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Effect of Nitrogen and Phosphorus on tomato (*Solanum lycopersicum* L.) grown under polyhouse condition

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ABSTRACT
The present investigation entitled "Effect of nitrogen and phosphorus on tomato (Solanum lycopersicum L.) grown under polyhouse condition" was conducted during Rabi 2015-16 at the polyhouse, Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab, India. The experiment was laid out in a randomized block design with three replications and seven treatments. The treatments consisted of T_1: Control, T_2: 100% Nitrogen, T_3: 100% Phosphorus, T_4: 75% Nitrogen, T_5: 75% Phosphorus, T_6: 100% Nitrogen + 75% Phosphorus, T_7: 75% Nitrogen + 100% Phosphorus. Application of different levels of nitrogen and phosphorus fertilizer significantly increased the growth and yield of tomato. The minimum days to 50 per cent flowering and days to first picking were recorded with the combined application of 100 per cent Nitrogen and 75 per cent Phosphorus. Maximum number of flowers cluster^{-1}, number of fruits cluster^{-1}, plant height, harvest index, number of fruits plant^{-1} and fruit yield hectare^{-1} content were recorded with the combined application of 100 per cent Nitrogen + 75 per cent Phosphorus. Whereas, maximum harvest duration, fruit length, fruit diameter and average fruit weight, were recorded with the conjoint application of 75 per cent Nitrogen + 100 per cent Phosphorus. These results suggested that the optimum production of tomato can be obtained with integrated application of 100 per cent Nitrogen + 75 per cent Phosphorus. Therefore, application of 100 per cent Nitrogen and 75 per cent Phosphorus may be suggested after on-farm testing for commercial cultivation of tomato for getting higher fruit yield with maximum net returns per unit area.
KEYWORDS: *Nitrogen, Phosphorus, Growth, Yield, Quality, Tomato, Polyhouse*

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INTRODUCTION

Tomato is known as protective food is being extensively grown all over the world both for fresh market and processing. Tomato has originated in Peru, Latin America (Villareal, 1979). It has taproot and growth habit of the plant is determinate, semi-determinate and indeterminate (Reddy *et al.,* 2013). Tomato production has increased in both open field and greenhouse in recent decades and about 14 per cent of the world's vegetable production is accounted for tomato (Henareh, 2015). Tomato is an important cash generating crop for small scale farmers and also provides employment opportunities in production and processing industries (Meena *et al.,* 2015). Lycopene is the principal carotenoid, causing the characteristic red colour of tomatoes used in treating various chronic human diseases like cancer, cardiovascular diseases, osteoporosis and diabetes. The red pigment (lycopene) in tomato is now being considered as the "world's most powerful natural antioxidant". Therefore, tomato is one of the most important "protective foods" because of its special nutritive value (Shankar *et al*., 2013). The fertilizer application is one of the most important factors for obtaining economical yield of tomato. Nitrogen and phosphorus are the two essential macronutrients to crops which improve their growth, yield and product quality (Chen *et al.,* 2008). Nitrogen enhanced optimum utilization of phosphorus and potassium. Phosphorus termed as the "key of life" for plant because of its direct involvement in most life processes (Amapu, 1998). Therefore it is necessary to increase the productivity of the present vegetable crops. Protected cultivation or controlled environment agriculture (CEA) is a total concept of modifying the natural environment for optimum health growth (Sirohi, 2002). The aim of protected cultivation is to achieve independence of climate and weather to allow crop production in the area where the natural environment limits or prohibits plant growth (Lorenzo *et al.,* 2005).

MATERIALS AND METHODS

The trial was conducted during *Rabi* season 2015 and 2016 at the polyhouse, Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab. The experiment was laid out in Randomized Block Design (RBD) with three replications and seven treatments along with control viz., T_1: Control, T_2: 100% Nitrogen T_3: 100 % Phosphorus T_4: 75% Nitrogen T_5: 75% Phosphorus T_6: 100% Nitrogen + 75% Phosphorus and T_7: 75% Nitrogen + 100% Phosphorus. The recommended doses of nitrogen (N), phosphorus (P) and potash (K) are 125, 62.5 and 62.5 kg ha^{-1}, respectively for tomato as per recommendation of Punjab Agricultural University (PAU), Ludhiana in its Package of Practices for cultivation of Vegetables (Anonymous, 2015).

RESULTS AND DISCUSSION

As early flower initiation leads to the early fruit formation and consequently helps in timely maturation of crop. Significant differences were observed among all the treatments after analysis of variance (Table 1) for days taken to 50 per cent flowering. Minimum days to 50 per cent flowering (30.33 days) were observed in the treatment T_6 (100% Nitrogen + 75% Phosphorus). This might be due to fact that higher content of nitrogen accelerated protein synthesis, photosynthesis and carbohydrate production which promotes earlier floral primordia development. The minimum days to first flowering appearance by the application of nitrogen and phosphorus might be due to the availability of nitrogen and phosphorus has positive effect, especially of phosphorus, on flower initiation and on its formation Kumar *et al.* (2013). These findings are conformity with findings of earlier reported by Balemi (2008) in tomato.

It is evident from the data presented in table 1 that different treatments showed significant effects on number of flowers $cluster^{-1}$ and number of fruit $cluster^{-1}$. Number of flowers $cluster^{-1}$ ranged from 5.69 to 6.20. Maximum number of flowers $cluster^{-1}$ (6.20) and maximum number of fruits $cluster^{-1}$ (5.42) was observed in treatment T_6 *i.e.* 100 per cent Nitrogen + 75 per cent Phosphorus. It may be due to the availability of nitrogen and phosphorus has positive effect, especially of phosphorus, on flower initiation and on its formation. By the supplied of major nutrients such as nitrogen and phosphorus resulted better performance in fruit formation (Balemi, 2008). Another possible reason may be due to with the increment supply of essential nutrients to tomato, there availability, acquisition, mobilization and influx into the plant tissues increased and thus improved of numbers of flower $cluster^{-1}$ and numbers of fruits $cluster^{-1}$ (Shukla *et al.,* 2009). Similar results have also been reported by Haque *et al.* (2011) in tomato.

Significant differences were observed after analyzing (Table 1) the data among all the treatments on days to first picking. Minimum days for first picking (63.67 days) were observed in treatment T_6 (100% Nitrogen + 75% Phosphorus). It may be due to vigour of plant by the uptake and utilized soil nutrients for their vegetative and reproductive growth. According to Aminifard *et al*. (2012) stated that it might be due to nitrogen enhanced the reproductive growth that were in agreement with findings of Satpal and Saimbhi (2003), Nawaz *et al*. (2012), Hozhbryan (2013) and Kumar *et al*. (2013) in tomato.

Table 1: Effect of nitrogen and phosphorus application on growth characteristics of tomato cv. Himsona

Treatment	Days to 50% flowering	Number of flowers $cluster^{-1}$	Number of fruits $cluster^{-1}$	Days to first picking	Plant height (m)	Harvest duration (Days)	Harvest index (%)
T1 : Control	39.67	5.69	4.27	72.00	2.30	74.33	69.71
T2 : 100% Nitrogen	37.67	5.80	4.94	70.33	2.58	76.00	77.36
T3 : 100% Phosphorus	32.67	5.90	5.08	68.00	2.41	77.67	75.83
T4 : 75% Nitrogen	34.00	5.86	5.03	69.33	2.54	77.00	75.90
T5 : 75% Phosphorus	34.67	5.95	5.18	67.00	2.36	79.33	74.88
T6 : 100% Nitrogen + 75% Phosphorus	30.33	6.20	5.42	63.67	2.65	81.00	78.29
T7 : 75% Nitrogen + 100% Phosphorus	31.67	6.13	5.30	65.33	2.59	82.33	77.93
SE (m) ±	0.40	0.01	0.02	0.39	0.01	0.31	0.22
CD (0.05)	1.22	0.04	0.06	1.20	0.04	0.95	0.68
CV (%)	2.16	0.33	0.64	1.03	0.94	0.65	0.49

Height of the plant is one of the most important factor determining yield and harvest duration in many indeterminate varieties of tomato. A perusal of the data revealed that there was significant effect of various treatments on plant height. Maximum plant height (2.65 m) was observed in treatment T_6 (100% Nitrogen + 75% Phosphorus). The increase in plant height by application of nitrogen along with phosphorus might be due to the availability of adequate supply of nitrogenous compound to the plant, which increases the foliage of the plant and there by increases the photosynthesis. The adequate supply of the three major nutrients nitrogen, phosphorus and potassium is expected to regulate plant physiological functions and morphological responses favourably (Shree *et al*., 2014). These findings are also conformity with the findings earlier reported by Singh and Sangama (2000) who reported that phosphorus is a constituent of nucleoprotein, known to play a leading role in photosynthesis, cell division and tissue formation. It might be due to availability of nitrogen and there uptake that progressively enhanced the vegetative growth of the plant (Ewulo *et al*., 2015) in tomato. These findings are agreement with the findings earlier reported by Solaiman and Rabbani (2006) in tomato Singh and Kumar (2010) and Haque *et al*. (2011).

Prolonged and extended harvest duration is preferred under Indian conditions. This ensures continuous supply of the produce over a long period of time. Furthermore, it avoids glut in the market on one hand and increase profit on the other. This trend is also desirable to catch early market thus ensures higher returns to small and marginal farmers. A perusal of the data revealed that there was significant effect of various treatments on harvest duration. Maximum days for harvest duration (82.33 days) were observed in 75% Nitrogen + 100% Phosphorus. This increase in harvest duration due to application of nitrogen resulted in greater assimilation of carbohydrates in plant, which would have increases duration of harvesting. The another possible reason may be due to the fact that application of nitrogen along with phosphorus in which nitrogen stimulated increases in yield and are associated with extended fruit development period and increased fruit sink capacity in plant Chatzitheodorou *et al.* (2004). These findings are similar with the results reported by Gene *et al.* (2010) in melon.

Table 2: Effect of nitrogen and phosphorus application on quantitative characters of tomato cv. Himsona

Treatment	Number of fruits plant^{-1}	Fruit length (mm)	Fruit diameter (mm)	Average fruit weight (g)	Fruit yield (kg plant^{-1})	Fruit yield (q ha^{-1})
T1 : Control	14.87	37.04	45.18	55.28	1.14	536.76
T2 : 100% Nitrogen	19.12	40.76	49.59	61.80	1.83	864.17
T3 : 100% Phosphorus	18.18	40.87	48.50	59.45	1.72	810.65
T4 : 75% Nitrogen	18.02	39.57	47.89	58.23	1.69	798.06
T5 : 75% Phosphorus	17.24	38.61	47.38	58.66	1.58	744.54
T6 : 100% Nitrogen + 75% Phosphorus	20.54	44.17	52.49	63.22	1.99	938.15
T7 : 75% Nitrogen + 100% Phosphorus	19.95	44.84	53.85	64.10	1.94	914.54
SE (m) ±	0.24	0.32	0.24	0.32	0.03	15.08
CD (0.05)	0.75	0.99	0.73	0.97	0.10	46.47
CV (%)	2.13	1.24	0.76	0.85	2.86	2.86

Maximum harvest index was recorded in T_6 (100% Nitrogen + 75% Phosphorus). Harvest index is higher due to higher plant dry biomass and fruit yield plant^{-1} by the effect of nitrogen and phosphorus fertilizers. The plant biomass increased might be due to the fundamental involvement of nitrogen, phosphorus and potassium in the large number of enzymatic reactions as well as other metabolic, energy transfer and biological processes which hasten cell division and growth in plants. Another possible reason may be due to fruit yield plant^{-1} increased with the application of nitrogen and phosphorus it is due to the more carbohydrate production and assimilation in fruit by the effect of nutrients supplied (Bidari and Hebsur, 2011). According to Rao *et al.* (2014) with increasing in nitrogen it might have assisted to greater photosynthesis and nitrogen being a basic constituent of protoplasm and chloroplast might have stimulated meristematic growth and thus increased the growth of plant and increases plant weight. Ultimately harvest index depends upon fruit yield plant^{-1} and same plant dry biomass. Similar finding are obtained from Baloch *et al.* (2014) in radish.

Number of fruits range varied between 14.87 to 20.54 fruits plant^{-1}. Maximum number of fruits plant $^{-1}$ (20.54) was observed in treatment T_6 (100% Nitrogen + 75% Phosphorus). It might be due to vigour of plant by uptake and utilized soil nutrients for the vegetative and reproductive growth. Increasing fruit number with increasing level of nitrogen along with phosphorus is probably due to the fact that nitrogen is the element to be absorbed in larger quantity of plants of Solanaceae family (Campos *et al.,* 2008) which were in agreement with the findings of Oliveira *et al.* (1999) who stated that nitrogen is fundamental of

growth and development of plants. Similar results were obtained from Solaiman and Rabbani (2006), Mahato *et al.* (2009) and Kumar *et al.* (2010) in tomato.
Maximum fruit length (44.84 mm) and fruit diameter (53.85 mm) was recorded in T_7 (75% Nitrogen + 100% Phosphorus). It might be due to vigour of plant by the uptake and utilized soil nutrients for the vegetative and reproductive growth. Another possible reason may be due to the increment in supply of essential nutrients to plant, their availability, mobilization and influx into the plant tissues increased and thus improved fruit size (Shukla *et al.*, 2009). According to Kumar *et al.* (2013) it may be due to nitrogen and phosphorus nutrition when supplied at adequate quantity promotes flowering and fruit setting with uniform fruit size but excess dose of nitrogen and phosphorus delayed fruit maturity and decreased fruit size. Present result was conformity with the findings earlier reported by Solaiman and Rabbani (2006), Kumar *et al.* (2010) and Ilupeju *et al.* (2015) in tomato.
Maximum average fruit weight (64.10 g) was recorded in treatment T_7 (75% Nitrogen + 100% Phosphorus). It may be due to the fact that the nitrogen and phosphorus rate has positive effect especially of phosphorus has positive effect on fruit weight. Nitrogen has a pronounced effect on growth and development of tomato. Another possible reason may be due to cumulative stimulating effect of nitrogen and phosphorus on vegetative growth, which forms the base for flowering and fruiting (Aminifard *et al,* 2012). These results are conformity with finding of Balemi (2008) and Fandi *et al.* (2010) in tomato and Zewide *et al.* (2012) in case of potato crop.
The main objective of cultivation of a crop is to have maximum marketable yield for better returns. Fruit yield is the ultimate objective for which different trials are conducted. Maximum fruit yield (938.15 q ha^{-1}) was obtained in treatment T_6 (100% Nitrogen + 75% Phosphorus) which was statistically at par with treatment T_7 (75% Nitrogen + 100% Phosphorus) with the value of 914.54 quintals fruit yield ha^{-1}. Higher yield with the level of nitrogen and phosphorus was may be due to better fertilizer responsiveness of the tomato crop (Mishra *et al.,* 2004). According to Aminifard *et al.* (2010) it may be due to the base of flowering and fruiting formed by cumulative stimulating effect of nitrogen on the vegetative growth characters. Another possible reason might be due to the more carbohydrate production and assimilation in fruit by the effect of nitrogen, phosphorus and potassium reported by Bidari and Hebsur (2011). Similar findings were obtained by Ahmad and Butt (1999) in tomato, Baloch *et al.* (2014) in radish. Therefore, application of 100 per cent Nitrogen and 75 per cent Phosphorus may be suggested after on-farm testing for commercial cultivation of tomato for getting higher fruit yield with maximum net returns per unit area.

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