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IMPACT OF DIFFERENT NUTRIENT TREATMENTS ON GROWTH ATTRIBUTES OF CHILI GENOTYPES UNDER POLY TUNNEL CONDITIONS

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Abstract
Chili (Capsicum annuum L.) is an important vegetable and spice crop cultivated widely in tropical and subtropical regions. The growth and yield of Chilli are influenced by several factors, particularly genotype and nutrient availability. Therefore, the present research work was conducted to evaluate the effects of different dose rates of three essential nutrients: nitrogen (N), phosphorus (P) and potash (K) on growth responses of two chili varieties, desi and super king, under poly tunnel conditions. NPK were tested at four dose rates: T_1- Half dose of recommended NPK, T_2-Recommended dose of NPK, T_3- 3/2 dose of recommended NPK and T_4- Double dose of recommended NPK. Data regarding various growth including plant height, leaves per plant, shoot length and flowers per plant for each of the genotype were recorded. Results showed that highest leaves per plant (84.67 leaves) were enumerated in case of T_4 treatment of NPK in case of super king genotype of chili while the lowest leaves count (51.80 leaves) were of desi chili. In case of plant height, the values were 112.33 cm and 49.46 cm, respectively with T_4 treatment. Maximum flowers (62.000 flowers/plant) were recorded in case of super king genotype with T_4 while minimum flowers (19.00 flowers/plant) in case of desi genotype with T_1 treatment of NPK. The values were 81.667 cm with T_4 and 32.67 cm with T_1 in case of shoot length of super king and desi genotypes, respectively. Overall results revealed that ratios of NPK nutrients affected the growth characteristics of chili genotypes and recommended dose rate of NPK proved more promising regrading enhancing the chili growth attributes than the other dose rates of NPK.

INTRODUCTION

Chili (*Capsicum annum L.*) member of nightshade family "Solanaceae". There are about 25 varieties are commonly cultivated throughout the world. The plant of Chilli is usually bushy 60-80cm high (Hussain *et al.*, 2011). It is widely cultivated crop known for their pungency, flavor, and nutritional benefit. Chilli, also called "Mirch". Originated from Peru, América. Chilli has been naturalized over five times by ancient cultures across Southern, Central, and Northern America (Mullett *et al.*, 2024). The genus "Capsicum" comprises five distinct species: *Capsicum annuum*, *Capsicum frutescens*, *Capsicum chinense*, *Capsicum pubescens*, and *Capsicum baccatum* Carvalho *et al.*, 2014). These species come in various varieties; for

example, C. *annuum* contains jalapenos, wax, and cayenne, among other ingredients. There are three types of capsicum frutescens: tabasco, piri piri, and malagueta. C. *chinense* comes in the varietals datil, habanero, and naga. On the other hand, American aji and American rocoto variants comprise C. *baccatum* and C. *pubescens* (AL-Anbari *et al.*, 2024).

Around the world, 1.98 million hectares are used to grow the vegetable crop chilli. Globally green chilli annual production is 35.13 million tons (Bindu *et al.,* 2021). Top green chilli producing nations include China, Mexico, Turkey, Indonesia, Spain, the United States of America, Nigeria, Egypt, Algeria, and Tunisia. China leads as the largest producer with an annual output of 17.79 million tons, followed by Mexico at 3.29 million tons annually. For dry pepper production, India, Thailand, China, Ethiopia, Cote Delvoire, Pakistan, Bangladesh, Myanmar, Ghana, and Vietnam are the top producers. India holds the highest position with an annual production of 2.09 million tons, Thailand on second number with 0.34 million tons annually. Pakistan ranks among the top twenty countries globally in terms of green chilli production. In dry pepper production, Pakistan holds the fourth position, cultivating over an area of 65.1 thousand hectares with an annual output of 148.13 thousand tons (Aslam et al., 2022).

Kunri, located in Sindh, serves as a central hub for chilli cultivation and was formerly recognized as the "Chilli Capital of Asia" (Roche *et al.,* 2016). The average yield of chilli in Pakistan is approximately 1.6 tons per hectare, which is slightly lower compared to other countries. However, Pakistan still holds significant potential for chilli export, with an estimated capacity to export 90 thousand tons annually. The species name "annuum," derived from Latin, translates to "annual." However, the chilli plant is not strictly an annual; rather, it is highly sensitive to frost. It exhibits characteristics of a perennial herb and can thrive across multiple seasons, particularly in environments without winter frost (Yasuor *et al.,* 2020).

Chilli plants are susceptible to significant damage when exposed to temperatures ranging from 0 to 15°C, while they thrive best within an optimal temperature range of 24 to 28°C for growth and development. Featuring dense, branched stems reaching heights of about 60 cm, chilli plants bear off-white flowers and produce berries initially green in color, which turn red upon ripening. Additionally, these fruits may display hues of yellow, red, orange, or various other colors. Chilli plants demonstrate heightened productivity in regions characterized by dry and warm climatic conditions (Hasanuzzaman *et al.*, 2013).

In Sindh province, hot pepper farming predominated, whereas in Punjab province, bell pepper cultivation accounted for more than half of the land. Since only 85% of the world's chilli pepper crop is cultivated in Sindh, the province's Kunri district is home to Asia's largest chilli market, Sindh is renowned for its spices, sauces, and pickles. In the case of NWFP, bell peppers predominated over spicy peppers, while both varieties were grown in the province's northern regions, particularly in Malakand Agency and district Swat. Due to the cultivation of hot chilli varieties on larger acreage in the province's southern regions (Karak, Kohat, and D.I. Khan), Bannu and D.I. Khan's hot spice and condiment quality are well-known across the region (Hussain *et al.,*2009).

The heat and pungency found in chilli are attributed to various biochemical and antioxidant compounds, with capsaicin being the most notable among them. The quantity of capsaicin varies across different chilli varieties. Chilli plants experiencing water stress tend to produce particularly potent pods, with the concentration of capsaicin increasing in these instances. Interestingly, capsaicin serves as a defensive mechanism against mammals and microbial organisms, including the fusarium fungus, which can be harmful to certain pepper species. Chilli plants elevate capsaicin levels as a response to fungal attacks, although birds are unaffected by this pungency Additionally, capsaicin acts as a protective agent against insect pests and molds. This characteristic has been harnessed by humans

for both medicinal purposes, treating various infectious diseases, and for food preservation (Ziglio and Goncalyes, 2014). However, chilli fruit yield in our region falls short compared to other chilli-growing areas worldwide. One of the main reasons for this low production is irregular nutrient management, where insufficient attention is paid to the proper application of various nutrients in the required quantities.

Some other factors those effect chili production is climate change, rainfall etc. The effects of climate change in global temperatures have changed the timing and volume of rainfall, the availability of water, and the frequency with which weather extremes like drought and floods occur (Bhutia *et al.*, 2018). Kumar and colleagues used monthly data set spanning 135 years (1871-2005) for 30 sub-divisions (sub-regions) of India to study the monthly, seasonal, and yearly changes of rainfall. There was significant diversity in the sub-divisional rainfall trends. In almost half of the subdivisions, the yearly rainfall trended upward, whereas the other half exhibited the reverse pattern. In addition to having detrimental effects on crop growth and development, the dry state negatively impacts seed germination.

In the field of statistics, a full factorial experiment is one in which the experimental units encompass all conceivable permutations of the discrete potential values or "levels" for each of the two or more factors in the design (Freiesleben *et al.*, 2020). The proposed study WAS carried out to evaluate the effects of different dose rates of NPK on growth related attributes in two chili varieties.

MATERIALS AND METHODS

This experiment was conducted in the Depalpur Okara research area of the University of Agriculture Faisalabad sub-campus. The goal of the current study was to determine how well certain chili cultivars cultivated in poly tunnels absorbed nutrients. Pots that were 0.5 feet broad and 1.5 feet height were used for this experiment under the high tunnel. Super King and Desi chili variants were gathered from reputable sources. After the containers were filled, the chili seedlings were moved into a tall tunnel. Pots were positioned within the tunnel's grooves. On both types, the NPK application response was examined. There were four replications of every fur treatment applied. Two Chili varieties: Desi and Super king were sown in pots and Urea, Single super phosphate, Murata of potash were applied.

Table 1. Treatments description

Treatments	Dose	Concentration
T1	Half dose of recommended NPK	32-15-15 kg ha^{-1}
T2	Recommended dose of NPK	65-30-30 kg ha^{-1}
T3	3/2 dose of recommended NPK	97.5-45-45 kg ha^{-1}
T4	Double dose of recommended NPK	130-60-60 kg ha^{-1}

T= Treatments

Observations

Plant Height (cm):

In each treatment, five plants of each variety were tagged, and the height of each plant was measured using a measuring tape that was placed on the soil at the base of the plant and extended to the plant's tallest growing point.

No. of leaves/plant:
Five randomly chosen plants from each variety in each treatment were counted for the number of leaves on each plant, and average values were computed.

Shoot length (cm):
Plant shoot length was measured using a measuring tape by placing it on the plant stem and measuring up to the tallest growing point. Five plants from each variety in each treatment were tagged.

Flowers/plant:
Five plants from each variety were tagged, the quantity of blooms on each plant was counted, and average values were determined.

Experimental Design and Statistical Analysis
The Factorial Completely Randomized Design was followed in the layout of the experiment. The gathered data were examined statistically. The technique of analysis of variance was used to determine the data's overall significance. The Least Significant Difference (LSD) Test is used to examine the differences between treatment means (Steel *et al.*,1997) was used.

Least significant Difference
Fisher created the first pairwise comparison method, known as the least significant difference (LSD) test, in 1935. Use of this method is restricted to cases where the ANOVA F omnibus is important. The primary goal of the LSD is to determine the significance of any difference greater than the LSD by computing the lowest significant difference (also known as the LSD) between two means as if these means had been the only ones to be compared (Williams and Abdi (2010).

RESULTS AND DISCUSSION

The highest mean plant height was observed in Treatment 4 (T4) with the Super King variety, which aligns with the findings of previous studies that emphasize the importance of genotype in determining plant height (Marschner, 2015). Taller plants generally have a competitive advantage for light interception, which is critical for photosynthesis and growth (Jones, 2016). The controlled environment of the poly tunnel likely provided optimal conditions for height growth, minimizing stress factors such as wind and temperature fluctuations that can affect plant height (Ozturk *et al.*, 2018). The stable conditions in the poly tunnel ensure that plants can fully exploit their genetic potential for height growth. The Super King variety exhibited superior height growth compared to the Desi variety, with Treatment 4 showing the highest mean height. This indicates that genetic factors play a significant role in determining plant height, and the poly tunnel environment supports optimal growth conditions.

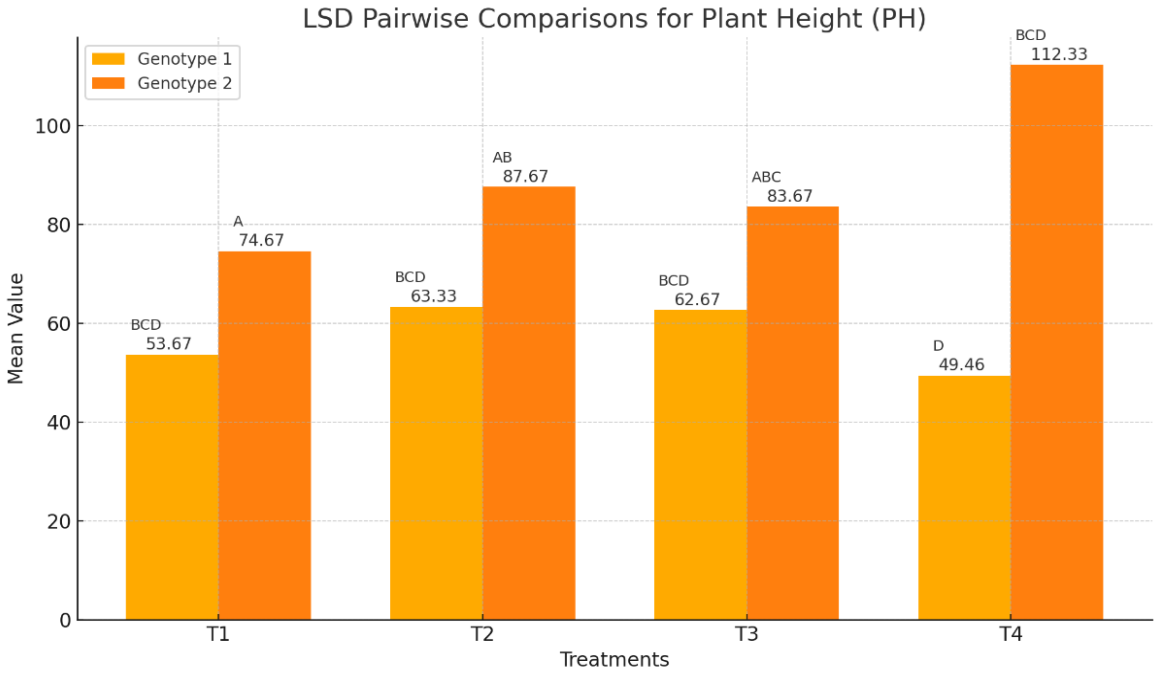


Figure 1. Effect of nutrient absorption on Plant Height of Chilli grown under poly tunnel.

The analysis of variance for the number of leaves per plant (NL) indicates no significant differences among the treatments (P = 0.6076). This suggests that the different nutrient regimes did not significantly impact the number of leaves of the chili plants. However, the genotype factor showed marginal significance (P = 0.1033), indicating a potential difference between the Desi and Super King varieties. Although no statistically significant differences were observed, Treatment 4 (T4) with Genotype 2 (Super King) had the highest mean number of leaves, suggesting that this combination may be more favorable for leaf production. This finding aligns with previous research that highlights the importance of nutrient balance in enhancing vegetative growth (Oliveira *et al.*, 2016). Leaf number is a critical factor in determining the photosynthetic capacity and overall growth of the plant, as it affects light interception and photosynthesis efficiency (Marschner, 2015). The controlled environment of the poly tunnel likely contributed to the overall leaf number by maintaining optimal growing conditions and reducing environmental stressors (Ozturk *et al.*, 2018). Poly tunnels provide a stable microclimate, which can mitigate the impact of external environmental factors such as temperature fluctuations and wind, leading to more consistent growth across different treatments (Kumar *et al.*, 2017). While the differences in leaf number were not statistically significant, the higher leaf number in the Super King variety under Treatment 4 suggests that this combination may offer advantages in terms of vegetative growth. This supports the hypothesis that balanced nutrient applications, combined with controlled environmental conditions, can enhance plant growth and productivity.

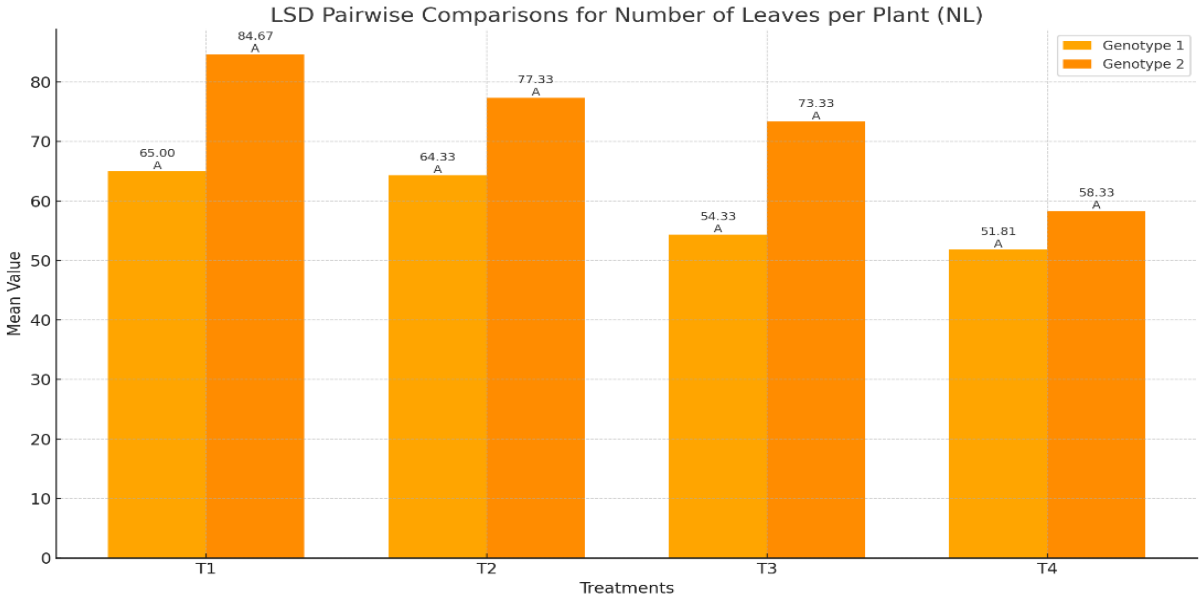


Figure 2. Effect of nutrient absorption on number of leaves per plant of chilli grown under poly tunnel

Results (Fig. 3) reveals that treatment 4 (T4) with Genotype 2 (Super King) had the highest mean number of flowers, indicating that this combination was most effective in promoting flower production. Previous studies have shown that balanced nutrient regimes can enhance reproductive growth and increase the number of flowers (Oliveira *et al.*, 2016). Adequate nutrient supply is essential for the development of reproductive organs, which directly influences the number of flowers and potential yield (Marschner, 2015). The poly tunnel environment likely provided optimal conditions for flowering by maintaining stable temperatures and humidity levels, which are crucial for the reproductive development of chili plants (Ozturk *et al.*, 2018). Controlled environments help in reducing stress factors that can negatively impact flowering, ensuring better flower production. The Super King variety under Treatment 4 exhibited the highest number of flowers per plant, indicating its superiority in reproductive growth. This suggests that balanced nutrient applications and stable environmental conditions are crucial for maximizing flower production in chili plants.

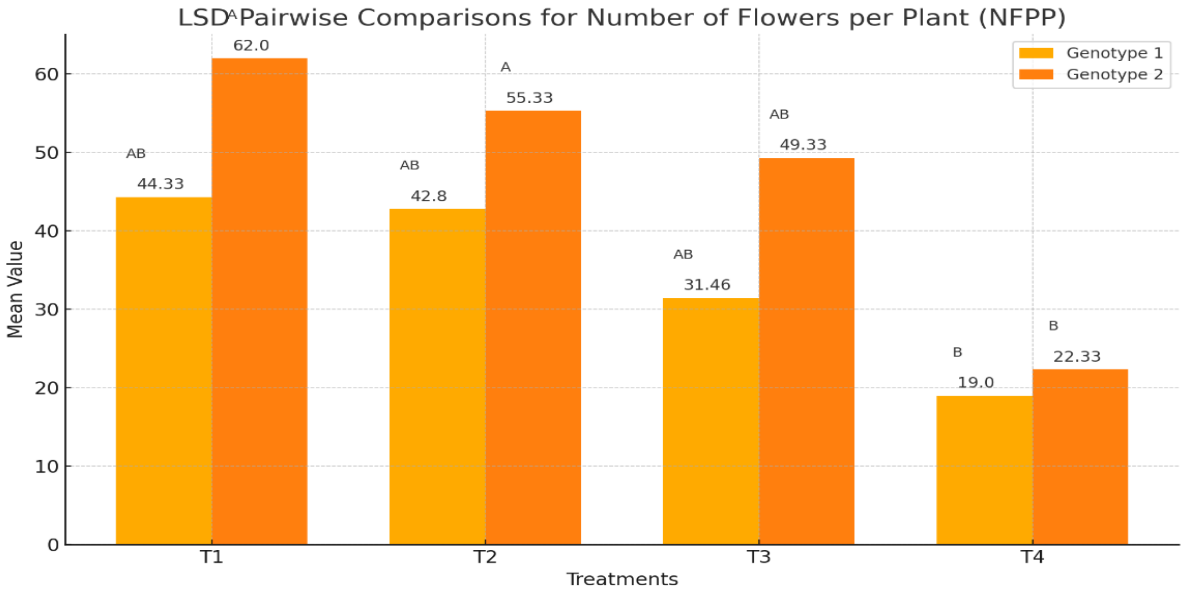


Figure 3. Effect of nutrient absorption on number of flowers per plant of chilli grown under poly tunnel

The analysis of variance for shoot length (SL) indicates no significant differences among the treatments (P = 0.6723). This suggests that the different nutrient regimes did not significantly impact the shoot length of the chili plants. Both Desi and Super King varieties exhibited similar shoot lengths across all treatments, indicating that the baseline conditions provided in the poly tunnel were sufficient for optimal vegetative growth. Previous studies have shown that the controlled environment of poly tunnels can minimize the effects of external stressors, leading to consistent shoot growth among different treatments (Ozturk *et al.*, 2018). Additionally, the nutrient levels provided were likely adequate to meet the plants' growth requirements, resulting in no significant differences in shoot length (Kumar *et al.*, 2017). Optimal nutrient management in controlled environments like poly tunnels has been shown to support uniform vegetative growth, including shoot elongation (Marschner, 2015). Therefore, it is clear that the poly tunnel environment played a significant role in ensuring uniform shoot growth across all treatments. Both Desi and Super King varieties responded similarly to the nutrient regimes, indicating that the poly tunnel conditions were conducive to maintaining consistent vegetative growth.

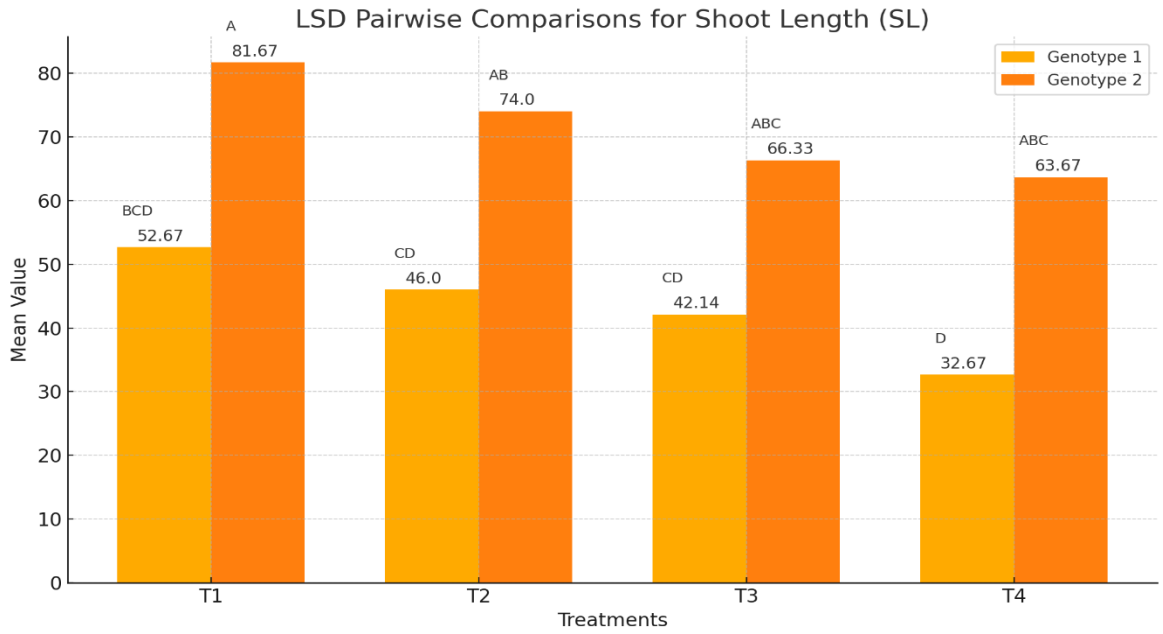


Figure 4 Effect of nutrient absorption on shoot length of chilli grown under poly tunnel

Conclusion

Overall, the study confirms that proper nutrient management plays an important role in improving chilli growth under controlled poly tunnel conditions. The Super King genotype showed better adaptability and growth potential compared with the Desi genotype. Although higher NPK doses produced maximum values for several growth attributes, the recommended dose of NPK was considered more promising and economical for improving chilli growth. Therefore, balanced application of NPK fertilizers, together with the selection of suitable genotypes, can contribute to improved growth and productivity of chilli under poly tunnel conditions.

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