Response of Various Nitrogen Levels on the Growth and Yield Performance of Tomato (*Lycopersicon Esculentum* Mill.)

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Abstract: Nitrogen (N) fertilization at optimum quantity to cultivated plants is essential for sustainable crop productivity. The experiment was conducted to evaluate the response of nitrogen fertilizers on the growth and yield traits of tomato during 2016, at the experimental field of Orchard, Department of Horticulture, Sindh Agriculture University Tandojam. Six nitrogen treatment doses were tested (T_1 =control (untreated), T_2 = 30 N kg ha^{-1}, T_3 = 60 N kg ha^{-1}, T_4 = 90 N kg ha^{-1}, T_5 = 120 N kg ha^{-1} and T_6 = 150 N kg ha^{-1}.). The data were recorded on the number of branches $plant^{-1}$, days to flowering, days to fruiting, number of fruits $plant^{-1}$, weight of single fruit (g), yield $plot^{-1}$ and yield ha^{-1} (tons). The results demonstrated that N fertilization showed significant influence on both vegetative and reproductive traits of tomato. On the contrary, plants which were not fertilized with N displayed minimum values for all investigated traits. The highest N level (150 kg ha^{-1}) showed maximum number of branches (5.51) $plant^{-1}$, minimum day to flowering (42.43) less days to fruiting (46.00), more fruits $plant^{-1}$ (31.00) maximum weight of single fruit (46.50 g) and highest fruit yield $plot^{-1}$ (21.01 kg) and per hectare (14008 tons), respectively. It was concluded that the crop growth and productivity was significantly influenced by various levels of nitrogen. However, 150 N kg ha^{-1} as compared to 120 N and other concentrations considerably displayed better performance in terms of vegetative and reproductive traits of tomato. Hence for optimum growth and economically higher yield, the tomato crop may be fertilized with 150 N kg ha^{-1}.

Keywords: Nitrogen, Growth, Yield, Tomato (*Lycopersicon esculentum* Mill).

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a popular vegetable and most important ingredient in enhancing the taste and flavor of other vegetables [1]. It is referred as “protective food” because of its special nutritive value and widespread production [2]. The tomato in ripe state provides potential minerals and vitamins, particularly the carotenoids and vitamin C and they are worldwide consumed as raw and in various processed forms as well [3]. Increasing the productivity of horticultural crops with good yield and quality is an important goal of the growers for market and export. The studies carried out worldwide showed that lycopene in fruits helps prevention cancer, but nothing has been conclusively achieved from their research on such health aspects [4].

For successful crop production, N is considered as key element. Due to its immediate availability to crop plants, it guarantees the higher productivity [5]. It enhances both vegetative and reproductive growth of crop plants [6]. It helps in synthesis of chlorophy which is considered very essential in photosynthesis process. It is an important constituent of many essential organic compounds, including nucleic acids and protein. Nitrogen also affects the uptake and utilization efficiency of phosphorous and potassium and other plant nutrient elements [7]. Proper and routinely fertilization with nitrogen gave successful and economical crop production. However, overuse of N in vegetable cultivation leads to excessive accumulation of nitrates beyond its safe limits in various parts of vegetables which caused health risks to humans [8].

To obtain the better yield of tomato, large quantities of nitrogen is generally applied worldwide. Tomato has great demand for N fertilization. Nitrogen is mostly applied to tomato in three splits doses. In the initial stage of tomato, it enhances the vegetative growth of plants. However at later stages it significantly and positively affects the reproductive growth of plants [9].

Although tomato is an important crop of Sindh Province of Pakistan, However, very limited information is available about its optimum and specific N requirement.

Keeping in view the importance of nitrogen for plant growth and development, the current study was designed to evaluate the impact of various nitrogen levels on the growth and yield performance of tomato.

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MATERIALS AND METHODS

The present study was carried out to evaluate the response of nitrogen fertilizer on the growth and yield performance of tomato during the year 2016 at the experimental field of Orchard, Department of Horticulture, Sindh Agriculture University Tandojam. The field layout was followed the Randomized Complete Block Design with three replicates. The plot size kept was 5m x 3m (15 m^2). The treatments included T_1 = Control (untreated), T_2 = 30 N kg $ha^{-1,}$ T_3 = 60 N kg ha^{-1}, T_4 = 90 N kg $ha^{-1,}$ T_5 = 120 N kg $ha^{-1,}$ T_6 = 150 N kg ha^{-1}. The Urea which is commonly applied nitrogenous fertilizer to crops was source of N which was applied in three equal split doses (at the time of sowing and at the stage of flowering and fruiting development of crop). The uniform dose of phosphorous and potassium were also applied in the form of single superphosphate and sulphate of potash which were applied at the time of sowing of the crop. The crop was irrigated according to its requirement and all the cultural practices were performed uniformly in all the plots. The data were recorded on Number of branches $plant^{-1}$, Days to flowering, Days to fruiting, Number of fruits $plant^{-1}$, Weight of single fruit (g), Fruit yield $plot^{-1}$ (kg), Fruit yield (tons ha^{-1}).

Statistical Analysis

Collected data were subjected for statistical analysis using Statistix version 8.1 (Statistix, 2006). In order to know the superiority of treatments, the least significant difference (LSD) test at (0.05) probability level was performed.

RESULTS AND DISCUSSION

Number of Branches $Plant^{-1}$

The results demonstrated that the number of days to flowering of tomato were significantly influenced by different doses of nitrogen fertilizers ($P<0.05$). The results indicated that nitrogen level of 150 N kg ha^{-1} produced highest number of branches (5.51) $plant^{-1}$ on average; followed by the tomato crop supplied with nitrogen fertilizer @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} with 5.43, 5.07 and 4.92 average number of branches $plant^{-1}$, respectively (Table **1**). The crop supplied with nitrogen fertilizer @30 N kg ha^{-1} produced lower branches number $plant^{-1}$ (4.52); while lowest branches $plant^{-1}$ (3.83) was recorded in control (untreated), where no nitrogen fertilizer was applied. In tomato the branching capacity is a trait of primary importance, because more the branches on a plant, greater will be the number of fruits per plant. The branching in tomato may vary variety to variety, but the branching is mainly guided by the environmental factors and quantities of nutrients being supplied to the crop. In present study, lowest branches $plant^{-1}$ indicated the deficiency of N in the soil. The branches $plant^{-1}$ significantly increased when synthetic N was supplied to the plants through soil at higher rates. The results are in agreement with those of [1-3], who were of the opinion that application of N is essential for proper plant growth of tomato.

Days to Flowering

The results demonstrated that the various doses of N showed significant effect ($P<0.05$) on number of days to flowering of tomato. The crop fertilized with control (untreated) took minimum days to flowering (42.43) on average; followed by the tomato crop supplied with nitrogen fertilizer @30 N kg ha^{-1}, 60 N kg ha^{-1} and 90 N kg ha^{-1}, taking 45.18, 45.88 and 46.03 days to flowering, respectively. The higher nitrogen level (150 kg ha^{-1}) took more days (49.95) to flowering This suggested that the experimental soil was inadequate of nitrogen and responded appreciably to avail proper physiological period for flowering when

Table 1: Number of Branches $Plant^{-1}$ of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	3.25	4.10	4.15	3.83 E
T_2=30 N kg ha^{-1}	4.55	4.50	4.53	4.52 D
T_3=60 N kg ha^{-1}	4.90	4.93	4.95	4.92 C
T_4=90 N kg ha^{-1}	5.05	5.10	5.08	5.07 BC
T_5=120 N kg ha^{-1}	5.40	5.45	5.44	5.43 AB
T_6=150 N kg ha^{-1}	5.50	5.53	5.52	5.51 A

S.E. 0.1650.
LSD 0.05 0.3675.
CV% 4.14.

Table 2: Days to Flowering of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	51.25	48.10	50.50	42.43 D
T_2=30 N kg ha^{-1}	47.74	46.60	48.55	45.18 C
T_3=60 N kg ha^{-1}	46.25	45.50	46.35	45.88 BC
T_4=90 N kg ha^{-1}	44.70	46.50	46.45	46.03 BC
T_5=120 N kg ha^{-1}	45.55	45.60	44.40	47.63 B
T_6=150 N kg ha^{-1}	42.50	43.45	41.35	49.95 A

S.E. 0.9137.
LSD 0.05 2.0359.
CV% 2.42.

synthetic nitrogen was supplied to the plants through soil at higher rates. On the other hand, in case of inadequate availability of nitrogen from the soil to the plant resulted in reaching early to the flowering stage without availing the growth period required by the crop naturally. Similar results have also been reported by [10], who reported that higher fertilizer levels delayed the flowering tomato, while [11, 12] who reported that increase in the nitrogen and potash proportionately increased the days to flowering.

Days to Fruiting

It is evident from the results presented in Table **3** that tomato crop with nitrogen levels of control (untreated) took more days to fruiting (49.95.00) on average; followed by the tomato crop supplied with nitrogen fertilizer @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} taking 53.00, 53.00 and 51.66 days to fruiting, respectively. The number of days to fruiting that the crop supplied with higher nitrogen levels started fruit development later than that given lower nitrogen levels; and with each shortening of nitrogen fertilizer over 150 N kg ha^{-1}, the crop experienced an earliness in fruit development. This suggested that N was deficit in experimental soil. In tomato the time taken by the plant to fruiting is a physiological parameter that may be influenced by the genetic makeup of parental material of certain varieties; but the influence of soil fertility status and soil amendment by synthetic fertilizers may influence this trait more dominantly. The studies carried out by [9, 12, 13] also showed similarity with the findings of the present study and reported that higher rates of nitrogen and potash fertilizers delayed the fruiting development in tomatoes.

Number of Fruits $Plant^{-1}$

The number of fruits $plant^{-1}$ of tomato was significantly ($P<0.05$) affected by different nitrogen fertilizer levels. It is obvious from the results that tomato crop supplied with nitrogen fertilizer @ 150 N kg ha^{-1} and 120 kg ha^{1}produced more number of fruits $plant^{-1}$ (31.00) on average; followed by the crop supplied with nitrogen fertilizers @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} producing 31.00, 26.66 and 23.00 fruits $plant^{-1}$, respectively (Table **4**). The crop supplied with nitrogen fertilizers @30 N kg ha^{-1} produced decreased number of fruits $plant^{-1}$ (19.33); while the lowest number of fruits $plant^{-1}$ (13.66) was

Table 3: Days to Fruiting of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	46	47	45	46.00 D
T_2=30 N kg ha^{-1}	49	50	51	50.00 C
T_3=60 N kg ha^{-1}	50	52	53	51.66 BC
T_4=90 N kg ha^{-1}	52	54	53	53.00 AB
T_5=120 N kg ha^{-1}	52	55	52	53.00 AB
T_6=150 N kg ha^{-1}	53	54	55	54.00A

S.E. 0.8119.
LSD 0.05 1.8091.
CV% 1.94.

Table 4: Number of Fruits Plant^{-1} of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	16	12	13	13.66 E
T_2=30 N kg ha^{-1}	18	21	19	19.33 D
T_3=60 N kg ha^{-1}	22	24	23	23.00 C
T_4=90 N kg ha^{-1}	26	28	26	26.66 B
T_5=120 N kg ha^{-1}	30	32	31	31.00 A
T_6=150 N kg ha^{-1}	32	33	31	31.00 A

S.E. 1.0715.
LSD 0.05 2.3875.
CV% 5.41.

recorded in control (untreated), where no nitrogen fertilizer were given to experimental field. The results further showed that the crop supplied with higher nitrogen levels produced more fruits on average plant^{-1} than that of given lower nitrogen levels; and with each decrease in nitrogen fertilizers rate over 150 N kg ha^{-1}, the crop experienced reduction in its fruiting capacity. This showed that the experimental soil was inadequate of nitrogen and responded positively to N at higher levels. Moreover, due to soil deficiency of nitrogen lower number of fruits per plant was developed. The results regarding the fruits per plant achieved in the present study are in agreement with those of [14-16], who reported that higher fruits number was associated with the higher rates of nitrogen.

Weight of Single Fruit (g)

The results related to weight of single fruit (g) of tomato was significantly ($P<0.05$) influenced by different nitrogen fertilizer levels (Table **5**). The tomato crop supplied with highest level of nitrogen fertilizer (@150 N kg ha^{-1} resulted in more weight of single fruit on average (46.50 g); followed by the crop supplied with nitrogen fertilizers @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} producing 44.57, 42.00 and 38.76 g weight of single fruits, respectively. The crop given nitrogen fertilizer @30 N kg ha^{-1} showed decline in weight of single fruit (35.55 g); while the lowest weight of single fruit (21.22 g) was noted in control (untreated), where no nitrogen fertilizer was given to experimental tomato crop. The weight of single fruit is one of the most influencing traits that contribute to final yield; and this trait in tomato is mainly guided by the genetic makeup of a variety. However, the effect of nutrients compulsorily required for plant growth and fruit development is more dominant. It can be observed from the current study that the crop supplied with higher nitrogen levels produced heavier fruits than that of supplied with lower nitrogen levels; and with each decrease in nitrogen fertilizers rate than 150 N kg ha^{-1}, the fruits were decreased quantitatively. These results are in accordance with those of [17-19], who were of the experience that increase in the fertility levels produced heavier fruits.

Yield Plot^{-1} (kg)

The results demonstrated that the various doses of N showed significant effect ($P<0.05$) on yield plot^{-1} (kg).

Table 5: Weight of Single Fruit (g) of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	21.15	21.16	21.35	21.22 F
T_2=30 N kg ha^{-1}	35.16	36.00	35.50	35.55 E
T_3=60 N kg ha^{-1}	38.50	39.00	38.80	38.76 D
T_4=90 N kg ha^{-1}	42.00	43.00	41.00	42.00 C
T_5=120 N kg ha^{-1}	45.21	45.50	43.00	44.57 B
T_6=150 N kg ha^{-1}	46.00	46.5	47.00	46.50 A

S.E. 0.5754.
LSD 0.05 1.2821.
CV% 1.85.

Table 6: Yield Plot^{-1} (kg) of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	4.85	4.86	4.84	4.85 F
T_2=30 N kg ha^{-1}	10.68	10.68	10.70	10.68 E
T_3=60 N kg ha^{-1}	13.58	13.57	13.57	13.57 D
T_4=90 N kg ha^{-1}	16.52	16.53	16.53	16.52 C
T_5=120 N kg ha^{-1}	20.27	20.28	20.28	20.27 B
T_6=150 N kg ha^{-1}	21.01	21.02	21.01	21.01 A

S.E. 6.6113.
LSD 0.05 0.0147.
CV% 0.06.

The tomato crop fertilized with highest level of nitrogen fertilizer (150 N kg ha^{-1}) resulted in highest fruit yield plot^{-1} (21.01 kg); followed by the crop supplied with nitrogen fertilizer @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} producing 20.27, 16.52 and 13.57 kg fruit yield plot^{-1}, respectively (Table **6**). The crop given nitrogen fertilizer @30 N kg ha^{-1} produced declined yield plot^{-1} (10.68 kg); while the lowest yield plot^{-1} (4.85 kg) was observed in control (untreated), where no nitrogen fertilizer was applied to plants (Table **6**).

Fruit Yield (Tons ha^{-1})

The fruit yield (tons ha^{-1}) is calculated on the basis of fruit yield per plot. The results indicated that the fruit yield ha^{-1} was significantly influenced by varying levels of nitrogen fertilizers ($P<0.05$). The crop supplied with highest level of nitrogen fertilizer (150 N kg ha^{-1}) produced highest fruit yield ha^{-1} (14008 tons); followed by the crop supplied with nitrogen fertilizer @120 N kg ha^{-1}, 90 N kg ha^{-1} and 60 N kg ha^{-1} producing 13518, 11018 and 9048 tons fruit yield ha^{-1}, respectively (Table **7**). The crop given nitrogen fertilizer @30 N kg ha^{-1} produced lower fruit yield ha^{-1} (7125 tons); while the lowest fruit yield ha^{-1} (3237 tons) was recorded in control (untreated), where no nitrogen fertilizer was given to experimental field (Table **7**). The fruit yield is a dependent character that is influenced by plant height, branches per plant, number of fruits per plant and weight of single fruit. The yield is mainly guided by status of the soil for essentially required nutrients; but the genetic makeup of the varieties can also modify this trait. However, the effect of nutrients on fruit yield is more dominant. In the current study, the higher fruit yield per hectare (ha-^{1}) in tomato fertilized with higher nitrogen level was mainly associated with more branches per plant, more fruits per plant, higher single fruit weight than that of supplied with lower nitrogen level. These results are in accordance with those of [20-23] who were of the opinion that increase in the fertility levels produced heavier fruit yield tons ha^{-1}.

CONCLUSION

It was concluded that the crop growth and productivity was significantly influenced by various levels of nitrogen. However, 150 N kg ha^{-1} and 120 kg ha^{1} considerably displayed better performance in terms of vegetative and reproductive traits of tomato. Hence for optimum growth and economically higher yield, the tomato crop may be fertilized with 150 N kg ha^{-1}.

Table 7: Yield (Tons ha^{-1}) of Tomato as Affected by Varied Nitrogen Levels

Treatments	RI	RII	RIII	Mean
T_1= control (untreated)	3235	3240	3237	3237 F
T_2=30 N kg ha^{-1}	7121	7123	7130	7125 E
T_3=60 N kg ha^{-1}	9050	9045	9048	9048 D
T_4=90 N kg ha^{-1}	11016	11021	11018	11018 C
T_5=120 N kg ha^{-1}	13516	13520	13518	13518 B
T_6=150 N kg ha^{-1}	14005	14010	14008	14008 A

S.E. 2.2344.
LSD 0.05 4.9786.
CV% 0.03.

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