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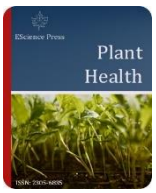

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Evaluation of Maize Cultivars in Varied Nitrogen Regimes within the Temperate Climate of Rawalakot

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ABSTRACT

Maize varieties differ in productivity with respect to different climatic conditions while nitrogen (N) fertilizer is also considered important affecting growth and grain yield of maize. It is important to determine the most suitable variety for a particular climatic area, so the present study was conducted to determine the performance of different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot, Azad Jammu and Kashmir. Three maize varieties (Azam, Hybrid variety and Kashmir Gold) and four nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) were evaluated using randomized complete block design with three replications. The nitrogen levels were kept in main plot while maize varieties were kept in sub plots. The results showed that yield and yield attributing traits of maize varieties increased with increasing level of nitrogen from 60 to 180 kg ha^{-1}. The hybrid maize variant demonstrates maximum plant height at 286 cm, leaf area index at 3.8%, cob length at 27.6 cm, and the number of rows per cob at 23 when nitrogen is applied at a rate of 180 kg N ha^{-1}. Additionally, the highest crude protein content, recorded at 15.7%, is observed for the hybrid maize variant with the application of 180 kg N ha^{-1}. Conversely, the highest levels of acid detergent fiber (29.6%) and neutral detergent fiber (49%) are noted for the hybrid maize variant under control conditions. This study recommended that maize production can be maximized by cultivating hybrid maize variety with the usage of 180 kg N ha^{-1} in temperate conditions of Rawalakot. The study on maize varieties in Rawalakot's temperate conditions reveals that varying nitrogen levels significantly impact performance. This insight emphasizes the importance of tailored nitrogen management for optimizing maize cultivation in the region.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crop cultivated throughout the world, belongs to family Poaceae and ranked third in cereals after wheat and rice. It is a short duration, quick growing and widely grown crop with high potential, there are no cereal crops with such an immense potentiality, so it is called as “queen of cereals” (Saudy and Mohamed El–Metwally, 2023). The

C4 crop maize is very nutritious, grows quickly, and produces a lot of biomass that may be used for food, feed, fibre, and forage. One of the most rich in nutrients crops, it has a greater amount of calories of dry matter, adequate proteins, minerals, and production of green feed per unit area to satisfy all the necessary essential qualities of silage (Pelloso et al., 2023).

The maize crop is extensively grown all year round in temperate, subtropical, and tropical parts of the world due to its greater flexibility under various agro-climatic conditions (Adhikari et al., 2023). Around the world, maize agriculture has greatly risen since the previous several decades. By 2050, the global production of maize will have doubled. In 2022, there was 197 million hectares under maize cultivation, yielding 1162 million tonnes globally. It is grown over an area of 1720,000 hectares in Pakistan and contributes 3.2% of the country's agricultural value addition and 0.7% of the country's gross domestic product. It produces 10.183 million tonnes annually (GOP, 2023). In Azad Jammu and Kashmir, it was grown on an area of 99.635 hectares with a yield of 1.82297 million tonnes (Bureau of Statistics AJK, 2020). Moreover, it was reported that 72% of maize's dietary components are starch, while 10% are protein. 4% fat, 8.5% oil and 9.5% fiber (Liu et al., 2023).

The most important macronutrient, nitrogen is a component of protoplasm, protein, and nucleic acids (Zhang et al., 2023). N is necessary for protein synthesis, cell differentiation, and cell division. N status, which makes up between 1 and 4 percent of the dry matter in plants, has a significant impact on physical processes change. The crop utilizes it to the greatest extent possible (Diédhiou et al., 2022). Nitrogen plays a crucial function in increasing the translocation of stored photoassimilates and nutritional absorption (Ariraman et al., 2020). It is an essential part of chlorophyll, which plants need to perform photosynthesis, or the process by which carbon dioxide and water are changed into sugars when they are exposed to light. It encourages biological processes in maize such water absorption, xylem movement, vacuole storage, and is a key regulator of grain yield. It contributes significantly to the amino acids, which are the fundamental constituents of proteins. Without proteins, plants wither and eventually perish. To increase grain yield, N fertilizer has frequently been administered excessively (Ansu et al., 2023). On growth and development, N fertilizer has a significant impact. According to Swamy et al. (2022) an increase in N causes the integrity of the kernel, which improves the grain's milling qualities. In the early phases of maize, N fertilizer has strong influence on growth and development. Increased supply of N causes integrity of kernel thus resulting in better milling properties of grain (Shrestha et al., 2018).

Maize varieties play a pivotal role in agriculture due to their adaptability to varying agro-climatic conditions. It encompass factors like temperature, rainfall, soil type and altitude, which differ significantly from one region to another. Different maize varieties have varying temperature requirements for optimal growth (Ibrahim et al., 2022). Some are more heat-tolerant, while others are adapted to cooler climates. By selecting the right maize variety, farmers can maximize their yield potential in their specific agro-climatic zone. They vary in their sensitivity to rainfall patterns. Some are drought-tolerant, thriving in regions with limited rainfall, while others are suited for high-rainfall areas (Kamsu et al., 2022). Matching the maize variety to the local rainfall pattern is essential for ensuring consistent yields. They can exhibit different soil preferences. Some thrive in well-drained soils, while others are adapted to waterlogged conditions. Selecting maize varieties that are well-suited to the soil type in a given region can improve crop performance and reduce the need for soil amendments. Maize varieties exhibit altitudinal preferences, with some being better suited to high-altitude regions and others to lowlands (Lai et al., 2022). This is critical in hilly or mountainous areas, where altitude can significantly impact growing conditions. Agro-climatic conditions can influence the prevalence of specific pests and diseases. Maize varieties with resistance or tolerance to locally prevalent pests and diseases can reduce the need for chemical interventions and enhance crop resilience (Coelho et al., 2020). So, maize varieties are a cornerstone of modern agriculture's adaptability to diverse agro-climatic conditions. By selecting the right maize variety for their specific region, farmers can optimize yields, reduce risks associated with adverse weather and contribute to sustainable and resilient agriculture. Research and development efforts in breeding maize varieties tailored to different agro-climatic conditions are essential for food security and agricultural sustainability worldwide.

The research aimed to identify an optimal maize variety and determine the ideal nitrogen level to enhance

productivity in Rawalakot. The primary focus was on addressing the constraints of the local environment to maximize maize production.

MATERIALS AND METHODS

Experimental design

The location had a latitude of 33.85 °N, a longitude of 73.76 °E, an altitude of 1638 meters, and an annual precipitation of approximately 700-800 mm. Prior to sowing, the field was prepared using a cultivator and then planked. The crop was planted with the recommended seed rate of 25 kg per hectare using the line sowing method, in plots measuring 2.5 meters by 2.5 meters. Each plot consisted of 4 rows with an inter-row spacing of 75 cm. The recommended amount of phosphorous (P_2O_5) fertilizer, 60 kg per hectare, was applied in the form of DAP. All cultural operations in the field were maintained consistent. The Experiment was laid out in randomized complete block design (RCBD) with split plot arrangement having three replications.

Varieties and treatments

Treatments comprised of three maize varieties (V_1 = Azam, V_2 = Hybrid variety and V_3 = Kashmir Gold) and four N levels N_0 = Control, N_1 = 60 kg ha^{-1}, N_2 = 120 kg ha^{-1} and N_3= 180 kg ha^{-1}.

Parameters studied

Data were gathered for various growth parameters, including plant height, leaf area index, cob length, and the number of rows per cob. Additionally, nutritional parameters such as crude protein, acid detergent fiber, and neutral detergent fiber were also documented. To determine plant height, five randomly chosen plants were selected, and their heights were measured by placing a meter scale from the base to the tip of the tallest leaf, with the average height calculated. The leaf area index was computed using the formula provided by Su *et al*., 2023. Cob lengths were measured using a measuring tape, and the average length was recorded. The data for the number of rows per cob were collected from five different cobs selected from each experimental plot. The number of rows on each cob was tallied, and the average count was recorded. The chopped fodder was separated into distinct samples and readied for the evaluation of nutritional aspects, including crude protein percentage, acid detergent fiber percentage, and neutral detergent fiber percentage, following established procedures (AOAC, 2012).

Statistical analysis

Statistical analysis was conducted using the "Statistix 8.1 version" software, as described by Coelho *et al*., 2020. To assess the significance of the treatment means, the Tukey's Honest Significant Test was employed at a 5% level of significance.

RESULTS AND DISCUSSION

The outcomes of study showed positive effect on the performance of various maize varieties under varying nitrogen levels in the temperate conditions of Rawalakot. The results provide valuable insights into how nitrogen application influences maize growth and yield in this specific agro-climatic setting. We have analyzed a range of agronomic and physiological parameters to assess the response of different maize varieties to nitrogen levels.

The hybrid maize variety produces maximum plant height (286 cm) using N3 treatment that was 180 kg ha^{-1}. The data suggest a trend of increasing values from N0 to N3 for each variety, and the overall mean values indicate a progressive increment across the levels (Table 1). Similarly, maximum leaf area index (3.8 %) was observed in hybrid maize variety using 180 kg ha-1 nitrogen (Table 2) while minimum leaf area index was recorded in Azam variety using 60 kg ha^{-1} nitrogen that was 1.4% as compared with control (0.9%).

Moreover, cob length progressively increased with increased nitrogen dose, indicating a positive response to higher nitrogen levels. Hybrid maize exhibited maximum cob length 27.6 cm using maximum level of nitrogen as compared with control (20.6 cm) (Table 3). The findings suggested that higher nitrogen application positively influenced the cob length of all three varieties as compared with control, showcasing the importance of nitrogen management in optimizing maize production.

Again on number of rows cob^{-1} across all varieties, there is a consistent positive correlation between nitrogen levels and the number of rows per cob. But maximum rows cob^{-1} that was 23 observed in hybrid maize variety with the application of nitrogen @ 180 kg N ha^{-1} as compared with control (Table 4).

Similarly, the highest crude protein, acid detergent fiber and neutral detergent fiber was recorded hybrid maize variety with the application of 180 kg ha^{-1} nitrogen that was 15.7 %, 29.6 % and 49% respectively as compared with the control (Table 5).

Table 1. Effect on plant height (cm) on different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot.

Varieties	Control	60 kg/ha	120 kg/ha	180 kg/ha	Mean
Azam	166.6h	176.3gh	218.3de	236.6bc	199.5C
Hybrid maize	193.0fg	221.0cde	260.0b	286.6a	240.1A
Kashmir Gold	177.3gh	206.0ef	234.3cd	252.3b	217.5B
Mean	179.0D	201.1C	237.5B	258.5A	

Table 2. Effect on leaf area index (%) on different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot.

Varieties	Control	60 kg/ha	120 kg/ha	180 kg/ha	Mean
Azam	0.9h	1.4g	1.7ef	2.4d	1.6C
Hybrid maize	1.5fg	2.2d	3.2b	3.8a	2.6A
Kashmir Gold	1.2gh	1.8e	2.3d	2.8c	2.0B
Mean	1.2D	1.8C	2.4B	3.0A	

Table 3. Effect on cob length (cm) on different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot.

Varieties	Control	60 kg/ha	120 kg/ha	180 kg/ha	Mean
Azam	14.0i	16.0hi	18.6fg	22.3cde	17.7C
Hybrid maize	20.6efg	23.3bcd	25.0b	27.6a	24.1A
Kashmir Gold	16.0i	18.3gh	21.0def	24.3bc	19.9B
Mean	16.8D	19.2C	21.5B	24.7A	

Table 4. Effect on rows cob^{-1} on different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot.

Varieties	Control	60 kg/ha	120 kg/ha	180 kg/ha	Mean
Azam	12.0I	13.6GH	15.3EF	18.3CD	14.8C
Hybrid maize	17.0DE	19.0C	21.0B	23.0A	20.0A
Kashmir Gold	12.6HI	14.6FG	17.0DE	20.0BC	16.0B
Mean	13.8D	15.7C	17.7B	20.4A	

Table 5. Effect on nutritional parameters on different maize varieties under varying nitrogen levels in temperate conditions of Rawalakot.

Varieties	Control	60 kg/ha	120 kg/ha	180 kg/ha	Mean
Crude protein (%)					
Azam	6.533h	8.4fg	10.633de	12.333bc	9.4C
Hybrid maize	8.133g	10.567de	12.633bc	15.767a	11.7A
Kashmir Gold	7.767gh	9.633ef	11.467cd	13.467b	10.5B
Mean	7.4D	9.5C	11.5B	13.8A	
Acid detergent fiber (%)					
Azam	29.667b	26.333de	22.333f	18g	24.0C
Hybrid maize	34.333a	29.333bc	27d	23.833f	28.6A
Kashmir Gold	30b	27.233cd	24.333ef	19.667g	25.3B

Mean	31.3A	27.6B	24.5C	20.4D	
Neutral detergent fiber (%)					
Azam	45.667bc	42def	39.667def	36.667gh	41B
Hybrid maize	49.667a	39.667efg	35.667h	31.667i	37C
Kashmir Gold	43bcd	46b	42.333cde	39fgh	44A
Mean	46.1A	42.5B	39.2C	35.7D	

The highest plant height and leaf area index seen in hybrid maize variety could be due to better genetic variation, nitrogen availability and environmental influences. Genetic diversity within maize varieties influences their inherent growth traits, with some naturally taller and others shorter. Our results were in agreement with Ibrahim et al. (2022) and Dai et al. (2015) who stated that a combination of genetic, nutritional, and environmental factors determines plant height variations observed among maize varieties in temperate conditions. Similarly, more cob length and rows cob^{-1} depicted by hybrid variety could be due to influenced by genetic diversity while better utilization of environmental conditions, such as temperature and moisture, affect their development. Better nutrient availability also results in improved and well-formed cobs with increased number of rows. So due to better genetic makeup and suitability of hybrid maize variety results in higher cob length and rows cob^{-1}. These findings were similar with Mahmood et al. (2022) and Kamsu et al. (2022).

Our results are parallel with the previous findings of Irfanullah et al. (2023) that the SGS-2002 variety demonstrated its highest values in various agronomic and quality traits when subjected to 150 kg ha-1 of nitrogen fertilization. The measurements at this level included a plant height of 271 cm, leaf area of 3894.7 cm2, thousand grain weight of 286 g, biological yield of 16888 kg ha-1, grain yield of 4930 kg ha-1, crude protein content of 14.7%, and ash content of 9.8%. Overall, nitrogen fertilization played a significant role in enhancing both the yield and quality characteristics of maize for the SGS-2002 variety.

Similarly, the results of current study was aligned with the previous findings of Jamil et al. (2021) that the oats cultivar exhibited superior performance in terms of fresh weight, dry weight, and leaf area per plant. Triticale crop showed higher crude protein contents at the N3 level when molasses was utilized, observed consistently across both years and cutting stages (booting and milking dough). Barley crop recorded higher crude fiber levels under nitrogen fertilization control at both booting and milking dough stages.

The highest crude protein observed in hybrid maize variety could be due to better suitability of the variety along with an increased nitrogen supply as nitrogen being an active ingredient of protein and building block of amino acid. As amino acid concentration increases ultimately the protein content also increases. These conclusions were in accordance with Memon et al. (2011) and Ning et al. (2019) who also stated similar results. ADF and NDF were recorded highest in hybrid maize variety at control could be attributed to the proportion of cellulose and lignin in the plant material, which makes up the structural components of the cell wall. When nitrogen levels are low, plants tend to allocate more resources to lignin production, which increases the ADF content. These findings were in accordance with Pelloso et al. (2023) and Ibrahim et al. (2022) who stated that varying nitrogen levels in maize varieties can influence ADF and NDF content due to their impact on cell wall composition, protein content, and plant growth. Low nitrogen levels tend to increase ADF by promoting lignin production.

CONCLUSION AND RECCOMENDATION

The study unequivocally establishes that superior agronomic and quality attributes were consistently observed when nitrogen (N) application rate of 180 kg N ha^{-1} was employed in conjunction with a hybrid maize variety. This key finding underscores the pivotal role of nitrogen in influencing both crop productivity and quality attributes in temperate conditions of Rawalakot. It is strongly recommended that maize growers in the region adopt a nitrogen application rate of 180 kg N ha^{-1} in combination with the hybrid maize variety.

CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

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