Pure Appl. Biol.,14(2):585-599,June, 2025
http://dx.doi.org/10.19045/bspab.2025.140056

Research Article

Assessing the performance of maize genotypes and nitrogen levels on agronomic traits and phytochemical composition of corn

Inayat Ullah[1], Khalid Naveed[1], Arbaz Hassan[2], Saman Khalid[3], Muhammad Sheraz[4], Muhammad Ibrar Hassan[5], Arshad Iqbal[6], Zehnoor Ahmad[1], Rafaquat[7], Malik Faizan Shoukat[8] and Abid Mehmood[1*]
1. Department of Agronomy, The University of Haripur, Pakistan
2. Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan
3. Institute of Forest Sciences, Faculty of Agriculture and Environment. The Islamia University of Bahawalpur,63100, Pakistan
4. Fodder and Forage Research Program, Crop Sciences Institute, NARC Islamabad, Pakistan
5. University College of Pharmacy university of the Punjab, Pakistan
6. Agricultural Research Station, Baffa Mansehra, Pakistan
7. Department of Food Science and Technology, The University of Haripur, Pakistan
8. Department of Horticulture, The University of Haripur, Pakistan
**Corresponding author's email: abidawan1990@gmail.com*

Citation
Inayat Ullah, Khalid Naveed, Arbaz Hassan, Saman Khalid, Muhammad Sheraz, Muhammad Ibrar Hassan, Arshad Iqbal, Zehnoor Ahmad, Rafaquat, Malik Faizan Shoukat, and Abid Mehmood. Assessing the performance of maize genotypes and nitrogen levels on agronomic traits and phytochemical composition of corn. Pure and Applied Biology. Vol. 14, Issue 2, pp585-599. http://dx.doi.org/10.19045/bspab.2025.140056

Received: 08/12/2024 Revised: 020/02/2025 Accepted: 09/02/2025 Online First: 12/02/2025

Abstract

Nitrogen (N) indeed plays a crucial role in maize productivity, and selecting suitable genotypes is essential for unlocking the potential benefits of different cultivars and adapting to seasonal environmental and climatic fluctuations. An experiment was conducted to assess the performance of maize genotypes and nitrogen levels on agronomic traits and phytochemical composition of corn. The experiment was laid out in RCBD two factorial replicated three times. Two factors were: Factor A: maize genotype (Sahara KS85, Pioneer 30K08, Azam and Qayyum), factor B: Nitrogen levels (0 $kgha^{-1}$, 120 $kgha^{-1}$, 240 $kgha^{-1}$ and 360 $kgha^{-1}$). The results showed that plant height, days to emergence, days to tasseling, days to silking, ear $plant^{-1}$, single cob weight (g), cob height (cm), grains cob^{-1}, grain yield, total phenolic content, total flavonoid and protein content of maize genotypes were significantly affected by nitrogen levels. Pioneer 30k08 showed maximum plant height, cob length, cob weight, grains cob^{-1} as well as maximum yield, followed by Sahara KS85. Higher levels of nitrogen i-e 360 $kgha^{-1}$, followed by 240 $kgha^{-1}$ also showed higher yield and quality of maize crop. From this study, it can be concluded that application of nitrogen @ 360 $kgha^{-1}$ showed promising results regarding growth and yield of maize. Furthermore, maize genotype Pioneer 30k08 performed very well and showed on par results as compared to other three genotypes. Hence it is recommended to use higher dose of nitrogen i-e 360 $kgha^{-1}$ and maize genotype pioneer 30k08 for obtaining maximum yield of maize crop.

Keywords: Biological yield; Grain Yield; Maize, Phytochemical analysis

Introduction

Pakistan's economy is mostly based on agriculture. Despite excellent conditions, the country's agriculture is under producing in terms of yield per hectare [1]. After rice and wheat, maize is the world's third most vital cereal crop [2]. It is a widely produced staple food grain that is more adaptable to a larger variety of environmental circumstances and is well suited to a wide range of environmental conditions [3]. It accounts for 62% of global cereal production and is commonly referred to as the "king of cereals" [4]. Maize's increased usage in industry has elevated it to a key position in the agricultural economy. It is not only used by humans as a food grain, but it also serves as a source of feed for cattle and fowl [5]. Aside from being a staple crop, maize is utilized in various industries, including food and textiles. It is used in the production of cornflakes, syrup, and starch. Maize also yields corn oil, a significant byproduct that is particularly suitable for human consumption due to its lower unsaturated fatty acid content [6].

Maize holds the position of being Pakistan's third most significant grain crop. It contributes to 3% of the total agricultural value and 0.7% of the GDP. In the 2022-23, maize was cultivated across 1720 thousand hectares, marking a 4.1% increase from the previous year. Production also saw a rise of 6.9 percent, reaching 10.183 million tons [7]. The expanding poultry and livestock sectors are the key drivers behind the growing demand for maize. Currently, Pakistan's maize production currently fulfills its domestic requirements, effectively maintaining equilibrium between supply and demand [8]. Maize cultivation in Pakistan is centered in two primary provinces, Khyber Pakhtunkhwa and Punjab. In Khyber Pakhtunkhwa, maize is commonly cultivated for both grain and fodder [9].

Maize silk is actually the basal portions of the style or female organ of the plant. Maize silk is line pattern and generally form a loose cluster and appear as a feathery structure. It has some colors like light green, Kelly or something like brown red. It is soft and tasteless and has no odor. Maize silk contains many substances including the fats, oils, volatile oils, gum, resins and many others [6]. The two most significant variables that improve plant yield and productivity are fertilizer application and mineral uptake/accumulation. The shape, kind, and amount of fertilizers can have a beneficial or detrimental impact on the production of essential oils in aromatic plants. Minerals like nitrogen, phosphorous, and potassium can impact plant development and essential oil production [10]. The function and levels of enzymes involved in terpenoides production are affected by these minerals. Several studies suggest that optimal fertilizer application rates and plant populations can lead to improved crop growth and higher yields. However, the response to fertilizer can vary significantly depending on factors such as the amount and distribution of moisture, soil fertility, and the variety of maize being grown [11].

Nitrogen has a major impact on yield and yield components, and raising nitrogen levels increases grain production [12]. As a result, optimizing nitrogen delivery to hybrid corn is critical for obtaining maximum yield. Nitrogen is crucial for the growth and development of crops. It boosts crop yield, and its deficiency can lead to stunted growth, pale yellow coloring, smaller grain size, and reduced yield [13]. Nitrogen is a key component of amino acids and proteins. Plant growth largely hinges on the availability of nitrogen in the soil solution and its uptake and utilization by crop plants [14].

Nitrogen (N) fertilizer plays a crucial role in corn dry matter production by affecting leaf area development, maintenance, photosynthetic capacity, yield, and grain quality. However, managing nitrogen in corn production is challenging due to economic, agronomic and environmental considerations [15]. Nitrogen is a vital plant nutrient and is involved in enzymatic reactions, protein synthesis and is a main constituent of nucleic and amino acids but it is the most deficient nutrient (94%) in Pakistani soils [16]. Soil of Khyber Pakhtunkhwa are generally medium to low in nitrogen content. Application of fertilizers, especially nitrogen had a considerable effect not only on quantity but also on the quality of the seed in many crops [17]. Amidst the growing global population, ensuring food security and optimizing the nutrition of staple crops, particularly maize, present significant challenges. The complex interplay between maize genotypes, nitrogen levels, and their combined effects on agronomic traits and the phytochemical content of corn silk remains poorly understood. This research aims to fill this knowledge gap, offering valuable insights to optimize nitrogen application strategies, enhance maize yield, and harness the health benefits of corn silk.

Materials and Methods

The study entitled "Assessing the performance of maize genotypes and nitrogen levels on agronomic traits and phytochemical composition of corn silk" was carried out at Agriculture Research Station, Baffa Mansehra, Pakistan during 2023.

Experimental soil

Soil samples were randomly collected from depths ranging from 0-15 cm, and a composite sample was prepared. These samples underwent various physiochemical tests using standard protocols. The soil was classified as sandy clay loam, mildly alkaline, with low organic carbon and nitrogen levels, moderate phosphorus concentrations, and sufficient potassium levels, as shown in (Table 1).

Table 1: Soil physiochemical analysis of experimental site

Soil texture	pH value	EC	N (%)	P (ppm)	K (ppm)	Organic matter	Ca+	Mg+	Hco_3	Cl
Sandy Clay loam	7.9	0.25	0.038	11.5	145	0.61	5.20	0.70	5.6	0.10

Experimental design

The experiment was set up in a randomized complete block design (RCBD) with a factorial arrangement of two factors, each with three replications. All agronomic practices were uniformly and consistently applied to all treatments throughout the study period, following the experimental protocol. The treatment detail is as under:

Factor-A; Maize genotypes

G1 = Sahara KS85
G2 = Pioneer 30K08
G3 = Azam
G4 = Qayyum

Factor-B; nitrogen doses (Kg/ha)

N1 = 0 $kgha^{-1}$
N2 = 120 $kgha^{-1}$
N3 = 240 $kgha^{-1}$
N4 = 360 $kgha^{-1}$

Cultural operations

Preparatory cultivation

The experimental plots were prepared according to the experimental protocols. The field was divided into sub plots as per the layout of experiment. Plot size was kept as $6.75m^2$. Seed rate of 25 kg ha^{-1} was used. In order to detect visual variations between the treatments and any kind of infestation by weeds, insects and diseases, the field was visited from time to time so that major pest losses could be reduced. The entire plots were hand harvested. Plants were left in the field for three weeks. After three weeks, the entire plot's ears were husked before being threshed.

Observations on the crop

Plant height

Plant height (cm) was measured from five random plants for data collection from each plot after harvesting.

Ear plant^{-1}

Ear plant^{-1} was recorded from randomly selected plants.

Single cob weight (g)

Weight of cobs from randomly selected plants were measured and average was recorded to measure weight of single cob.

Moisture content

Mayak [18] method was used to calculate moisture content

$$(RWC)\ \% = \frac{FW - DW}{FTW - DW}$$

Grains cob^{-1}

To calculate grain cob^{-1}, five cobs from randomly selected plants in each subplot were harvested to count the number of grains and average was worked out.

Grain yield (kgha^{-1})

Once threshing and winnowing was done, weight of clean seeds obtained from individual plots was recorded and then converted into kgha^{-1}.

Total polyphenol content

The total phenolic content was determined using the method described by [19].

Total flavonoid

Atanassova [20] method was used to find out the total flavonoid content.

Protein content

To determine the crude protein percentage [21] method was used.

Statistical analysis

Analysis of variance was performed using computer-based software Statestix 8.1. The differences amongst treatments were separated using Tukey test at 0.05 [22].

Results and Discussion

Plant height (cm)

The overall radiation capture and efficient photosynthetic activity is associated with greater heights and canopy of plants. Greater plant heights and uniformity across the field also help in proper maturity of crop in case of maize. Analysis of variance for plant height revealed that application of nitrogen as well as maize genotypes showed significant results, whereas, their interaction remained non-significant. The (Table 2) showed that maximum plant height (225.07 cm) was observed in Pioneer 30k08, followed by Sahara KS85 (203.89 cm), whereas, minimum plant height (160.45 cm) was recorded in genotype Qayyum. Regarding nitrogen levels, maximum plant height was observed with highest level of nitrogen. Gradual increase in nitrogen results in gradual increase in plant height. Nitrogen at the rate of 360 kgha^{-1} results in maximum plant height (199.6 cm), followed by nitrogen at the rate of 240 kgha^{-1}, whereas, minimum plant height was observed in control. Morphological and biochemical characterization plays a crucial role in identifying genotypes with desirable fodder and yield related traits [2]. These traits can then be deployed in crop improvement programs, either as cultivars or as donors of genetic material [23]. Nitrogen not only enhanced days to tasseling and silking but also increased plant height. The most probable reason for this could be that nitrogen improved leaf chlorophyll content and ultimately photo assimilate synthesis through the process of photosynthesis [24], which resulted in the high vegetative growth of the crop. It's likely that nitrogen's positive impact on plant metabolism is responsible for the observed increase in plant height. [25] demonstrated that higher nitrogen treatment rates led to taller plants, possibly because of increased absorption of residual nitrogen.

Single cob weight (g)

Analysis of variance results for single cob weight (g) of maize were presented in (Table 2). ANOVA performed for single cob weight showed that application of nitrogen as well as maize genotypes showed statistically similar results, whereas, their interaction remained non-significant. Maximum cob weight (278 g) was recorded in Pioneer 30k08, followed by (244 g) statistically similar results in maize genotype Sahara KS85, whereas, minimum single cob weight (193.08 g) was recorded in maize genotype Qayyum. Regarding nitrogen levels, maximum cob weight (260.2 g) was observed in highest nitrogen level i-e 360 $kgha^{-1}$, followed by (240.5 g) statistically similar results in nitrogen level-3 (240 $kgha^{-1}$), whereas, control showed lowest single cob weight (202.5 g). The heavier cobs at higher levels of nitrogen could be attributed to several factors, including the optimum utilization of solar light, higher assimilated production, and the conversion of this production into starches [26]. [27] observed the heavier cobs with the application of higher nitrogen doses. Similarly, [28] noted a significant increase in cob weight with increasing levels of nitrogen. The observed increase in cob weight may be attributed to the availability of adequate nitrogen, which plays a crucial role in cell division and elongation, ultimately resulting in heavier cobs [29]. [30] conducted previous research suggesting that path analysis indicates ear weight could be a valuable selection criterion due to its significantly positive direct effects on forage yield.

Grains cob^{-1}

Data presented in (Table 2) illustrated that grins cob^{-1} of maize genotypes significantly affected from nitrogen levels as well as genotypes, whereas, their interaction remained non-significant. Maximum number of grains (518) was recorded in Pioneer 30k08, followed by (516) maize genotype Sahara KS85, whereas, minimum number of grains (513) were recorded in maize genotype Qayyum. Regarding nitrogen levels, maximum number of grains (516) were observed in highest nitrogen level i-e 360 $kgha^{-1}$, followed by (515) statistically similar results in nitrogen level-3 (240 $kgha^{-1}$), whereas, control showed lowest number of grains (514). In plant nutrition, nitrogen is the most important necessary nutrient, present in essential organic molecules, including proteins, amino acids, ribosomes, cytochrome, certain vitamins and chlorophyll [31]. [32] found that number of seeds/plant were increased by raising N up to optimum level. [33] observed that yield components were increased by escalating N doses. Raising N fertilization improved plant height, seeds $capsule^{-1}$ and seed yield/ha. [34] found highly significant differences among genotypes for grain yield and yield-contributing traits, which aligns with the present findings. Similarly, [35] observed significant variation in grain yield when comparing thirty maize genotypes.

Cob length (cm)

Cob length is considered one of the fundamental yield components of maize crop. Analysis of variance results for cob length (cm) of maize were presented in (Fig. 1). ANOVA performed for single cob weight showed that application of nitrogen levels, maize genotypes as well as their interaction showed statistically significant results. Maximum cob length (21.25 cm) was recorded in Pioneer 30k08, followed by (20.83 cm) statistically similar results in maize genotype Sahara KS85 and Azam (20 cm), whereas, minimum cob length (18.5 cm) was recorded in maize genotype Qayyum. Regarding nitrogen levels, maximum cob length (21.5 cm) was observed in highest nitrogen level i-e 360 $kgha^{-1}$, followed by (240.5 g) statistically similar results in nitrogen level-3 (21 cm), whereas, control showed lowest single cob length (18.25 cm). Concerning the interaction, maximum cob length (24 cm) was recorded in Pioneer 30k08 with application of nitrogen @ 360 kgha^{-1}, whereas minimum cob length (17 cm) was recorded in Qayyum genotype without nitrogen application. [36] discovered that N fertilizer had no impact on cob length, but [37,38] reported that cob length was higher as the rate of N application increased. Another possibility might be related to late maturity induced by N fertilization, which, according to some authors, resulted in poor seed filling and a higher proportion of green seeds, however this was not seen in our study. [39] reported a significant increase in maize cob length with nitrogen application compared to the control. Genetic differences in ear length and diameter in maize have also been reported by [40, 41].

Moisture content (%)

Seed moisture level plays a critical role in determining the susceptibility of seeds to damage or deterioration. When seed moisture levels are high, typically above 18%, seeds become vulnerable to damage from high temperatures, such as those encountered during mechanical drying, or to low temperatures, such as those experienced during a frost. ANOVA performed for seed moisture content (%) showed that application of nitrogen levels, whereas, maize genotypes as well as their interaction showed statistically non-significant results. Maximum moisture content (14.58 %) was recorded in Qayyum, followed by (13.91 %) statistically similar results in maize genotype Azam, whereas, minimum moisture content (13.5 %) was recorded in Sahara KS85. With an increase in moisture content, the elastic modulus of the four corn varieties decreases [42]. Nitrogen fertilizer application is indeed crucial for achieving high and stable corn yields [43]. Additionally, the moisture content of corn grains plays a significant role in determining the quality of mechanical grain harvesting [44]. The grain moisture content of corn is influenced by various factors, including genotype, environment, and cultivation practices [45]. Different corn varieties exhibit significant differences in grain moisture content, with early-maturing cultivars drying faster before physiological maturity, while late-maturing cultivars dry more slowly. This is supported by studies from [46].

Grain yield (kgha^{-1})

Grain yield represents the culmination of various yield-contributing factors, including the number of cobs per plant, number of grain rows per cob, and thousand grain weights. These parameters are directly affected by the genetic makeup of the crop, as well as certain agricultural practices and climatic conditions during the crop's growth and development stages. Analysis of variance results for grain yield (kgha^{-1}) of maize were presented in (Fig. 2). ANOVA performed for grain yield (kgha^{-1}) showed that application of nitrogen levels, maize genotypes as well as their interaction showed statistically significant results. Maximum grain yield (7661.9 kgha^{-1}) was recorded in Pioneer 30k08, followed by (7506.6 kgha^{-1}) maize genotype Sahara KS85, whereas, minimum grain yield (6873.8 kgha^{-1}) was recorded in maize genotype Qayyum. Regarding nitrogen levels, maximum grain yield (7415.3 kgha^{-1}) was observed in highest nitrogen level i-e 360 kgha^{-1}, followed by (7378.4 kgha^{-1}) statistically similar results in nitrogen level-3, whereas, control showed lowest grain yield (7189.4 kgha^{-1}). Concerning the interaction, maximum grain yield (7726.5 kgha^{-1}) was recorded in Pioneer 30k08 with application of nitrogen @ 360 kgha^{-1}, whereas minimum grain yield (6783.3 kgha^{-1}) was recorded in Qayyum genotype without nitrogen application. The increase in yield could be attributed to the greater availability of nitrogen, which would result in faster photosynthesis and hence higher carbohydrate production. Similar findings were also reported by [47]. Our findings were consistent with those of Shrestha et al., (2018), who demonstrated that applying a high nitrogen dose at 200 kg N/ha resulted in the highest grain yield. Similarly, [48] reported the highest grain yield with the application of 225 kg N/ha, while [49] found significantly higher grain yields with up to 240 kg N/ha. Additionally, [50,51] observed that maize grain yield increased with higher nitrogen doses. This increase in grain yield at higher nitrogen levels may be attributed to reduced nutrient competition, allowing for a larger plant canopy, higher photosynthetic activity, and greater biomass accumulation with larger grains [52].

Total phenolic content (mgg^{-1})

Analysis of variance results for total phenolic content (mgg^{-1}) of maize were presented in (Fig. 3). ANOVA performed for total phenolic content (mgg^{-1}) showed that application of nitrogen levels, maize genotypes as well as their interaction showed statistically significant results. Maximum total phenolic content (0.09 mgg^{-1}) was recorded in Qayyum, followed by statistically similar results in all genotypes. Regarding nitrogen levels, maximum total phenolic content (0.09 mgg^{-1}) was observed in nitrogen level-2 i-e 240 kgha^{-1}, followed by (0.045 mgg^{-1}) statistically similar results in nitrogen level-4, whereas, control showed total phenolic content (0.015 mgg^{-1}). Concerning the interaction, maximum total phenolic content (0.22 mgg^{-1}) was recorded in Qayyum genotype with application of nitrogen @ 240 kgha^{-1}, whereas minimum total phenolic content (0.013 mgg^{-1}) was recorded in Azam genotype without nitrogen application. Our study demonstrated the importance of nitrogen application in improving plant growth by inhibiting ethylene emissions, with evidence of an increase in these compounds' protective effects against stress, aiding plants in maintaining ROS levels under challenging conditions, and facilitating rapid elimination so that metabolism stays stable. Furthermore, the maize silk phenolic increase was consistent with earlier research by [53], which could be attributed to the discovery that certain enzymes in the phenolic biosynthesis pathway, like phenylalanine ammonia-lyase and chalcone synthase, are involved in the process [54]. The accumulation of nitrogen in plants has been shown to correlate with a reduction in lipid peroxidation, which indirectly contributes to lower levels of intracellular reactive oxygen species (ROS). This effect was observed in the study conducted by [55]. The rise in total phenolics content at higher nitrogen levels may be linked to nitrogen's influence on the plant's growth rate. According to the carbon/nutrient balance theory, when plant photosynthesis is high relative to nitrogen supply, excess carbon is directed towards phenolics, which are nitrogen-free defense compounds [56]. This suggests that nutrient scarcity, especially low nitrogen availability due to slow mineralization rates in organic production, could stimulate phenolic synthesis while limiting rapid leaf growth.

Total flavonoids content (mgg^{-1})

The (Table 3) illustrates total flavonoids content of maize genotypes as affected by different nitrogen levels. ANOVA performed for total flavonoids content showed that application of nitrogen levels resulted in significant difference in total flavonoids content of maize, whereas, maize genotypes as well as their interaction showed statistically non-significant results. Maximum total flavonoids content (0.1 mgg^{-1}) was recorded in higher nitrogen level i-e nitrogen @ 360 kgha^{-1}, followed by statistically similar results in all nitrogen levels. Nitrogen nutrition is crucial as it affects both primary and secondary metabolic pathways, including the accumulation of secondary plant metabolites [57]. Deficiency in essential elements such as nitrogen has been shown to increase the accumulation of phenolic compounds in plant tissues [58]. Previous studies by [59] have shown that different rates of nitrogen application can influence the buildup of phytochemicals in plant tissues, but there is limited research on the effects of different forms of nitrogen. [60] noted that nitrogen deficiency can enhance the production of secondary plant metabolites, including total phenolic and betacyanins. Likewise, [61] observed a significant increase in total phenolics concentration in nitrogen-starved plants, suggesting that nitrogen deficiency can stimulate the synthesis of secondary plant metabolites. This observation is consistent with the findings of [62]. Lower levels of phenolic and flavonoid compounds have been reported in plants grown under high nitrogen supply, as seen in apple trees [63].

Protein content (%)

Analysis of variance results for protein content (%) of maize silk is presented in (Fig. 4). ANOVA performed for protein content (%) showed that application of nitrogen levels, maize genotypes as well as their interaction showed statistically significant results. Maximum protein content (2.17 %) was recorded in pioneer 30k08, followed by (2.13 %) statistically similar results in sahara KS85, whereas, Qayyum genotype showed minimum protein content (2.06 %). Regarding nitrogen levels, maximum protein content (2.23 %) was observed in nitrogen level-4 i-e 360 kgha^{-1}, followed by (2.19 %) in nitrogen level-3, whereas, nitrogen @ 120 kgha^{-1} and control showed minimum protein content. Concerning the interaction, maximum protein content (2.31 %) was recorded in Qayyum genotype with application of nitrogen @ 360 kgha^{-1}, whereas minimum protein content (1.84 %) was recorded in Qayyum genotype without nitrogen application. Traditionally, the selection of maize genotypes has been based on productivity and yield stability [64]. However, in recent years, quality parameters have become increasingly important. These alternative purposes require a deeper understanding of the hybrids' inner content values and the impact of various agrotechnical factors on quality [65]. The current study indicates a rise in the total protein percentage with elevated nitrogen levels. This escalation might be attributed to the augmented dry matter production in plants, which directly or indirectly contributes to the biosynthesis of minerals [66]. Similarly, [50] also documented a notable increase in protein percentage with rising nitrogen levels.

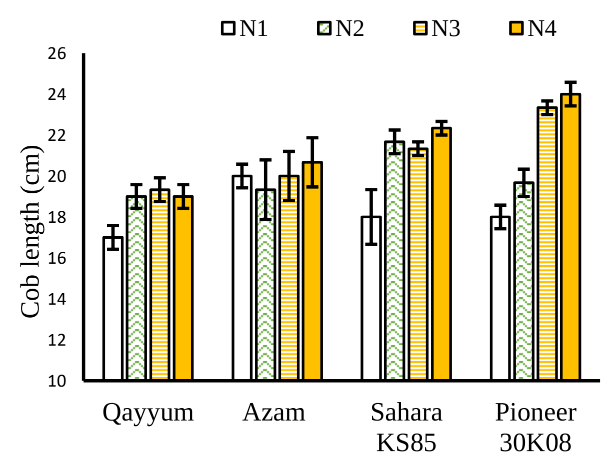

Figure 1. Interactive effect of nitrogen levels on cob length (cm) of maize genotypes

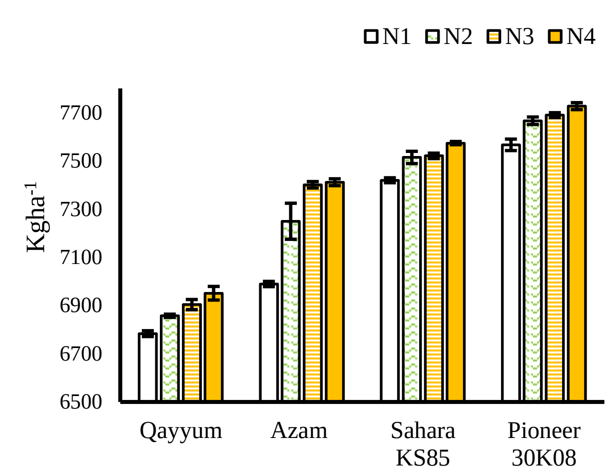

Figure 2. Interactive effect of nitrogen levels on grain yield of maize genotypes

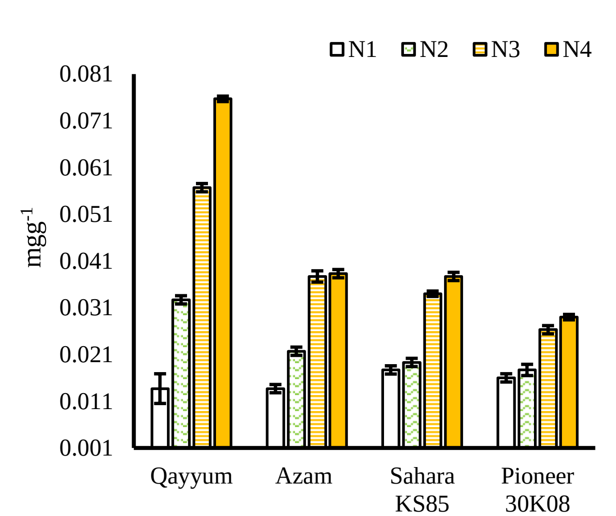

Figure 3. Interactive effect of nitrogen levels on total phenolic content of maize genotypes (mgg^{-1})

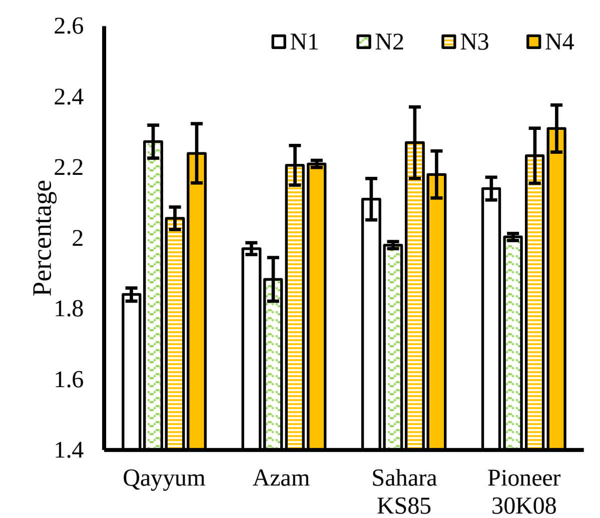

Figure 4. Interactive effect of nitrogen levels on total protein content of maize genotypes

Table 2: Plant height (cm), Cob weight (g), Grains cob^{-1}, Cob length (cm) and Moisture content (%) of maize genotypes as affected by different nitrogen levels

	Plant height (cm)	**Cob weight (g)**	**Grains cob^{-1}**	**Cob length (cm)**	**Moisture content (%)**
Genotypes					
Qayyum	160.45 d	193 c	512 c	18.58 b	14.58 a
Azam	179.17 c	214 bc	514bc	20 a	13.91 ab
Sahara KS85	203.89 b	244 ab	515 b	20.83 a	13.5 b
Pioneer 30K08	225.07 a	278 a	518a	21.25 a	13.75 b
LSD (0.05)	2.63	34.61	1.88	1.38	0.82
Nitrogen Levels					
0 kg ha^{-1}	185.27 d	202.5 b	14.25 b	18.25 c	13.5
120 kg ha^{-1}	189.78 c	226.7 ab	14.83 ab	19.91 b	13.83
240 kgha^{-1}	193.92 b	240.5 a	15.41 ab	21 ab	14.08
360 kg ha^{-1}	199.6 a	260.2 a	16.41 a	21.5 a	14.33
LSD (0.05)	2.63	34.61	1.88	1.38	NS
Interaction genotypes × nitrogen levels	NS	NS	NS	Fig 1	NS

Table 3: Mean table for cob length, grain yield, total phenolic content and total protein content of maize genotypes as affected by different nitrogen levels

	Total flavonoids content (mgg^{-1})	Grain yield (kg ha^{-1})	Total Phenolic Content (mgg^{-1})	Total Protein Content (%)
Genotypes				
Qayyum	0.092	6873 d	0.044 a	2.102 c
Azam	0.072	7262 c	0.027 b	2.067 d
Sahara KS85	0.085	7506 b	0.027 b	2.135 b
Pioneer 30K08	0.082	7661 a	0.022 c	2.171 a
LSD (0.05)	NS	36.97	0.0002	0.022
Nitrogen Levels				
0 kg ha^{-1}	0.0664 b	7189 c	0.015 d	2.015 c
120 kg ha^{-1}	0.0835 b	7321 b	0.022 c	2.035 c
240 $kgha^{-1}$	0.0751 b	7378 a	0.038 b	2.191 b
360 kg ha^{-1}	0.1075 a	7415 a	0.045 a	2.235 a
LSD (0.05)	0.023	36.97	0.0002	0.022
Interaction genotypes × nitrogen levels	NS	Fig 2	Fig 3	Fig 4

Conclusion and Recommendations

From this study, it is concluded that application of nitrogen @ 360 $kgha^{-1}$ and 240 $kgha^{-1}$ showed promising results regarding growth and yield of maize. Furthermore, maize genotype Pioneer 30k08 performed very well and showed on par results as compared to other three genotypes. Hence it is recommended to use higher dose of nitrogen i-e 240 $kgha^{-1}$ and 360 $kgha^{-1}$ for obtaining maximum yield of maize genotype Pioneer 30k08.

Authors' contributions

Conceived and designed the experiments: I Ullah & K Naveed, Performed the experiments: A Mehmood, A Hassan, S Khalid & M Sheraz, Analyzed the data: MI Hassan & A Iqbal, Contributed materials/ analysis/ tools: Z Ahmad & Rafaquat, Wrote the paper: MF Shoukat, & A Mehmood.

References

1. Mehmood A, Naveed K, Liu K, Harrison MT, Saud S, Hassan S & Fahad S (2024). Exogenous application of ascorbic acid improves physiological and productive traits of Nigella sativa. *Heliyon* 10(7).
2. Sravanti K, Devi IS, Sudarshan MR & Supriya K (2017). Evaluation of maize genotypes (*Zea mays* L.) for variability, heritability and genetic advance. *Inter J of Curr Microbiol and Appl Sci* 6(10): 2227-2232.
3. Ayub Q, Khan SM, Hussain I, Gurmani AR, Naveed K, Mehmood A & Hussain A (2021). Mitigating the adverse effects of NaCl salinity on pod yield and ionic attributes of okra plants by silicon and gibberellic acid application. *Italus Hortus* 28(1): 1-59.
4. Oyetunde OA, Benson GAS, Osho BT, Oyetunde AK & Adeshina GA (2024). Estimation of Genetic Variability in Maize Genotypes under Infestation by the Maize Storage Weevil, Sitophilus zeamais Using Multivariate Analysis. *Inter J of Plant & Soil Sci* 36(4): 241-250.
5. Rouf ST, Prasad K & Kumar P (2016). Maize—A potential source of human

nutrition and health: A review. *Cogent Food & Agric* 2(1): 1166995.
6. Erenstein O, Jaleta M, Sonder K, Mottaleb K & Prasanna BM (2022). Global maize production, consumption and trade: Trends and R&D implications. *Food Sec* 14(5): 1295-1319.
7. Government of Pakistan. Economic Survey of Pakistan, 2022-23.
8. Majeed A, Anwar-ul-Haq M, Akhtar J & Basra S (2014). Screening of maize genotypes against poor quality water in solution culture. *J of Agric Res* 52(3).
9. Haseeb A, Nawaz A, Rao MQA, Ali Q & Malik A (2020). Genetic variability and association among seedling traits of *Zea mays* under drought stress conditions. *Biol and Cli Sci Res J* (1).
10. Mehmood A, Naveed K, Azeem K, Khan A, Ali N & Khan SM (2018). 10. Sowing time and nitrogen application methods impact on production traits of Kalonji (*Nigella sativa* L.). *Pure and Appl Biol* 7(2): 476-485.
11. Hussain R, Noor, Rafaquat M, Khalid N, Hajra Z & Abid M (2025). A comprehensive review on resistant starch, its types, sources, application and health benefits. *Pure and Appl Biol* 14(2): 531-542.
12. Rehman AU, Mehmood A, Naveed K, Haq NU, Ali S, Ahmed J & Shahzad Q (2022). Integrated effect of nitrogen and Sulphur levels on productive traits and quality of black cumin (*Nigella sativa* L.). *J of Xi'an Shiyou Uni, Nat Sci Edi* 18(10): 38-58.
13. Wysokinski A & Kożuchowska M (2024). Increasing silage maize yield and nitrogen use efficiency as a result of combined rabbit manure and mineral nitrogen fertilization. *Sci Rep* 14(1): 5856.
14. Shaukat MF, Hussain I, Mehmood A, Naveed K, Ayub A, Ayub Q & Ahmad M (2023). Improving storability and quality of peach fruit with post-harvest application of calcium chloride and potassium permanganate. *Pure and Appl Biol* 12(1): 414-423.
15. Mehmood A, Naveed K, Jadoon N, Ayub Q, Hussain M & Hassaan M (2021). Phytochemical screening and antibacterial efficacy of black cumin (*Nigella sativa* L.) seeds. *FUUAST J of Biol* 11(1): 23-28.
16. Gul H, Rahman S, Shahzad A, Gul S, Qian M, Xiao Q & Liu Z (2021). Maize (*Zea mays* L.) productivity in response to nitrogen management in Pakistan. *Am J of Plant Sci* 12(8): 1173-1179.
17. Khan A, Ali S, Khan A, Waqas M & Khan SU (2020). Technical efficiency of maize in district Lakki Marwat of Khyber Pakhtunkhwa, Pakistan. *Sarhad J of Agric* 36(2).
18. Mayak S, Tirosh T & Glick BR (2004). Plant growth-promoting bacteria confer resistance in tomato plants to salt stress. *Plant physiol and Biochem* 42(6): 565-572.
19. Julkenen-Titto R (1985). Phenolic constituents in the leaves of northern willows: methods for the analysis of certain phenolics. *Agric Food Chem* 33: 213–217.
20. Atanassova M, Georgieva S & Ivancheva K (2011). Total phenolic and total flavonoid contents, antioxidant capacity and biological contaminants in medicinal herbs. *J of the Uni of Chem Technol & Meta* 46(1).
21. Salo-väänänen PP & Koivistoinen PE (1996). Determination of protein in foods: comparison of net protein and crude protein (N× 6.25) values. *Food Chem* 57(1): 27-31.
22. Gomez KA & Gomez AA (1984). *Statistical procedures for agricultural research*. John wiley & sons.
23. Loro MV, Carvalho IR, Pradebon LC, Sangiovo JP, Dalla Roza JP, Zuse GH &

Foleto EE (2024). Maize genetic breeding for tolerance to abiotic stress with focus on sustainable use of environmental resources. *Agr Sci and Biotechnol* 10: 1-12.

24. Taran SN U, Ali SA, Haq NU., Faraz A, Ali S & Mehmood A (2022). Antioxidant and antimicrobail activities, proximate analysis and nutrient composition of eight selected edible weeds of Peshawar region. *J of Xi'an Shiyou Uni, Nat Sci Ed* 18(9): 517-545.
25. Abera K, Tana T & Takele A (2020). Effect of rates and time of nitrogen fertilizer application on yield and yield components of sorghum (*Sorghum bicolor* L.) at Raya Valley, Northern Ethiopia. *Inter J of Plant Breeding* 7(1): 598-612.
26. Audu I (2020). The Effect of Different Rates of Nitrogen Fertilizer and Cow Dung on Yield and Yield Components of Maize Varieties (*Zea mays* L.) in Mubi, Adamawa State, Nigeria. *J Agric Eco Res Ins* 21(2): 1-8.
27. Kamal AA, Rahman TU & Mehmood A (2022). Identification, adaptability, phytochemical and nutritional potential of Slender amaranth: A review. *J of Xi'an Shiyou Uni, Nat Sci Ed* 18(9): 517-545.
28. Olaiya AO, Oyafajo AT, Atayese MO & Bodunde JG (2020). Nitrogen use efficiency of extra early maize varieties as affected by split nitrogen application in two agroecologies of Nigeria. *MOJ Food Pro & Technol* 8(1): 5-11.
29. Singh S & Misal NB (2022). Effect of different levels of organic and inorganic fertilizers on maize (*Zea mays* L.). *Ind J of Agric Res* 56(5): 562-566.
30. Mahmood T, Qasim M, Ahmad S, Sajid HB, Abdullah M, Dilshad R & Tahir N (2022). *Zea mays* L. Germplasm Characterization Based on Various Morphological Attributes. *The Inter J of Biol Res* 5(1): 1-18.
31. Kuntoji A, Subbarayappa CT, Sathish A, Ramamurthy V & Mallesha BC (2021). Effect of different levels of nitrogen and zinc application on growth, yield and quality of maize in rural and peri-urban gradients of southern transect of Bengaluru. *J of Pharmacog and Phytochem* 10(1): 1562-1568.
32. Mehmood A, Naveed K, Muzaffar Iqbal, RA, Shaukat MF, Shahzad H, Rehman AU & Haq NU (2023) Improving gas exchange characteristics, antioxidant enzymes, yield and yield attributes of black cumin through foliar application of ascorbic acid. *J of Xi'an Shiyou Uni, Nat Sci Ed* 18(10): 887-901.
33. Wang X, Wang G, Turner NC, Xing Y, Li M & Guo T (2020). Determining optimal mulching, planting density, and nitrogen application to increase maize grain yield and nitrogen translocation efficiency in Northwest China. *BMC Plant Biol* 20: 1-21.
34. Kizilgeci F, Yildirim M, Albayrak O, Bicer BT, Hossain A, El Sabagh A & Akinci C (2018). Evaluation of Turkish maize landraces through observing their yield and agro-morphological traits for genetic improvement of new maize cultivars. *Acta Fytotechnica et Zootechnica*, 21(2): 31-43.
35. Raut SK, Ghimire SK, Kharel R, Kuwar CB, Sapkota M & Kushwaha UKS. (2017). Study of yield and yield attributing traits of maize. *Am J of Food Sci and Health* 3(6): 123-129.
36. Mehmood A, Naveed K, Ayub Q, Alamri S, Siddiqui MH, Wu C & Fahad S (2021). Exploring the potential of moringa leaf extract as bio stimulant for improving yield and quality of black cumin oil. *Sci Rep* 11(1): 24217.
37. Budiastuti MTS, Purnomo D, Pujiasmanto B & Setyaningrum D (2023). Response of maize yield and nutrient uptake to indigenous organic

fertilizer from corn cobs. *Agric* 13(2): 309.

38. Mehmood A, Naveed K, Khan SU, Haq NU, Shokat MF, Iqbal M & Ali S (2022). Phytochemical screening, antioxidants properties and antibacterial efficacy of moringa leaves. *J of Xi'an Shiyou Uni, Nat Sci Ed* 18(10): 59-70.
39. Chinasho A, Bedadi B, Lemma T, Tana T, Hordofa T & Elias B (2023). Response of maize to irrigation and blended fertilizer levels for climate smart food production in Wolaita Zone, southern Ethiopia. *J of Agric and Food Res* 12: 100551.
40. Noor M, Nisa Basharat MA, Naveed K, Hussain R, Arif MS, Qadir G & Mehmood A (2024). Extraction techniques and purification methods: Precision tools for pure innovation. *Pure and Appl Biol* 14(2): 224-248.
41. Amin SE, Haq NU, Haider S, Shaukat MF, Arif A, Fareed A & Mehmood A (2021). Emergence and transboundry spread of lumpy skin disease in South Asian Countries: a review. *J of Xi'an Shiyou Uni, Nat Sci* 18(9): 517-545.
42. Zhu X, Chi R & Ma Y (2023). Effects of corn varieties and moisture content on mechanical properties of corn. *Agr* 13(2): 545.
43. Ayub M, Ahmad R, Nadeem MA, Ahmad B & Khan RMA (2003). Effect of different levels of nitrogen and seed rates on growth, yield and quality of maize fodder. *Pak J of Agric Sci* 40: 140-143.
44. Maqsood M, Shehzad MA, Sarwar MA, Abbas HT & Mushtaq S (2012). Impact of different moisture regimes and nitrogen rates on yield and yield attributes of maize (*Zea mays* L.). *Afr J of Biotechnol* 11(34): 8449-8455.
45. Ayub MU, Ayub Q, Khan SM, Khan MA, Ahmad S, Hussain I & Mehmood A (2022). Pre-storage application of ascorbic acid and salicylic acid to preserve quality of peach fruits during cold storage. *J of Pure and Appl Agric* 7(4): 73-89.
46. Zhang YM, Jun XUE, Juan ZHAI, Zhang GQ, Zhang WX, Wang KR & Li SK (2021). Does nitrogen application rate affect the moisture content of corn grains? *J of Integrative Agric* 20(10): 2627-2638.
47. Sokólski M, Załuski D & Jankowski K (2020). Crambe: seed yield and quality in response to nitrogen and sulfur—a case study in northeastern Poland. *Agr* 10(9): 1436.
48. Ayub Q, Hussain I, Naveed K, Ali S, Mehmood A, Khan MJ & Shehzad Q (2021). Responses of different okra (*Abelmoschus esculentus*) cultivars to water deficit conditions. *J of Hortic Sci* 16(1): 53-63.
49. Shah SU, Ayub Q, Hussain I, Khan SK, Ali S, Khan MA & Mehmood A (2021). Effect of different growing media on survival and growth of Grape (*Vitus Vinifera*) cuttings. *J Adv Nut Sci Technol* 1: 117-124.
50. Davies B, Coulter JA & Pagliari PH (2020). Timing and rate of nitrogen fertilization influence maize yield and nitrogen use efficiency. *Plos one* 15(5): e0233674.
51. Shahzad Q, Sammi S, Mehmood A, Naveed K, Azeem K, Ahmed Ayub MH & Shokat O (2020). 43. Phytochemical analysis and antimicrobial activity of adhatoda vasica leaves. *Pure and Appl Biol* 9(2): 1654-1661.
52. Ayub Q, Mehmood A, Hayat U, Shahzad Q & Ahmad S (2020). 7. Effect of salinity on physiological and biochemical attributes of different Brinjal (*Solanum melongena* L.) cultivars. *Pure and Appl Biol* 9(4): 2190-2198.
53. Khan MJ, Qasim Ayub IH, Mehmood A, Arif N, Mehmood S, Shehzad Q & Haq NU (2020). Responses of persimmon

(*Diospyros kaki*) fruits to different fruit coatings during postharvest storage at ambient temperature. *J of Pure and Appl Agric* 5(3).

54. Park CY, Kim YJ & Shin Y (2016). Effects of an ethylene absorbent and 1-methylcyclopropene on tomato quality and antioxidant contents during storage. *Hortic, Environ, and Biotechnol* 57: 38-45.
55. Mehmood S, Ayub Q, Khan SM, Arif N, Khan MJ, Mehmood A & Ayub MU (2020). Responses of Fig Cuttings (*Ficus Carica*) to different sowing dates and potting media under agro-climatic conditions of Haripur. *RADS J of Biol Res & Appl Sci* 11(2): 112-119.
56. Ayuba Q, Khana SM, Mehmood A, Haqc NU, Alia S, Ahmadd T & Shoukata MF (2020). Enhancement of Physiological and Biochemical Attributes of Okra by Application of Salicylic Acid under Drought Stress. *J of Hortic Sci and Technol* 3(4): 113-119.
57. El-Leithy AS, El-Hanafy SH, Khattab, ME, Ahmed SS & El-Ghafour A (2017). Effect of nitrogen fertilization rates, plant spacing and their interaction on essential oil percentage and total flavonoid content of summer savory (*Satureja hortensis* L.) plant. *Egy J of Chem* 60(5): 805-816.
58. Iqbal M, Naveed K, Ali R, Hussain R, Ahmed SS, Shaukat MF & Mehmood A (2023). Agronomic and nutritional evaluation of Groundnut crop as affected by moringa leaf extract and zinc application. *Pure and Appl Biol* 13(1): 82-92.
59. Mogren LM, Olsson ME & Gertsson UE (2006). Quercetin content in field-cured onions (*Allium cepa* L.): effects of cultivar, lifting time, and nitrogen fertilizer level. *J of Agric and Food Chem* 54(17): 6185-6191.
60. Prinsi B, Negrini N, Morgutti S & Espen L (2020). Nitrogen starvation and nitrate or ammonium availability differently affect phenolic composition in green and purple basil. *Agr* 10(4): 498.
61. Marlin M, Simarmata M, Salamah U & Nurcholis W (2022). Effect of nitrogen and potassium application on growth, total phenolic, flavonoid contents, and antioxidant activity of Eleutherine palmifolia. *AIMS Agric & Food* 7(3).
62. Kim YH, Hamayun M, Khan AL, Na CI, Kang SM, Han HH & Lee I (2009). Exogenous application of plant growth regulators increased the total flavonoid content in Taraxacum officinale Wigg. *Afr J of Biotechnol* 8(21).
63. Tustiyani I, Melati M, Aziz SA, Syukur M & Faridah DN. (2023). Pruning and additional fertilizer applications affect morphophysiological characters and flavonoid content of winged bean. *Ind J of Agr* 51(1): 54-64.
64. Ali N & Anjum MM (2017). Effect of different nitrogen rates on growth, yield and quality of maize. *Middle East J Agric Res* 6(1): 107-112.
65. Zhang L, Liang ZY, He XM, Meng QF, Hu Y, Schmidhalter U & Chen XP (2020). Improving grain yield and protein concentration of maize (*Zea mays* L.) simultaneously by appropriate hybrid selection and nitrogen management. *Field Crops Res* 249: 107754.
66. Yue K, Li L, Xie J, Liu Y, Xie J, Anwar S & Fudjoe SK (2022). Nitrogen supply affects yield and grain filling of maize by regulating starch metabolizing enzyme activities and endogenous hormone contents. *Front in Plant Sci* 12: 798119.