulator of Plant Responses and Tolerance to Abiotic Stresses. Agronomy, 8(3), 31.

Tahir, M.M., M. Khurshid, M.Z. Khan, M.K. Abbasi and M.H. Kazmi. 2011. Lignite-derived humic acid effect on growth of wheat plants in different soils. Pedosphere, 21(1): 124-131. https://doi.org/10.1016/S1002-0160(10)60087-2