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Influence of Varying Nitrogen and Potassium Levels on the Agronomic Performance of Chili (*Capsicum annuum* L.)

Darwish Mohammad Omer[1*], Ghafari Sayed Rahim[2] and Faqiri Ghulam Maruf [1]
[1]Department of Horticulture, Faculty of Agriculture, Ghazni University, Ghazni, Afghanistan
[2]Department of Agronomy, Faculty of Agriculture, Ghazni University, Ghazin, Afghanistan

*Corresponding author: omerdarwish153@gmail.com

ABSTRACT
The present study was conducted in 2023 to evaluate the effect of nitrogen and potassium on the growth and yield of chili crop through a randomized completely block design with three replications. The experimental design contained twelve treatment combinations, namely, four nitrogen doses (0, 45, 90, and 135 kg/ha) and three potassium dosages (0, 25, and 50 kg/ha as basal). Nitrogen was applied in two splits (transplanting and first picking) at a dose of 45 kg/ha, and in three splits (transplanting, first, and third picking) at doses of 90 and 135 kg/ha. Compared to the other nitrogen rates, 135 kg/ha of nitrogen produced superior growth and yield-contributing parameters such as plant height (81.4 cm), number of branches per plant (4.80), number of leaves per plant (37.22), leaf area index (1.404), fruit length (6.20 cm), fruit diameter (0.64 cm), number of fruits per plant (70.2), average fruit weight (2.8 g), and weight of fruit per plant (201.0 g). With respect to potassium, the application of 50 kg K_2O ha^{-1} produced comparatively higher plant growth parameters, including plant height (78.8 cm), number of branches per plant (4.77), number of leaves per plant (36.25), leaf area index (1.375), fruit length (5.88 cm), fruit diameter (0.60 cm), number of fruits per plant (68.0), average fruit weight (2.8 g), and fruit weight per plant (188.8 g). In addition, the application of 135 kg of N/ha and 50 kg of K_2O/ha in chili resulted in increased production of green and red ripe fruits, which were 11.07 tons/ha and 10.71 tons/ha, respectively. In conclusion, the study recommends applying 135 kg of nitrogen in three splits and 50 kg of K_2O at base application per hectare for chili production in Ghazin province.

Keywords: Chili, growth, nitrogen, potassium, yield

INTRODUCTION
Chili (*Capsicum annuum* var. annuum L.), also known as spicy pepper, belongs to the Nightshade family (Solanaceae) and is usually called "chili" in Southeast Asia. It is one of the most important economic and agricultural vegetables in the world in terms of cultivation, production, commercial value, and consumption (FAOSTAT, 2020). Red pepper is known as the third most important product in the family of Nightshade after tomatoes and potatoes (Dubey *et al*., 2017). This crop is cultivated in various countries, including Afghanistan (Gulab *et al*., 2019). The main areas of red pepper production are in warm and humid areas with temperatures between 18 and 30 ° C (Khaitov *et al*., 2019). Significant production areas include the Yangtze River Basin in China, Chihuahua in Mexico, and the Black Sea region in Türkiye (Tang *et al*., 2023). According to the World Health Organization's global strategy on diet, physical activity and health, adults should consume at least 400 grams of fruits and vegetables daily (Cammarano *et al*., 2022). Green pepper is particularly nutritious, with 100 grams containing 564 mg potassium (K), 25-49 mg phosphor (P), 10 mg magnesium (Mg), 10-16 mg calcium (Ca), and 0.7 -1.4 mg of iron (Fe) absorbed from the soil (Agheli, 2005). In recent years, the focus has increased on the production of red pepper due to its various health benefits, including vitamins E and C, provitamin A, dietary fiber, capsaicin, and other bioactive compounds (Baenas *et al*., 2019). Red pepper is widely recognized for its therapeutic benefits and drug quality, including increased blood circulation and regulation of blood pressure and cholesterol levels. Therefore, they may be useful for heart disease (Saleh *et al*., 2018). In addition, red pepper can reduce the rate of cancer and heart disease (Kaur *et al*., 2022). Red pepper, well- known for their flavors, pungency, spices, and pleasant aroma, are a staple in many

culinary traditions. In addition to being used as a spice, red pepper fruits are also used to make oleoresin and red pepper powder, used in medicinal formulation. Chili peppers are very important in Afghanistan's gardening because they can be resistant to hot and dry conditions and have less post -harvest losses than other fleshy-fruited crops. They are eaten in Afghanistan as fresh fruits or spices in the form of dried red powder (Alan Walters). Since red pepper plants short life and shallow root structure, nutrients produced by fertility in open-field cultivation are sometimes a short fall from what vegetables need (Liu *et al*., 2012; Tei *et al*., 2020). As a result, reducing performance can occur without the use of extra fertilizer. However, excessive fertility in the fields can have harmful effects on plant growth, including lower agricultural efficiency, and cause significant nutrient contamination (Le Tian, 2017). Fertilizer management should be maximized and adapted with local conditions to protect the environment and provide food security, especially in terms of nutrition. Clay loam or silt soils with well drainage are ideal for the growth of chili pepper (Khan *et al*., 2014). Numerous experiments around the world have shown that the use of commercial fertilizers is profitable, highlighting the significance of choosing the appropriate fertilizer for the best possible crop growth and development. The performance of the crop improves and the availability of vital nutrients is guaranteed using appropriate fertilizer mixture. However, many farmers often choose low-yielding indigenous cultivars, indicating that better fertilization and cultivation methods are needed. The availability of nutrients in the soil is one of several factors that affect the growth and function of chili plants. The growth of the plant depends strongly on the nutrients, each performing a specific physiological and biochemical functions. Fertilizer or manure can be applied to the soil to increase its nutrient content. If the soil nutrients are not replenished, the crop yields will ultimately decrease. Nitrogen and potassium are two of the most important nutrients for plant growth, development and production. Although previous studies have examined the effects of these nutrients on various crops, there has been limited research has been done specifically on red pepper cultivation in Afghanistan. Therefore, the purpose of this study is to investigate how nitrogen and potassium, both separately and in combination, affect chili development and yield. When nitrogen is given in suitable values, it promotes initial meristematic activity and cell division and is essential for the construction of proteins and protoplasm (Singh & Kumar, 1999). Nitrogen, as one of the essential components of vegetable production, has a major impact on red pepper agriculture through its effects on fruit quality, flower development and total yield. Nitrogen application in chili pepper has been shown to improve plant growth parameters, leaf color, and nutritional value and overall production (Alhrout, 2017). Nitrogen is the most essential macronutrient for optimal plant growth as it is an essential component of all amino acids in proteins and lipids and is also essential for the structural organization of cells and chloroplasts (Uddin, 2003). However, excessive nitrogen application may lead to physiological problems, environmental pollution, and uneconomical practices (Islam *et al*., 2018). Cultivated soils in Afghanistan are often low in fertility, especially in terms of nitrogen, hence nitrogen fertilizers are required. Since potassium supports various functions such as photosynthesis, enzyme activity, water uptake and flow, stomatal regulation, and stress tolerance, it is essential for the growth of all plants, including red pepper plants. Sufficient potassium supplementation can improve fruit quality overall, as well as yields, fruit size, ascorbic acid levels, and shelf life. However, little is known about the use of fertilizers for chili crops in Afghanistan, w highlighting the need for region-specific research and agricultural practices (Gulab *et al*., 2019). While increasing fertilizer rates may increase fruit yield, cautious management is necessary to avoid detrimental effects on financial returns and nutrient use efficiency

(Ayodele *et al*., 2015). In order to provide useful advice to farmers on nutrient management and cultivation methods, this study attempts to determine the exact nitrogen and potassium requirements for chili cultivation. Improved fruit quality and yield of red pepper are among the anticipated outcomes of this study, which will ultimately benefit the Afghan farming community. The experiment was conducted in Ghazni province, Afghanistan, at the Faculty of Agriculture's farm at Ghazni University.

MATERIALS AND METHODS

This study was conducted in 2023 at the Research Farm of the Faculty of Agriculture, University of Ghazni, Ghazni, Afghanistan. In this study, the cultivar " Kadrucing" was used as the plant material. The experiment was conducted in three replications in a randomized complete block design (RCBD). Furrow irrigation system was used for crop irrigation and standard cultural practices including weeding and hoeing were carried out regularly. In the experiment, twelve treatment combinations were formulated through a factorial arrangement of three potassium levels (0, 25, and 50 kg K_2O ha^{-1} as basal application) and four nitrogen levels (0, 45, 90, and 135 kg N ha^{-1}). Potassium sulfate containing 50% K_2O was used as the source of potassium fertilizer, and the amount of pure K_2O per plot was calculated based on the treatment requirements. Similarly, urea was used as the nitrogen source, and the corresponding amount of pure nitrogen per plot was determined according to each treatment. The treatments were designated as T_1 = 0N + 0K, T_2 = 0N + 25K, T_3 = 0N + 50K, T_4 = 45N + 0K, T_5 = 45N + 25K, T_6 = 45N + 50K, T_7 = 90N + 0K, T_8 = 90N + 25K, T_9 = 90N + 50K, T_{10} = 135N + 0K, T_{11} = 135N + 25K, and T_{12} = 135N + 50K, where N and K represent nitrogen and potassium in kg ha^{-1}, respectively. Depending on the application rate, nitrogen was splits of 45 kg/ha (at transplanting and the first picking) and three splits of 90 kg/ha and 135 kg/ha (at transplanting, the first picking, and the third picking). ANOVA method was used for statistical analysis. The research focused on growth-related parameters, which included measuring plant height at 30, 60, and 90 days after transplanting, counting the number of branches per plant, counting leaves per plant, and evaluating leaf area index, in addition to yield-related parameters such as fruit length, fruit diameter, average fruit weight, number of fruits per plant, fruit weight per plant and yield of green fruits.

The economically optimum dose of nitrogen or potassium fertilizers was determined using a quadratic response equation, which describes the relationship between fertilizer level and green fruit yield as follows:

$$Y = a + bx + cx^2$$

where:

Y = green fruit yield (kg ha^{-1}),

x = level of nitrogen or potassium fertilizer applied (kg ha^{-1}),

a, b, and *c* = constants of the quadratic response equation.

Based on this relationship, the optimum fertilizer dose was calculated using the following expression:

$$Optimum\ dose = \frac{\left(\frac{q}{p}\right) - b}{2c}$$

where:

b and c = constants derived from the quadratic response function,

q = cost per unit of nitrogen or potassium fertilizer,

p = market price per unit of green fruit yield.

This equation provides an estimate of the fertilizer rate that yields the maximum economic return, ensuring an optimal balance between the cost of fertilizer application and the resulting increase in crop yield.

RESULTS AND DISCUSSIONS

Plant height

One of the important factors that indicates the health of the plant is the height. Table 1 shows how several treatments affected the height of red pepper plants 30, 60 and 90 days after transplanting. According to the observations, the plant height increased simultaneously with the increase in nitrogen (N) and potassium (K) levels as nutrition levels increase. After 30, 60 and 90 days after transplanting, the highest height was measured with the application rate of 135 kg nitrogen per hectare, which was significantly higher than the other treatments. However, at these intervals, the control group showed the lowest plant height. Plants treated with 45 and 90 kg nitrogen per hectare had heights that were statistically comparable. Different doses of potassium also had a significant effect on plant height. The tallest plants were found in plots receiving 50 kg K_2O ha^{-1} after 30, 60, and 90 days after transplanting, which was significantly higher than other treatments. However, no significant interaction was found between potassium and nitrogen levels. These results are in agreement with the research of Kacha et al. (2008), which showed that plants grew taller when receiving higher doses of nitrogen than when receiving lower doses. Similarly, studies by Mavengahama *et al*. (2003) and Dileep & Sasikala (2009) showed that use of mineral sources of nitrogen and potassium plant height in chilli crops. Plant height increase is associated with the production of structural proteins, where nitrogen and potassium play a key role. High applications of these nutrients increase the production of amino acids that are essential for protein formation, resulting in taller plants. The increase in height of red pepper species can be attributed to the improved nutrient availability resulting from nitrogen and potassium applications, which enhance carbohydrate metabolism and cell elongation. This mechanism leads to the efficient synthesis of chlorophyll, photosynthates, phytohormones, and cytokinins, all of which aid plant growth and promote faster cell formation and elongation. Similar findings were observed by Gouthami *et al*. (2022), while Monica (2015) observed greater heights in paprika when exposed to the highest levels of nitrogen and potassium, specifically 125% nitrogen and 125% K_2O.

Number of branches plant^{-1}

The number of branches at 30, 60, and 90 days after transplanting was significant. At 90 DAT, the maximum number of branches was observed in chilli (Table 2). At all growth stages (30, 60 and 90 DAT), the highest number of branches per plant (1.42, 3.23, and 4.80 respectively) was recorded at N_{135}, which was significantly higher than the other levels of nitrogen. The lowest values were observed for N_0. Regarding the different doses of potassium, K_{50} recorded significantly the most branches per plant (1.40, 3.23, and 4.80), while K_0 recorded the lowest. The interaction effect of nitrogen level with potassium on the number of branches per plant was not significant.

Table 1: Effect of different levels of nitrogen and potassium on plant height (cm) at different growth stages of chili

Treatment	Plant height (cm)			Number of branches plant^{-1}		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Nitrogen levels						
N_0	23.1^c	37.9^c	68.8^c	1.13^b	2.73^c	4.09^c
N_{45}	26.3^b	41.1^b	73.9^b	1.22^b	2.82^{bc}	4.34^{bc}
N_{90}	27.1^b	43.1^b	77.2^b	1.36^a	2.99^b	4.51^b
N_{135}	30.8^a	46.1^a	81.4^a	1.42^a	3.23^a	4.80^a
SEm (±)	0.71	0.86	1.27	0.039	0.073	0.093
CD (P=0.05)	2.08	2.52	3.72	0.114	0.216	0.272
Potassium levels						
K_0	24.8^c	39.7^c	71.9^c	1.17^c	2.78^b	4.08^c
K_{25}	26.8^b	42.0^b	75.3^b	1.28^b	2.90^b	4.47^b
K_{50}	28.9^a	44.5^a	78.8^a	1.40^a	3.16^a	4.77^a

SEm (±)	0.61	0.74	1.10	0.034	0.064	0.080
CD (P=0.05)	1.80	2.18	3.22	0.099	0.187	0.236

Number of leaves plant^{-1}

The number of leaves at 30, 60, and 90 days after transplanting was significant. At 90 DAT, the maximum number of leaves was observed in chilli (Table 2). At all growth stages (30, 60 and 90 DAT), the highest number of leaves per plant (10.00, 31.33, and 37,22 respectively) was recorded at N_{135}, which was significantly higher than the other levels of nitrogen. The lowest values (7.89, 26.78, and 31.44) were observed for N_0. Regarding the different doses of potassium, K_{50} recorded significantly the most leaves per plant (9.75, 31.00, and 36.25), while K_0 recorded the lowest (8.25, 26.58, and 31.67). Leaves are the main site of photosynthesis in addition to being the main source of several types of sinks. According to Sankar *et al.* (2008), increased nutrient uptake causes plants to grow taller and have more branches, which stimulates the production of indole acetic acid (IAA), a plant growth hormone. This results in the production of more leaves throughout the growing season. The interaction effect of nitrogen level with potassium on the number of leaves per plant was not significant.

Leaf Area Index (LAI)

Leaf area index is essential in assessing photosynthesizing surface area, transpiration area, and as a primary trait in plant ecology in portraying foliage cover around the plant. The leaf area index has several physiological implications strongly affecting plant growth and biomass accumulation (Patil et al. 2018). The data on the effects of nitrogen and potassium treatments on the leaf area index are presented in Table 2. Nitrogen and potassium treatments significantly affected LAI at 30, 60, and 90 DAT. The interaction effects between nitrogen and potassium treatments were not significant. The maximum LAI (0.073, 0.862, and 1.404) at all growth stage of a plant (30, 60 and 90 DAT) was observed with N_{135}, which was significantly superior to the other levels except for N_{90}, while N_0 recorded the minimum. With the regard of potassium, at all growth stages (30, 60 and 90 DAT) the highest LAI (0.073, 0.836 and 1.375) was noticed with K_{50} as compared to the control (K_0), which recorded the lowest value of LAI. An increase in leaf area is a positive indicator of growth response in several nutritional studies and also directly indicates an increase in the photosynthetic activity of plants which further increases the production of photosynthates and metabolic activity. The combination produced more leaf area due to the proper use of nutrition. LAl increase monotonically increased with increasing N and K levels at all growth stages due to better availability of N and K nutrients and absorption by plants; hence, there was more leaf formation and higher LAI. These findings corroborate those of Mounika, (2015), who did research on paprika. Similarly, Akanbi *et al.* (2007) reported that an increment in the leaf area index was observed with an increase in the nitrogen dose. Nitrogen facilitates the production of amino acids that build up different structural proteins and motivate better plant growth.

Table 2: Effect of different levels of nitrogen and potassium on number of leaves plant^{-1} and leaf area index (LAI) at different growth stages of chili

Treatment	Number of leaves plant^{-1}			Leaf Area Index (LAI)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Nitrogen levels						
N0	7.89^{b}	26.78^{c}	31.44^{b}	0.058^{b}	0.719^{c}	1.238^{c}
N45	8.56^{b}	28.33^{bc}	32.44^{b}	0.064^{b}	0.770^{b}	1.298^{b}

N90	9.56[a]	29.22[b]	33.78[b]	0.072[a]	0.817[ab]	1.364[a]
N135	10.00[a]	31.33[a]	37.22[a]	0.073[a]	0.862[a]	1.404[a]
SEm (±)	0.335	0.624	0.862	0.0025	0.0167	0.0185
CD (P=0.05)	0.981	1.831	2.529	0.0073	0.0490	0.0543
Potassium levels						
K0	8.25[b]	26.58[c]	31.67[b]	0.061[b]	0.731[b]	1.262[b]
K25	9.00[ab]	29.17[b]	33.25[b]	0.068[a]	0.809[a]	1.342[a]
K50	9.75[a]	31.00[a]	36.25[a]	0.073[a]	0.836[a]	1.375[a]
SEm (±)	0.290	0.541	0.747	0.0022	0.0145	0.0160
CD (P=0.05)	0.850	1.586	2.191	0.0063	0.0424	0.0471

Fruit Length (cm)

Fruit length is one of the key factors in chili production of chilies, which has a favorable correlation with fruit yields. Nutrient and potassium levels have significant effects on fruit length. The greatest nitrogen dosage (135 kg N ha-1) produced the longest mean fruit length (6.20 cm), followed by the second-highest (90 kg N ha-1) (5.58 cm), while the control plots generated the shortest fruit length (4.82 cm). These findings slightly agree with those of Subedi et al. (2023), who found that fruit size increased as nitrogen treatment increased. In terms of potassium, the longest fruit measured at the maximum level of 50 kg K ha-1 was 5.88 cm, which was comparable to the other length measured at 25 kg K2O ha-1 (5.88 cm). In comparison, the fruit length in the control plots was the smallest, measuring 4.98 cm (table 3). Potassium has been recognized as an effective nutrient for fruit quality and has a considerable impact on a variety of fruit quality parameters, which may explain the results (Khan et al., 2014). Similar outcomes were seen in the experiment by Lodhi et al. (2019), in which they found that increased doses of potassium and nitrogen increased the fruit length. The amount of nitrogen and potassium in a plant's system is directly correlated with the length of the fruit, which was positively correlated with increasing plant biomass. The combination of potassium and nitrogen levels had no significant effect on the length of the chili fruit.

Fruit diameter

Fruit yield and fruit diameter are positively correlated. Determining the fruit's true size is crucial. It also indicates the fruit's health and the plant's consumption of secondary metabolites. Fruit diameter data is presented in Table 3. Interaction effects were found to be non-significant. The largest fruit diameter (0.64 cm) among the nitrogen levels was produced by N135, which was noticeably larger than the other nitrogen levels. Our findings contradict previous studies by Mahmud et al. (2020) and Islam et al. (2018), which demonstrated that fruit width increased with increasing nitrogen contents. Different potassium dosages had no significant effects on fruit diameter. These results are in line with those of Hartz et al. (1999), who found that soils saturated with a greater potassium concentration had no significant effect on fruit diameter. The justification for this discovery is that higher potassium levels may result in an improvement in the synthesis of organic acids, which could lead to osmotic imbalances and adversely impact nutrient translocation in plant systems, ultimately producing insignificant impacts on fruit diameter.

Number of fruits Plant^{-1}

The capacity of plants to yield fruit and flowers is indicated by the number of fruits per plant. The number of fruits produced by a chili plant is linked with its fruit product. As nitrogen levels increased, the number of fruits per plant increased significantly (Table 3). 135 kg N ha^{-1} produced the greatest number fruits per plant (70.2), while the control treatment produced the least number of fruits per plant (55.7). As the quantity of nitrogen increased, the number of fruits per plant grew incrementally. These findings are in line with those of Bar-Tal *et al*. (2001) and Akanbi *et al*. (2007), who similarly found that pepper fruit weight and number per plant rose as nitrogen fertilization rate increased. The increase in potassium level in the capsicum increased the number of fruits per plant significantly (Table 3). Potassium fertilizer applied at 50 kg K2O ha-1 gave the maximum number of fruits per plant (68.0). The least number of fruits per plant was recorded in the control treatment (57.2). According to Fawzy *et al*. (2005), potassium played an essential role in the fresh weights of leaves and stems and the early and average yield of sweet pepper plants. According to Kanai *et al*. (2007), adequate K supplementation has also been linked to improved fruit color, longer shelf life, higher soluble solid and ascorbic acid concentrations, larger fruit sizes, higher yields, and better shipping quality for many types of horticultural crops. The number of fruits produced per plant was significantly impacted by the combined nitrogen and potassium treatments (Fig 1). The N_{135} K_{50} treatment had the greatest number fruits per plant (76.7). The control treatment (N_0 K_0) produced the smallest number of fruits per plant (47.0) (Table 4). These findings suggested that increased potassium and nitrogen concentrations had an impact on the number of fruits produced per plant. Similarly, Bhuvaneswari *et al*. (2013) found that increasing the amount of both nutrients simultaneously increases the number of fruits per plant, because nitrogen and potassium are necessary components of protoplasm, which is required for high-quality fruit development.

Average fruit weight (g)

There is a clear and positive correlation between average fruit weight and yield. Consequently, the average fruit weight is crucial for increasing chili yield. A larger yield is indicated by an increase in the average fruit weight. Table 3 displays the average fruit weight data. The Average fruit weight of chilies was significantly affected by nitrogen and potassium, but their interaction was not significant. As nitrogen levels rose, there was a considerable rise in the average fruit weight (Table 3). Applying a nitrogen level of 135 kg N ha^{-1} produced an average maximum fruit weight of 2.8 grams, which was statistically comparable to the average weight at 90 kg N ha^{-1}. The treatment without nitrogen application had the lowest average fruit weight, measuring 2.6 grams. Higher potassium levels also resulted in a rise in the average fruit weight. 50 kg K_2O ha^{-1} produced the highest average fruit weight of 2.8 g, while the control treatment without potassium fertilizer produced the lowest average weight of 2.7 g. These outcomes are consistent with research by Babanjeet *et al*. (2022) and Sat Pal & Saimbhi (2003), which found that higher dosages of potassium and nitrogen fertilizers significantly enhanced the average fruit weight. Nitrogen is a vital component of chlorophyll, where photosynthesis takes place. Potassium aids in the translocation of photosynthesis products to the fruits, increasing their weight.

Fruit weight plant^{-1} (g)

Nitrogen and potassium had significant effects on the fruit weight per plant of chilies. In comparison to control plots (0 kg/ha), which shown a lower fruit weight per plant (141.1 g), plants exposed to a higher nitrogen dose (135 kg/ha) exhibited a greater fruit weight per plant (201.1 g). Fruit weight per plant varied significantly depending on the potassium level as well. Fruit weight per plant from the maximal potassium treatment (188.8 g) were higher than those from other potassium doses of 25 and 0 kg K_2O ha^{-1}. In the meantime, 0 kg K_2O ha^{-1} produced the lowest fruit weight per plant (149.4 g). The fruits' weight $plant^{-1}$ was significantly impacted by the nitrogen and potassium treatments combination (Fig 1). The N_{135} K_{50} treatment had the largest fruit weight per plant (229.7 g) (Table 4). The control treatment (N_0 K_0) had the lowest fruit weight per plant (118.7 g). Based on these findings, it was concluded that increased potassium and nitrogen concentrations had an impact on fruit weight $plant^{-1}$.

Green fruit yield (ton/ha)

This indicates the overall amount of fruit produced on each hectare of land. The total fruit weight, quantity of fruits, and length all affect the value. Green fruit yield is the result of combining numerous characteristics that allow for the detection of their impacts. It aids in our comprehension of the different elements that restrict agricultural plant adaptability. Both nitrogen and potassium have a considerable impact on chili yield. Table 3 displays the information pertaining to this characteristic. 135 kg N ha^{-1} produced the highest yield (11.07 $tonsha^{-1}$), which was considerably greater than the yields from the other treatments. Treatments N_{45} and N_{90} were found to be statistically comparable to one another, while control plots produced the lowest yield (8.38-ton ha^{-1}). These outcomes closely match those of Kulvinder (1990), who discovered that the highest nitrogen rate produced the highest yield. Regarding potassium, the control plot produced the lowest yield (9.00-ton ha^{-1}), while 50 kg K_2O ha^{-1} produced the maximum yield (10.71 tons ha^{-1}), which was significantly larger than that achieved with the remaining potassium dose (Table 3). Additionally, the outcomes are consistent with those of Padem *et al*. (1997), who showed that a considerable increase in fruit weight and overall yield was a result of increasing the K-humate treatment dose. Since N and K are the main nutrients in plant systems, this could be the cause. The quantity of biomass generated and transmitted throughout the plant system determines a plant's yield. Here, both potassium and nitrogen are essential for all physiological and metabolic activities that increase yield. The yield of green fruit was significantly impacted by the nitrogen and potassium treatments combination (Table 4). The N_{135} K_{50} treatment produced the highest green fruit yield (12.48-ton ha^{-1}). The control treatment (N_0 K_0) produced the least amount of green fruit yield (7.22-ton ha^{-1}). Based on these findings, it was concluded that increased potassium and nitrogen concentrations had an impact on the yield of green fruit (Fig 1).

Table 3: Effect of different levels of nitrogen and potassium on yield and yield components of chili

Treatment	**yield-contributing parameters**					**Green and red ripe fruits yield *ton/ha***
	Fruit Length (cm)	**Fruit diameter (cm)**	**Number of fruits per Plant**	**Average fruit weight (g)**	**Fruit weight per plant(g)**	
Nitrogen levels						
N0	4.82^{c}	0.53^{b}	55.7^{c}	2.61^{b}	141.1d	8.38^{c}
N45	5.23^{bc}	0.57^{b}	63.1^{b}	2.68^{b}	158.7c	9.66^{b}
N90	5.58^{b}	0.60^{ab}	64.0^{b}	2.78^{ab}	181.7b	10.13^{b}
N135	6.20^{a}	0.64^{a}	70.2^{a}	2.83^{a}	201.0a	11.07^{a}

SEm (±)	0.152	0.014	0.99	0.041	2.60	0.171
CD (P=0.05)	0.444	0.042	2.89	0.141	7.62	0.501
Potassium levels						
K0	4.98^{b}	0.58	57.2^{c}	2.63^{b}	149.4^{c}	9.00^{c}
K25	5.53^{a}	0.59	64.6^{b}	2.73^{a}	173.7^{b}	9.72^{b}
K50	5.88^{a}	0.60	68.0^{a}	2.81^{a}	188.8^{a}	10.71^{a}
SEm (±)	0.131	0.012	0.85	0.042	2.25	0.148
CD (P=0.05)	0.385	ns	2.50	0.122	6.60	0.434

Table 4: Interaction effects of nitrogen levels and potassium levels on number of fruits plant^{-1}, fruit weight plant^{-1} (g)and green yield (t ha^{-1}) of chili

Nitrogen levels	Potassium levels								
	Number of fruits Plant^{-1}			Fruit weight plant^{-1} (g)			Green yield (t ha^{-1})		
	K_0	K_{25}	K_{50}	K_0	K_{25}	K_{50}	K_0	K_{25}	K_{50}
N_0	47.0^{e}	57.0^{d}	63.0^{c}	118.7^{f}	144.3^{e}	160.3^{d}	7.22^{e}	8.31^{d}	9.61^{cd}
N_{45}	57.0^{d}	66.0^{bc}	66.3^{bc}	141.0^{e}	161.3^{d}	173.7^{cd}	9.00^{d}	9.84^{cd}	10.14^{bc}
N_{90}	59.0^{c}	67.0^{bc}	66.0^{bc}	168.3^{d}	185.3^{c}	191.3^{bc}	9.86^{cd}	9.92^{c}	10.61^{bc}
N_{135}	65.7^{bc}	68.3^{b}	76.7^{a}	169.7^{d}	203.7^{b}	229.7^{a}	9.91^{cd}	10.81^{b}	12.48^{a}
SEm (±)	1.71			4.50			0.296		
CD (P=0.05)	5.01			13.20			0.867		

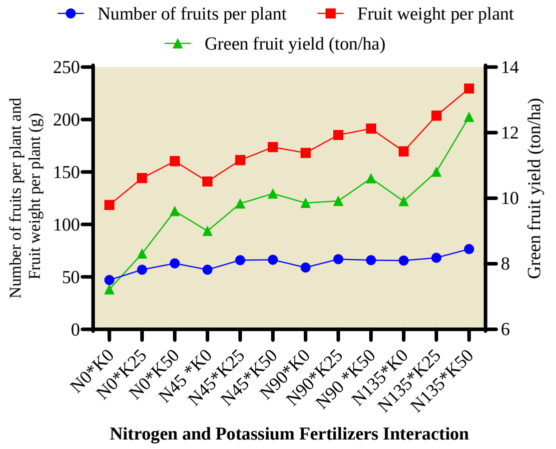

Fig 1: Interaction effects of nitrogen levels and potassium levels on number of fruits plant^{-1}, fruit weight plant^{-1} (g) and green yield (t ha^{-1}) of chili

CONCLUSION

After reviewing the results of this study, it can be concluded that applying 135 kg of nitrogen per hectare along with 50 kg of K_2O per hectare had a greater efficiency than other treatment combinations in achieving higher growth parameters, yield-contributing parameters, and green fruit yield of chili. Using the quadratic response equation, the economically optimal rate of nitrogen for chili was calculated as 113.0 kg per hectare, and based on the same equation, the economically optimal rate of potassium for chili was calculated as 47.5 kg per hectare.

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AUTHORS CONTRIBUTIONS:
The study's conception and design, fieldwork, and data collecting were all done by Mohammad Omer Darwish. Agronomic data, statistical analysis, and article drafting were all done by Sayed Rahim Ghafari. In addition to helping with the literature review and data interpretation, Ghulam Maruf Faqiri also revised the text. The final draft of the manuscript has been read and approved by all authors to guarantee its factual accuracy and scientific rigor.

REFERENCES

Akanbi, W. B., Togun, A. O., Olaniran, O. A., Akinfasoye, J. O., & Tairu, F. M. (2007). *Physico-chemical properties of egg plant (Solanum melongena L.) fruit in response to nitrogen fertilizer and fruit size.*

Alhrout, H. H. (2017). Response of growth and yield components of sweet pepper to tow different kinds of fertilizers under green house conditions in Jordan. *J. Agric. Sci*, *9*(10), 265–276.

Ayodele, O. J., Alabi, E. O., & Aluko, M. (2015). Nitrogen fertilizer effects on growth, yield and chemical composition of hot pepper (Rodo). *International Journal of Agriculture and Crop Sciences*, *8*(5), 666.

Babanjeet, Dilpreet, T., Kulbir, S., & Kumar, J. S. (2022). *Influence of nitrogen and potassium on growth and yield of chilli (Capsicum annuum L.).*

Baenas, N., Belović, M., Ilic, N., Moreno, D. A., & García-Viguera, C. (2019). Industrial use of pepper (Capsicum annum L.) derived products: Technological benefits and biological advantages. *Food Chemistry*, *274*, 872–885.

Bar-Tal, A., Aloni, B., Karni, L., & Rosenberg, R. (2001). *Nitrogen nutrition of greenhouse pepper. II. Effects of nitrogen concentration and NO3: NH4 ratio on growth, transpiration, and nutrient uptake.*

Bhuvaneswari, G., Sivaranjani, R., Reeth, S., & Ramakrishnan, K. (2013). *Application of nitrogen and potassium efficiency on the growth and yield of chilli Capsicum annuum L.*

Cammarano, D., Jamshidi, S., Hoogenboom, G., Ruane, A. C., Niyogi, D., & Ronga, D. (2022). Publisher Correction: Processing tomato production is expected to decrease by 2050 due to the projected increase in temperature. *Nature Food*, *3*(7), 552.

Dileep, S. N., & Sasikala, S. (2009). *Studies on the effect of different organic and inorganic fertilizers on growth, fruit characters, yield and quality of chilli (Capsicum annuum L.) cv. K-1.*

Dubey, A. K., Singh, D., Rajput, P. S., Kumar, Y., Verma, A. K., & Chandraker, S. K. (2017). Effect of NPK on plant growth, yield and quality of Capsicum (Capsicum annum L.) cv Swarna Under Shade Net Condition. *Int. J. Curr. Microbiol. App. Sci*, *6*(3), 1085–1091.

FAOSTAT, 2020. Crops and Livestock Products.

Fawzy, Z. F., Behairy, A. G., & Shehata, S. A. (2005). Effect of potassium fertilizer on growth and yield of sweet pepper plants (Capsicum annuum, L.). *Egyptian*

Journal of Agriculture Research, *2*(2), 599–610.

Gouthami, B., Uma Devi M., M., Avil Kumar. K. and Ramulu .V. (2022). Growth Parameters of Capsicum (Capsicum annuum var. grossum L.) as Influenced by Different Nitrogen and Potassium Fertigation Levels under Poly House. Biological Forum – An International Journal, 14(2): 624-629.

Gulab, G., Abdiani, S. A., Kakar, K., & Aryan, S. (2019). Effects of urea foliar application on growth and yield of green pepper. *International Journal of Innovative Research and Scientific Studies*, *2*(2).

Hartz, T. K., Miyao, G., Mullen, R. J., Cahn, M. D., Valencia, J., & Brittan, K. L. (1999). Potassium requirements for maximum yield and fruit quality of processing tomato. *Journal of the American Society for Horticultural Science*, *124*(2), 199–204.

Islam, M. R., Sultana, T., Haque, M. A., Hossain, M. I., Sabrin, N., & Islam, R. (2018). Growth and yield of chilli influenced by nitrogen and phosphorus. *Journal of Agriculture and Veterinary Science*, *11*(5), 54–68.

Kanwar, D. P. S., Dikshir, S. N., Sharma, G. L., Patel, K. L., Rajesh Agrawal, R. A., & Sarnaik, D. A. (2013). *Studies on effect of fertigation on growth and yield-attributing characters of sweet pepper (Capsicum annuum L.) under black polyethylene mulch.*

Kaur, M., Verma, B. R., Zhou, L., Lak, H. M., Kaur, S., Sammour, Y. M., Kapadia, S. R., Grimm, R. A., Griffin, B. P., & Xu, B. (2022). Association of pepper intake with all-cause and specific cause mortality-A systematic review and meta-analysis. *American Journal of Preventive Cardiology*, *9*, 100301.

Khaitov, B., Umurzokov, M., Cho, K.-M., Lee, Y.-J., Park, K. W., & Sung, J. (2019). Importance and production of chilli pepper; heat tolerance and efficient nutrient use under climate change conditions. *Korean Journal of Agricultural Science*, *46*(4), 769–779.

Khan, A., Shah, S. N. M., Rab, A., Sajid, M., Ali, K., Ahmed, A., & Faisal, S. (2014). Influence of nitrogen and potassium levels on growth and yield of chillies (Capsicum annuum L.). *International Journal of Farming and Allied Sciences*, *3*(3), 260–264.

Liu, H., Yang, H., Zheng, J., Jia, D., Wang, J., Li, Y., & Huang, G. (2012). Irrigation scheduling strategies based on soil matric potential on yield and fruit quality of mulched-drip irrigated chili pepper in Northwest China. *Agricultural Water Management*, *115*, 232–241.

Lodhi, Y., Chakravorty, S., Prasad, B. V, & Chandrakar, S. (2019). Influence of nutrients and mulching on fruiting and fruit characteristics of bell pepper (Capsicum annum L.). *Pharma Innonvation J.*, *8*, 791–794.

Lu, C., & Tian, H. (2017). Global nitrogen and phosphorus fertilizer use for agriculture production in the past half century: shifted hot spots and nutrient imbalance. *Earth System Science Data*, *9*(1), 181–192.

Mahmud, K., Hossain, T., Mou, T. H., Ali, A., & Islam, M. (2020). Effect of Nitrogen On Growth and Yield of Chili (Capsicum annuum L.) in Roof Top Garden. *Turkish Journal of Agriculture-Food Science and Technology*, *8*(1), 246–251.

Mavengahama, S., Ogunlela, V. B., & Mariga, D. I. K. (2003). Response of paprika (Capsicum annuum L.) to different basal fertilizers. *African Crop Sci. Conference Proc*, *6*, 9–13.

Mounika, D. (2015). *PAPRIKA (Capsicum annuum. L) RESPONSE TO*

FERTIGATION LEVELS OF NITROGEN AND POTASSIUM. PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY. HYDERABAD.

Padem, H., Ocal, A., & Alan, R. (1997). Effect of humic acid added to foliar fertilizer on quality and nutrient content of eggplant and pepper seedlings. *International Symposium Greenhouse Management for Better Yield & Quality in Mild Winter Climates 491*, 241–246.

Saleh, B. K., Omer, A., & Teweldemedhin, B. (2018). Medicinal uses and health benefits of chili pepper (Capsicum spp.): a review. *MOJ Food Process Technol*, *6*(4), 325–328.

Sankar, V.; Lawande, K.E. and Tripathy, P.C. (2008). Effect of micro irrigation on growth, yield and water-useefficiency of onion (Allium cepa) under western Maharashtra conditions. Indian Journal of Agricultural Sciences, 78(7): 584-588.

Sat Pal, S. P., & Saimbhi, M. S. (2003). *Effect of varying levels of nitrogen and phosphorus on earliness and yield of brinjal hybrids (Solanum melongena L.).*

Subedi, P., Bhattarai, P., Lamichhane, B., Khanal, A., & Shrestha, J. (2023). Effect of different levels of nitrogen and charcoal on growth and yield traits of chili (Capsicum annuum L.). *Heliyon*, *9*(2).

Tang, R., Supit, I., Hutjes, R., Zhang, F., Wang, X., Chen, X., Zhang, F., & Chen, X. (2023). Modelling growth of chili pepper (Capsicum annuum L.) with the WOFOST model. *Agricultural Systems*, *209*, 103688.

Tei, F., De Neve, S., de Haan, J., & Kristensen, H. L. (2020). Nitrogen management of vegetable crops. *Agricultural Water Management*, *240*, 106316.

Uddin, M. K. (2003). Yield and Yield Components of Winter Chilli (Capsicum annum L.) as Affected by Different Levels of Nitrogen and Boron Md. Kalim Uddin," KM. Khalequzzaman," Md. Matiar Rahman," Nur-e-Alam Siddquie and “Md. Omar Ali. *Pakistan Journal of Biological Sciences*, *6*(6), 605–609.

Wahocho, N. A., Zeshan Ahmed, S., Jogi, Q., Talpur, K. H., & Leghari, S. J. (2016). GROWTH AND PRODUCTIVITY OF CHILLI (CAPSICUM ANNUUM L.) UNDER VARIOUS NITROGEN LEVELS. *Science International*, *28*(2).