GROWTH AND PRODUCTIVITY OF CHILLI (*CAPSICUM ANNUUM* L.) UNDER VARIOUS NITROGEN LEVELS

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ABSTRACT: *Nitrogen (N) is one of the most important nutrients for plant growth and productivity. Hence its judicious use in crop cultivation is essential for achieving desirable productivity of crops. A pot experiment was designed in the experimental site of the Horticulture Garden, Sindh Agriculture University, Tandojam during 2014-15, using Randomize complete design (CRD), where five cultivars of chilli (Kunri 1, Nagina, Ghotki, Tota puri and Longi) were evaluated to four nitrogen levels, including a control, (0, 50, 150 and 250 kg ha^{-1}). The results exhibited that all growth and yield characters of chilli were significantly (P<0.05) influenced by N levels and cultivars. However, interaction between N levels × cultivars was only significant (P<0.05) for plant height (cm) and branches plant^{-1}. The plants treated with higher N level of 250 Kg ha^{-1} produced maximum plant height (71.27 cm), number of branches (9.42), days to flower initiation (74.62), fruit length (3.12 cm), fruits plant^{-1} (142.00), weight of single fruit (3.44 g) and fresh weight of fruit plant^{-1} (486.36). The plants fertilized with 150 kg ha^{-1} ranked second and showed plant height (70.56 cm), number of branches (9.06), days to flower initiation (exposed) 74.33, fruit length (3.02), fruits plant^{-1} (139.20), weight of single fruit (3.34), and fresh weight of fruit plant^{-1} (468.51). There was significant reduction in all the growth and yield attributed parameters at control, where N was not applied to plants. Among cultivars, Ghotki exhibited a better performance. Moreover, interaction of N levels and cultivars (250 Kg ha^{-1} x Ghotki) also displayed higher values for most of the traits. The findings of the current study demonstrated that although higher N level 250 kg ha^{-1} showed greater values for all traits, but these results were statistically similar to results obtained from 150 kg ha^{-1}, Hence, it is concluded that N 150 Kg ha^{-1} is an economic dose for better growth and fruit yield of Chillies.*

Key words: Chilli, Nitrogen, Growth, Productivity, Cultivars

INTRODUCTION

Chilli (*Capsicum annum* L.) is one of the important vegetable crops of the Solanaceae family and is grown worldwide in large scale. It orginates from South and Central America where it is still under cultivation [1]. In Brazil, diverse Chilli varieties are grown on a large scale [2]. It is well documented, chilli is the first spice to have been used by human being and there is archaeological proof of consumption of chillies of about 6000 years ago [3]. Chilli contains proteins, vitamins including vitamin A and C and is also a rich source of various minerals including calcium, phosphorous and irons [4]. In addition, hot types of chillies are rich in digestive stimulant capsaicin [5].

Currently chillies are gaining popularity in the country due to its economic and sufficient profit margins to the growers. After potato and onion, it occupies the largest area in the country [6]. Chilli is largely cultivated in Sindh and southern Punjab in the country. In sindh, chilli s grown on a large scale and contributes 85% of the production followed by Punjab with 11% [6]. Kunri, which is also known as "Chilli Capital of Asia" produces chili of about 55%. The other cities of Sindh province in which chillies are grown on large scale included Mirpurkhas, Hyderabad and Ghotki. Pakistan has best and valuable genetic resource of chilli, However the yield per hectare of chilli is quite low than potential exists. Several factors might be associated to low yields of chillies, including climatic conditions unavailability of high-yielding cultivars, provision of the imbalanced amount of organic manures and non judicious use of chemical fertilizers especially N. Moreover, the varietal effect also influences on productivity [7]. Nutrients play a vital role in enhancing the yield of cultivated plants [8]. Among the various elements, nitrogen is most limiting nutrients affecting crop growth and productivity [9]. Nitrogen is a necessary part of agriculture and ecological ecosystems in which the main objective is to enhance or maintain acceptable crop yield [10]. Nitrogen is known to promote the production, ventilation and aggregation of the dry matter crop [11]. Nitrogen fertilizer plays a fundamental role in enhancing the fruit production [10;12;13]. Chilli is one of the N demanding vegetables; hence its optimum use of N in chilli cultivation is essential for getting desirable yield [14]. Several studies documented the essential role of N in enhnacing the growth and fruit yield of Chilli [15;16;17]. [18] reported that in chilli chlorophyll content, N concentration in leaf and shoot dry weight, enhanced with application of nitrogen in large quantity. [19] documented that nitrogen fertilizers had great significance in enhancing the fruit numbers and fruit weight of chilli peppers. [20] also reported that higher level of N significantly showed better growth and yield of chillies. It has been widely observed that various crop species showed highly different response to different N levels [21]. In further, [20] also found different response of nitrogen on the growth and productivity of chilli varieties. It is therefore mandatory to investigate response of N on the growth and productivity of various cultivars of chilli. In the light of above mentioned facts, the current study was designed to assess the growth and productivity of cultivars of chilli under various N levels.

MATERIALS AND METHODS

The pot trial was carried out at the experimental site of the Horticulture Garden, Sindh Agriculture University TandoJam during 2014-15 in a completely randomized design (CRD) to evaluate the growth and productivity of chilli (*capsicum annuum* L.) under different nitrogen levels. Five varieties including Kunri, Nagina**,** Tota puri**,** Longi and Ghotki were evaluated to four N levels (0, 50, 150, 250 kg ha^{-1}). The soil was collected from Latif farm of Sindh Agriculture University Tandojam. In order to ensure uniformity and to

remove any course earth, soil was dried and passed through a sieve having a 2 mm mesh. Plastic pots having a capacity of 15 kg of soil in pot^{-1} with enough perforation (hole) at the bottom for drainage was used for the present study. After that, relative quantity of N was applied in three split doses. The seed were sown at a density of 5 seeds pot^{-1}. When plants reached at third leaf stage, only a single healthy seedling was allowed to grow in each pot. Nitrogen was applied in the in the form of urea and recommended dose of phosphorus and potassium (60 and 50 kg ha^{-1}) was applied in the form of single super phosphate (SSP) and sulfate of potash (SOP), respectively. The crop was irrigated at seven days interval, and all the required cultural practices were applied throughout the growing season. The data were recorded on the parameters includes, plant height (cm)**,** branches plant-1, days to flower initiation, fruit length (cm)**,** fruits plant^{-1}**,** weight of single fruit (g)**,** fresh weight of fruits (g). The collected data were statically analyzed using Statistics- 8.1 computer software (Statistics, 2006). The LSD test was performed at P≤0.5 probability level to compare treatment superiority.

RESULT AND DISCUSSION

Influence of N on growth parameters of Chilli

The growth parameters of chillies were greatly influenced by nitrogen levels and cultivars. The findings of the current study showed that the higher nitrogen level of 250 kg ha^{-1} showed higher values for all the investigated growth parameters including plant height, number of branches, days to flower initiation. However, statistically, the differences between 250 kg ha^{-1} and 150 kg ha^{-1} was non-significant (P>0.05) for all assessed growth related attributes. The greatest plant height (71.27 cm) was recorded when plants received maximum N level 250 kg ha-^{1} followed by (70.56 cm) when plants took N level of 150 kg ha^{-1}. The plants treated with N level of 50 kg ha-^{1} produced 61.76 cm height of plant while lowest height of plant was recorded (58.20 cm) at control (untreated) plants, where N was not applied. Among cultivars, Longi showed maximum (79.16 cm) plant height, while the minimum (58.28 cm) plant height was noted in Kunri 1. Moreover, among interactions, the interactive effect of (250 kg ha^{-1} x Longi) showed maximum (82.95 cm) plant height. The maximum plant height might be due to better cell division and formation of tissues that causing better vegetative growth of plant that finally enhanced the plant height. These results are strongly supported by [20] who reported that, N level at 150 kg per ha^{-1} showed significantly better results with regard to growth parameters like plant height, plant spread, primary and secondary branches in a single plant as well as yield characteristic like fruits numbers and fruit weight.

The results further revealed that the maximum (9.42) numbers of branches were observed at increasing N level of 250 kg ha^{-1} closely followed by the (9.06) when the plants were fertilized at N level of 150 kg ha^{-1}. At 50 kg ha^{-1} plants showed branches plant^{-1} (7.20). The minimum branches (4.80) were recorded at control, where N was not applied. Among cultivars the maximum (9.33) branches were observed in Ghotki. Kunri 1 produces minimum (5.91) branches. Among interaction the maximum (11.66) branches were noted in Ghotki cultivar at the N level of 250 kg ha^{-1} and the minimum (3.66) were observed in Kunri 1 at N level 0 control (un treated). This indicates that the high nitrogen was good for chilli crop to produce more branches than those under limiting nitrogen conditions. Similarly, [22;23] documented that the nitrogen application in adequate quantity significantly enhanced plant height, branches, leaves and leaf area plant^{-1}, root dry weight and ripe fruit yield (number and weight) at 75 kg N ha^{-1}. Moreover, nitrogen application in sufficient quantity significantly increased the fat, protein, carbohydrate, and crude fibber and ash contents, vitamin C and mineral nutrients of the fruits.

Similarly, the maximum days to flower initiation (74.62) was noted in plants which were fertilized at the N level of 250 kg ha^{-1} followed by (74.33) days at the N level (150 kg ha^{-1}). At the N level 50 ka ha^{-1}, the days to flower initiation (69.35) were observed. The chilli crop took minimum days (66.00) at the N level 0 control (in untreated plants). Among the cultivars, the maximum days to flower initiation (72.59) was observed in Longi. However the minimum days to flower initiation (68.39) was noted in Tota puri. Among interactions, the maximum days (76.4) were observed in Kunri 1 at the highest N level of 250 kg ha^{-1} and the minimum days to flower initiation (65.86) was recorded in Nagina at N level 0 control. In the present study, the maximum days to flower initiation at the highest N level might be associated with the luxurious vegetative growth that delayed the reproductive growth of the plants. Among cultivars, the highly different responses of the cultivars for the flowering time might be related to genetic variation. These results are endorsed by [24] who also documented delay flowering in plants which was fertilized with the highest quantity of nitrogen.

Influence of N on Yield parameters

Various nitrogen levels and cultivars also showed a significant (P< 0.05) response to yield parameters including fruit length, fruits plant^{-1}, and fruit weights plant^{-1}. However, statistically, the differences between 250 kg ha^{-1} and 150 kg ha^{-1} was non-significant (P>0.05) for all analyzed yield attributed parameters. The maximum fruit length (3.12 cm) was noted at the highest N level of 250 kg ha^{-1} followed by (3.02 cm) at N level 150 kg ha^{-1}. The N level 50 kg ha^{-1} showed (2.64 cm). The minimum fruit length (2.37 cm) was recorded at N level of 0 kg ha^{-1}. Among cultivars, Ghotki produced greatest fruit length (4.62 cm) and the minimum fruit length (1.75 cm) was observed in Longi. Among interactions, Ghotki produced maximum fruit length (5.08 cm) at the N level of 250 kg ha^{-1}. However the lowest value (1.4 cm) was observed in Longi at control. This indicates that the highest dose of nitrogen was best for the fruit length of chilli crop to produce better fruit length than those under deficit nitrogen conditions. Moreover, better fruit length might have linked to the presence of important nutrient N in the soil due to its application in large amount that increased fruit length and number of branches, while the short length of fruit might be due to the absence of important nutrients especially N in the soil that ultimately reduced the length of fruit. These results are strongly endorsed by [24] who also found the significant response of N on fruit length of chilli.

From yield point of view the fruits plant^{-1} are determinant of yield. The present study illustrated that the maximum number of fruits plant^{-1} (142.00) was observed at N level of 250 kg ha^{-1} followed by (139.20) at N level of 150 kg ha^{-1}. At N level 50 kg ha^{-1} the fruits (111.60) were noted and the minimum fruits (93.33) were noted at N level of 0 control. Among

cultivars, the maximum fruits (139.00) were recorded in Ghotki and the minimum fruits (106.33) were observed in Kunri 1. Among interactions, the maximum fruits (163.66) were observed in Ghotki at N level (250 kg ha^{-1}) and the minimum fruits (80.66) were noted at N level 0 kg ha^{-1} in Kunri 1. Similarly, [25] also found the maximum fruit numbers at a highest N level.

Similarly, for single fruit weight, the higher N level of 250 kg ha^{-1} showed significant results and showed highest single fruit weight (3.44 g), followed by (3.34 g) at N level of 150 kg ha^{-1}. At N level 50 kg ha^{-1} the single fruit weight (3.13 g) was observed. While, the lowest value (2.72 g) were noted from treatment control, where nitrogen not applied. Among cultivars, greatest single fruit weight (4.13 g) was noted in Ghotki and the minimum fruit weight (2.73 g) was recorded in Longi. Among interactions the maximum fruit weight (4.38 g) was observed in Ghotki at N level of 250 kg ha^{-1}. The minimum fruit weight (2.16 g) was noted in Longi at N level (0 kg ha^{-1}). The findings of the present studies are according to the results of [26] who documented that fruit weight increased considerably up to 150 kg N ha^{-1}.

The fresh weight of fruit is considered as a one of the important yield parameters. In the current study, the maximum fruit weight $plant^{-1}$ (486.36 g) was obtained at N level of 250 kg ha^{-1} followed by (468.51 g) at N level of 150 kg ha^{-1}. The weight of fruits (354.74 g) was noted at N level of 50 kg ha^{-1}. However, the minimum weight of fruits (256.19 g) $plant^{-1}$ was observed at N level 0 control (untreated). However, the results obtained from 250 kg ha^{-1} were statistically non- significant (P> 0.05) with the results obtained from 150 kg ha^{-1}. Among cultivars, the maximum fruits weight (585.47 g) $plant^{-1}$ was noticed in Ghotki and the minimum value (316.93 g) was observed in Nagina. Among interactions, the highest weight of fruits (727.73 g) was observed in Ghotki at N level (250 kg ha^{-1}). However, Longi produced minimum fruits weight (194.56 g) $plant^{-1}$ at N level 0 control (untreated plants). These results are in accordance with the findings of [27] who assessed the growth and yield performance of hot pepper varieties to various doses of nitrogen and phosphorous. The results exhibited that the interaction effect of nitrogen and phosphorous was highly significant for most of the investigated traits. Plants treated with the fertilizer combination of 92 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1} produced the highest fresh fruit yield and total dry fruit production as well as greater marketable production.

Table: 1. Plant height (cm) of chilli cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	53.7	57.3	55.1	73.83	51.06	58.200 C
N2 (50 Kg ha^{-1})	58.23	61.33	58.8	77.26	53.2	61.767 B
N3 (150 Kg ha^{-1})	68.83	69.6	67.56	82.6	64.23	70.567A
N4 (250 Kg ha^{-1})	69.21	69.96	69.6	82.95	64.63	71.273A
Mean	62.496 C	64.550 B	62.767 C	79.162 A	58.283 D	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	0.3525	0.3941	0.7881
LSD 0.05	0.7135	0.7977	significant
LSD 0.01	0.9557	1.0685	significant
CV(%)	1.47		

Table: 2. Number of branches of chilli cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	5.33	6	4.66	4.33	3.66	4.8000 C
N2 (50 Kg ha^{-1})	7.33	8.33	6.66	7.33	6.33	7.2000 B
N3 (150 Kg ha^{-1})	10.33	11.33	9.66	7.33	6.66	9.0667A
N4 (250 Kg ha^{-1})	10.76	11.66	10	7.66	7	9.4200A
Mean	8.4417 B	9.3333 A	7.7500 C	6.6667 D	5.9167 E	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	0.2946	0.3294	0.6588
LSD 0.05	0.5964	0.6668	non significant
LSD 0.01	0.7989	0.8932	non significant
CV(%)	10.59		

Table: 3. Days to flower initiation chilli cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	65.86	66.2	63.8	67	67.13	66.000 C
N2 (50 Kg ha^{-1})	68.9	69.2	66.8	71.06	70.8	69.353 B
N3 (150 Kg ha^{-1})	74.13	74.23	71.36	75.95	76	74.337A
N4 (250 Kg ha^{-1})	74.36	74.4	71.6	76.35	76.4	74.623A
Mean	70.817 B	71.008 B	68.392 C	72.592 A	72.583 A	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	0.2408	0.2693	0.5386
LSD 0.05	0.4876	0.5451	non significant
LSD 0.01	0.6531	0.7302	non significant
CV(%)	0.93		

Table: 4. Fruit lenght of chilli cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	2.36	4.16	2.2	1.4	1.75	2.3767 B
N2 (50 Kg ha^{-1})	2.53	4.33	2.76	1.7	1.86	2.6400 B
N3 (150 Kg ha^{-1})	2.83	4.93	3.23	1.93	2.2	3.0267A
N4 (250 Kg ha^{-1})	2.96	5.08	3.36	1.96	2.23	3.1233 A
Mean	2.6750 B	4.6292 A	2.8917 B	1.7500 C	2.0125 C	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	0.1354	0.1514	0.3028
LSD 0.05	0.2741	0.3065	non significant
LSD 0.01	0.3672	0.4105	non significant
CV(%)	13.28		

Table: 5. Number of fruits plant $^{-1}$ of chilli cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	97.33	105	94	89.66	80.66	93.33 C
N2 (50 Kg ha^{-1})	114	127.33	111.33	107.66	97.66	111.60 B
N3 (150 Kg ha^{-1})	141	160	140	132.33	122.66	139.20 A
N4 (250 Kg ha^{-1})	143.33	163.66	143	135.66	124.33	142.00 A
Mean	123.92 B	139.00 A	122.08 B	116.33 C	106.33 D	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	1.8177	2.0322	4.0645
LSD 0.05	3.6797	4.1140	non significant
LSD 0.01	4.9288	5.5105	non significant
CV(%)	4.10		

Table: 6. Single fruit weight (g) of chilli Cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	2.23	3.86	2.26	2.16	3.1	2.7267 B
N2 (50 Kg ha^{-1})	2.6	4.03	2.9	2.76	3.36	3.1333 AB
N3 (150 Kg ha^{-1})	2.8	4.26	3.13	2.96	3.53	3.3400 A
N4 (250 Kg ha^{-1})	2.9	4.38	3.26	3.03	3.65	3.4467 A
Mean	3.4467 A	4.1375 A	2.8917 C	2.7333 C	3.4125 B	

	Nitrogen	Cultivar	Nitrogen x Cultivar
S.E	0.2059	0.2302	0.4604
LSD 0.05	0.4168	0.4660	non significant
LSD 0.01	0.5583	0.6242	non significant
CV(%)	17.84		

Table: 7. Fresh weight of fruits per plant of chilli Cultivars as influenced by various nitrogen levels

Treatment	Cultivars					Mean
	Nagina	Ghotki	Tota puri	Longi	Kunri 1	
N1 (0)	217.33	407.66	212.4	194.56	249	256.19 C
N2 (50 Kg ha^{-1})	299.73	524.16	324.03	297.33	328.43	354.74 B

N3 (150 Kg ha^{-1})	396.2	682.33	438.33	391.83	433.83	468.51 A
N4 (250 Kg ha^{-1})	354.46	727.73	471.05	418.13	460.4	486.36 A
Mean	316.93 B	585.47 A	361.45 B	325.47 B	367.92 B	

	Nitrogen	**Cultivar**	**Nitrogen x Cultivar**
S.E	28.006	31.312	62.624
LSD 0.05	56.695	63.387	non significant
LSD 0.01	75.940	84.904	non significant
CV(%)	19.59		

CONCLUSION AND SUGGESTIONS

It is concluded that growth and yield attributed characters of chilli were significantly affected by various N levels. The highest N level of 250 Kg ha^{-1} showed better results for all investigated growth and yield related characters. However, statistically, the differences between 250 kg ha^{-1} and 150 kg ha^{-1} was non-significant (P>0.05). Among cultivars, Ghotki significantly produced higher values for most of the traits as compared to other cultivars. Hence, for achieving economically higher yield of chilli, the crop may be fertilized with N level of 150 Kg ha^{-1}. Moreover, further investigation needs to be carried out under field conditions and different locations for getting an optimum yield of chilli under low nitrogen conditions.

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