PERFORMANCE OF CHERRY TOMATO [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] UNDER OPEN FIELD AND POLYHOUSE CONDITIONS WITH VARIED LEVELS OF NITROGEN AND PHOSPHORUS FERTIGATION

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PALB 5247

DEPARTMENT OF HORTICULTURE

UNIVERSITY OF AGRICULTURAL SCIENCES

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Thesis submitted to the

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MASTER OF SCIENCE (Agriculture)

in

HORTICULTURE

BENGALURU **December, 2017**

AFFECTIONATELY
DEDICATED TO MY
PARENTS
&
GRANDPARENTS

DEPARTMENT OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
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CERTIFICATE

This is to certify that the thesis entitled "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" submitted by **Mr. ARSHAD, I D. No. PALB 5247** for the award of degree of **Master of Science (Agri.) in HORTICULTURE** to the University of Agricultural Sciences, Bangalore is a record of research work done by him during the period of his study in this university under my guidance and supervision. This thesis has not previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Bengaluru
December, 2017

(N.C. NARASE GOWDA)
Major advisor

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(THIMMEGOWDA, M.N)

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*……………..****any omission in this brief acknowledgement does not mean lack of gratitude.***

December, 2017

Bengaluru ***(Arshad)***

PERFORMANCE OF CHERRY TOMATO [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] UNDER OPEN AND POLYHOUSE CONDITIONS WITH VARIED LEVELS OF NITROGEN AND PHOSPHORUS FERTIGATION

ARSHAD

ABSTRACT

The investigation on "Performance of cherry tomato [*Solanum lycopersicum* L *var. cerasiforme* (Dunnal) A. Gray] under open and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" was carried out at the Department of Horticulture, University of Agricultural Sciences, Bangalore during *summer* 2017. There were 12 treatment combinations comprising of two growing conditions (open field and polyhouse), three levels of nitrogen (120, 150 and 180 kg N ha^{-1}) and two levels of phosphorus (100 and 120 kg P_2O_5 ha^{-1}) supplied through fertigation with recommended potassium (150 kg ha^{-1}) as a common dose. The experiment was laid out in Factorial Randomized Complete Block Design with three replications. Result revealed that plant height and number of leaves per plant at 120 DAT (384.39 cm and 49.33 respectively), fresh and dry weights (3.00 kg and 446.51 g $plant^{-1}$, respectively), nitrogen balance index (48.56), total leaf area per plant (6293 cm^2), mean fruit weight (15.84 g), TSS content (6.30 ºB), shelf life (15.66 days) and uptake of nitrogen, phosphorus and potassium (181.41, 30.72 and 159.88 kg ha^{-1} respectively) were significantly higher under polyhouse condition with fertigation level of 180:120 kg N:P_2O_5 ha^{-1} ($C_1N_3P_2$). However, significantly higher number of fruits per plant (316.63), yield per plant (4.46 kg), yield per hectare (78.16 t), Shelf life (15.66 days), net returns ha^{-1} (Rs.1294081) and cost benefit ratio (4.81) were observed under open field condition with fertigation level of 150:120 kg N: P_2O_5 ha^{-1} ($C_2N_2P_2$). Further, it can be concluded from the study that application of 150:120 kg N: P_2O_5 ha^{-1} through fertigation under open field condition is profitable especially during summer season in the Eastern Dry Zone of Karnataka.

December, 2017

Department of Horticulture | **(N.C. NARASE GOWDA)**

UAS, GKVK, Bengaluru- 65 | Major Advisor

ಹಸಿರು ಮನೆ ಮತ್ತು ಹೊರ ವಾತಾವರಣದಲ್ಲಿ ಚೆರ್ರಿ ಟೊಮೋಟೊ *(ಸೊಲಾನಮ್ ಲೈಕೋಪರ್ಸಿಕಮ್* ಎಲ್. ತಳ *ಸೆರಸಿಪಾರ್ಮೆ* (ದುನ್ನಲ್) ಎ. ಗ್ರೆಯ್) ದಲ್ಲಿ ವಿವಿಧ ಸಾರಜನಕ ಮತ್ತು ರಂಜಕದ ರಸಾವರಿ ಪ್ರಮಾಣದ ಪರಿಣಾಮ

ಅರ್ಶದ್

ಸಾರಾಂಶ

ಹಸಿರು ಮನೆ ಮತ್ತು ಹೊರ ವಾತಾವರಣದಲ್ಲಿ ಚೆರ್ರಿ ಟೊಮೋಟೊ *(ಸೊಲಾನಮ್ ಲೈಕೋಪರ್ಸಿಕಮ್* ಎಲ್. ತಳ *ಸೆರಸಿಪಾರ್ಮೆ* (ದುನ್ನಲ್) ಎ. ಗ್ರೆಯ್) ದಲ್ಲಿ ವಿವಿಧ ಸಾರಜನಕ ಮತ್ತು ರಂಜಕದ ರಸಾವರಿ ಪ್ರಮಾಣಗಳ ಸಂಶೋಧನೆಯನ್ನು ತೋಟಗಾರಿಕೆ ವಿಭಾಗ, ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರಿನಲ್ಲಿ 2017 ರ ಬೇಸಿಗೆಯಲ್ಲಿ ನಡೆಸಲಾಯಿತು. ಈ ಸಂಶೋಧನೆಯು 12 ಉಪಚಾರಗಳನ್ನೊಳಗೊಂಡಿದ್ದು, ಇದರಲ್ಲಿ ಎರಡು ವಿಧದ ವಾತಾವರಣ (ಹೊರಗೆ ಹಾಗೂ ಹಸಿರು ಮನೆ), ಮೂರು ಪ್ರಮಾಣದ ಸಾರಜನಕ (120, 150 ಮತ್ತು 180 ಕಿ.ಗ್ರಾಂ/ ಹೆ) ಹಾಗೂ ಎರಡು ಪ್ರಮಾಣದ ರಂಜಕ (100 ಮತ್ತು 120 ಕಿ.ಗ್ರಾಂ/ಹೆ) ಉಪಚಾರಗಳನ್ನು ಶಿಫಾರಸ್ಸು ಮಾಡಿದ ಪೊಟ್ಯಾಸಿಯಮ್ (150 ಕಿ.ಗ್ರಾಂ/ಹೆ) ನ ಜೊತೆ ರಸಾವರಿಯಲ್ಲಿ ನೀಡಲಾಯಿತು. ಈ ಪ್ರಯೋಗವನ್ನು ಫ್ಯಾಕ್ಟೋರಿಯಲ್ ರ್‍ಯಾಂಡಮೈಸಡ್ ಕಂಪ್ಲೀಟ್ ಬ್ಲಾಕ್ ಡಿಸೈನ್ (ಏಫ್. ಆರ್.ಸಿ.ಬಿ.ಡಿ) ವಿನ್ಯಾಸದಲ್ಲಿ ಮೂರು ಬಾರಿ ಪುನರಾವರ್ತನೆಯೊಂದಿಗೆ ಅಭ್ಯಾಸಿಸಲಾಯಿತು. ಇದರಿಂದ ಕಂಡುಬಂದ ಫಲಿತಾಂಶಗಳೆಂದರೆ ಹಸಿರು ಮನೆಯಲ್ಲಿ ರಸಾವರಿ ಮೂಲಕ 180: 120 ಕಿ.ಗ್ರಾಂ/ಹೆ ಸಾರಜನಕ: ರಂಜಕ ನೀಡಿದ ಉಪಚಾರದಲ್ಲಿ ಗರಿಷ್ಠ ಗಿಡದ ಉದ್ದ (384.39 ಸೆಂ. ಮೀ.), ಎಲೆಗಳ ಸಂಖ್ಯೆ (49.33), ಹಸಿ ಗಿಡದ ಒಟ್ಟು ತೂಕ (3.00 ಕಿ.ಗ್ರಾಂ), ಒಣ ಗಿಡದ ಒಟ್ಟು ತೂಕ (446.51 ಗ್ರಾಂ), ಸಾರಜನಕದ ಸಮತೋಲನತೆ (48.56), ಮತ್ತು ಎಲೆಗಳ ವಿಸ್ತೀರ್ಣ (6293 ಚ.ಸೆಂ. ಮೀ) ದಾಖಲಾಗಿದೆ. ಇದೇ ಉಪಚಾರದಲ್ಲಿ ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದ ಸರಾಸರಿ ಹಣ್ಣಿನ ತೂಕ (15.84 ಗ್ರಾಂ), ಪೂರ್ತಿಯಾಗಿ ಕರಗುವ ಸಕ್ಕರೆ ಅಂಶ (6.30° ಬ್ರಿಕ್ಸ್), ಸಂಗ್ರಹಣಾ ಅವಧಿ (15.66 ದಿನಗಳು) ಹಾಗೂ ಸಂಗ್ರಹಣೆಯ ಸಾರಜನಕ, ರಂಜಕ ಮತ್ತು ಪೊಟ್ಯಾಷಿಯಂ (181.41, 30.72 ಮತ್ತು 159.88 ಕಿ.ಗ್ರಾಂ/ಹೆ) ಕ್ರಮವಾಗಿ ದಾಖಲಾಗಿದೆ. ಆದಾಗ್ಯೂ, ಪ್ರತಿ ಗಿಡದಲ್ಲಿ ಹೆಚ್ಚಿನ ಸಂಖ್ಯೆಯ ಹಣ್ಣುಗಳು (316.63), ಗಿಡದ ಇಳುವರಿ (4.46 ಕಿ.ಗ್ರಾಂ), ಹೆಕ್ಟೇರಿನ ಇಳುವರಿ (78.16 ಟನ್), ಸಂಗ್ರಹಣಾ ಸಾಮರ್ಥ್ಯ (15.66 ದಿನ), ಹೆಕ್ಟೇರಿಗೆ ನಿವ್ವಳ ಆದಾಯ (12,94,081 ರೂ.) ಮತ್ತು ಖರ್ಚು: ಲಾಭ ಅನುಪಾತವು (4.81) ಹೊರಗಿನ ವಾತಾವರಣದಲ್ಲಿ ರಸಾವರಿ ಮೂಲಕ 150:120 ಕಿ.ಗ್ರಾಂ ಸಾರಜನಕ: ರಂಜಕ ನೀಡಿದಾಗ ಉತ್ತಮವೆಂದು ಕಂಡುಬಂದಿದೆ. ಅಲ್ಲದೆ ಹೊರಗಿನ ವಾತಾವರಣದಲ್ಲಿ ರಸಾವರಿ ಮೂಲಕ 150:120 ಕಿ.ಗ್ರಾಂ ಸಾರಜನಕ:ರಂಜಕ ಹೆಕ್ಟೇರಿಗೆ ನೀಡುವುದರಿಂದ ಕರ್ನಾಟಕದ ಪೂರ್ವ ಒಣ ವಲಯದಲ್ಲಿ ಉತ್ತಮ ಲಾಭಗಳಸಬಹುದು.

ಡಿಸೆಂಬರ್, 2017 (ಎನ್.ಸಿ.ನರಸೇಗೌಡ)

ತೋಟಗಾರಿಕೆ ವಿಭಾಗ ಮುಖ್ಯ ಸಲಹೆಗಾರರು

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರು-65

Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation

ARSHAD AND N.C. NARASE GOWDA
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Introduction

- Cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] belongs to the Solanceae family which is a popular type of table tomato with small fruit, mostly used for table purpose. Cherry tomatoes are in great demand; the demand is mostly driven by processing industries due to its high nutritional value.
- Tomato responds well to the application of fertilizers and is reported to be a heavy feeder of NPK.
- Efficient use of fertilizer and water is highly critical to sustained agricultural production. In fertigation, nutrients are applied directly into the zone of maximum root activity and consequently fertilizer-use efficiency can be improved.

Objectives

- To study the effect of different levels of nitrogen and phosphorus and their interactions on growth, yield and quality of cherry tomato under open and polyhouse conditions.

Material and Methods

Crop and variety : Cherry tomato cv. Moscatel RZ F1

Agro climatic zone : Eastern Dry Zone of Karnataka

Location : Division of Horticulture, UAS(B), G.K.V.K

Season and Date of planting :Summer, 4th January 2017

Number of treatment combinations: 2x3x2= 12

Number of replications : 3

Design : Factorial RCBD

Spacing : 1.2m x0.45m

Plot size : 5.4 m x 1.2 m = 6.48 sq.m

No. of plants / plot / replication : 12

Treatment details:

T_1- $C_1N_1P_1$: 120:100 kg N & P_2O_5 ha^{-1}

T_2- $C_1N_1P_2$: 120:120 kg N & P_2O_5 ha^{-1}

T_3- $C_1N_2P_1$: 150:100 kg N & P_2O_5 ha^{-1}

T_4- $C_1N_2P_2$: 150:120 kg N & P_2O_5 ha^{-1}

T_5- $C_1N_3P_1$: 180:100 kg N & P_2O_5 ha^{-1}

T_6- $C_1N_3P_2$: 180:120 kg N & P_2O_5 ha^{-1}

T_7- $C_2N_1P_1$: 120:100 kg N & P_2O_5 ha^{-1}

T_8- $C_2N_1P_2$: 120:120 kg N & P_2O_5 ha^{-1}

T_9- $C_2N_2P_1$: 150:100 kg N & P_2O_5 ha^{-1}

T_{10}- $C_2N_2P_2$: 150:120 kg N & P_2O_5 ha^{-1}

T_{11}- $C_2N_3P_1$: 180:100 kg N & P_2O_5 ha^{-1}

T_{12}- $C_2N_3P_2$: 180:120 kg N & P_2O_5 ha^{-1}

Potassium @ 150 kg ha^{-1} is common for all combinations

Note: C_1 : Polyhouse condition, C_2 : Open condition

Experimental Results

Table 1: Interaction effect of nitrogen and phosphorus levels on vegetative and reproductive parameters of cherry tomato under open and polyhouse conditions.

Treatments	Plant height (cm) @ 60 DAT	No. of leaves per plant @ 60 DAT	No. of clusters per plant @ 70 DAT	No. of flowers per plant @ 70 DAT
C_1N_1	238.33^{c}	64.93^{cd}	9.38^{a}	147.94^{a}
C_1N_2	242.30^{c}	68.50^{e}	13.38^{c}	215.94^{c}
C_1N_3	238.46 ^{c}	66.70^{de}	12.55^{c}	193.94^{c}
C_2N_1	167.46^{a}	57.80^{a}	11.05^{b}	171.77^{b}
C_2N_2	179.90^{b}	62.06^{bc}	10.66^{b}	163.60^{b}
C_2N_3	179.56^{b}	61.23^{b}	10.66^{b}	166.94^{b}
C.D.(p=0.05)	4.63	NS	1.16	22.01

Table 2: Interaction effects of nitrogen and phosphorous levels on vigor and yield of cherry tomato.

Treatments	Chlorophyll content (µg/cm^2)	Flavanols Content (µg/cm^2)	N. balance index	Yield/ plant (kg)
N_1P_1	28.88^{d}	0.65^{ab}	41.84	1.35^{ab}
N_1P_2	26.03^{ab}	0.68^{ab}	39.66	1.25^{a}
N_2P_1	26.24^{abc}	0.70^{ab}	38.29	1.30^{ab}
N_2P_2	27.77^{abc}	0.63^{a}	39.27	1.44^{b}
N_3P_1	26.99^{abcd}	0.63^{a}	38.34	1.33^{ab}
N_3P_2	25.84^{a}	0.76^{b}	38.14	1.28^{ab}
C.D.(p=0.05)	2.44	NS	NS	0.17

- Treatment combination of C_1N_2 *i.e.,* polyhouse with 150 kg N/ha., resulted in highest plant height, no. of clusters and flowers per plant (242.3 cm, 13.38 and 215.94, respectively) and it was at par with C_1N_3 (238.46 cm, 12.55 and 193.94 , respectively).
- Significantly highest chlorophyll content (28.88 ug/cm^2) was observed in the interaction combination of N_1P_1 *i.e.,* 120 kg of N and 100 kg of P_2O_5 /ha and it was at par with the treatment combination of N_3 P_1 (26.99) .
- Significantly highest yield / plant (1.44 kg) and yield per ha. (26.92 t) was observed in N_2P_2 *i.e.,* N at 150 kg /ha. and P_2O_5 at 120 kg / ha. and it was at par with N_1P_1, N_2P_1, N_3P_1 and N_3P_2.

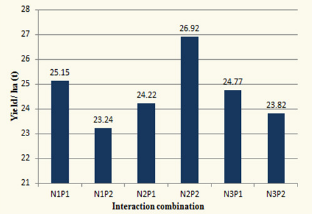

Fig.1: Interaction effect of nitrogen and phosphorus levels on yield / ha. of cherry tomato

Plate 1: General view of cherry tomato grown under polyhouse condition

Plate 2: General view of cherry tomato grown under open field condition

Discussion

- Increased growth and reproductive parameters under C_1N_2 *i.e.,* Polyhouse condition with higher nitrogen levels could be due to favorable climatic conditions under protected structure with optimum nitrogen supply which has increased the rate of metabolism.
- Increased yield per plant and per ha., under interaction levels of N_2 P_2 (150:120 kg N & P_2O_5 / ha.) (Table 2 and Fg..1) might be due to optimum combination of nitrogen and phosphorus resulting in a favorable source to sink ratio.

Summary

- Cultivation of cherry tomato under polyhouse condition with optimum levels of nitrogen (C_1N_2) has resulted significantly higher plant height, no. of clusters and flowers per plant. Further, interaction combination of optimum levels of nitrogen and phosphorus levels N_2P_2 (150:120 kg N & P_2O_5) recorded higher yield per plant and hectare.

Advisory committee

Chairperson: Narase Gowda, N.C.

Members : Sreeramu, B.S.

Prakash, N.B.

Thimme Gowda, M.N.

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LIST OF SYMBOLS AND ABBREVIATIONS USED

1	DAT	Days after transplanting
2	pH	Potential of Hydrogen
3	EC	Electrical conductivity
4	dS m^{-1}	Decisiemen per meter
5	mS/cm	Millisiemen per centimeter
6	C.D.	Critical Difference
7	S.Em.	Standard Error of Mean
8	*et al.*	Et alii (and other)
9	*viz.*,	Namely
10	*i.e.*,	Id est (that is)
11	m	Meter
12	cm	Centimeter
13	g	Gram
14	mm	Millimeter
15	kg/ha	Kilogram per hectare
16	t	Tonnes
17	ug/cm^2	Microgram per centimeter squire
18	^oC	Degree Celsius
19	Fig.	Figure
20	GI	Galvanized Iron
21	cv.	Cultivare
22	L	Litre
23	T	Treatment
24	N,P,K	Nitrogen, Phosphorus, Potassium
25	RDF	Recommended dose of fertilizers
26	FYM	Farm yard manure
27	@	At the rate
28	%	Per cent
29	Rs.	Rupees
30	/	Per
31	&	And

I. INTRODUCTION

Cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] is a botanical form of cultivated tomato. Cherry tomatoes are characterized by their small size fruits, bright red colour resembling a cherry and excellent taste. They are becoming popular in the retail chains and are marketed at a premium price compared to regular tomato. They are joining the growing market of mini vegetables and are one of the most promising differentiated products. Cherry tomato often called 'salad tomato'. Its fruits are consumed more as a fruit rather than as a vegetable and are perfect for making processed products like sauce, soup, ketchup, puree, curries, paste, powder, rasam and sandwich.

Cherry tomato has good nutritional qualities such as total carbohydrates, sugars, protein, calcium and iron. They are a great source of vitamin C (13mg 100 g^{-1}), dietary fibre (2.0 g), vitamin A (25 %), vitamin K and also a good source of vitamin E (Alpha Tocopherol), thiamine, niacin, vitamin B_6, folate, phosphorus, copper, potassium and manganese. They are low in sodium and very low in total fat (0.3 g), saturated fat (0.1 g) and cholesterol (Renuka *et al*., 2015).

Although definitive data on area and production of cherry tomato is not available, the area under common tomato in the world is 4.42 million hectares with an annual production of about 120.38 million tonnes (Anon., 2004). In India, tomato has become an important vegetable crop and occupies an area of 882 thousand hectares with a production of 18735.9 thousand MT and the productivity is 21.2 MT ha^{-1} (Shilpa, 2016). In Karnataka, tomato occupies an area of 42,920 hectares with a production of 10.48 lakh tonnes among which, Bangalore and Kolar districts contribute nearly 35 per cent of production (Bineeth *et al*., 2004).

Efficient use of fertilizer and water is highly essential for sustainable horticulture and agriculture, in the context of declining per capita land, dwindling water resources, receding water table, increasing ecological disturbance and cost escalation of fertilizer. Pressure on agriculture is increasing due to population growth, necessitating efficient utilization of all these inputs in agriculture. India needs to produce about 300 million tons of food by 2020 to feed its growing population. As there is not much scope to expand the net cultivated area (142.5 million hectare), the future requirement has to be met through vertical growth by intensification of horticulture.

Greenhouse is a framed or inflated structure, covered with transparent or translucent materials and large enough to grow crops under partial or fully controlled environmental conditions to obtain optimum growth and production. Protected cultivation is a most contemporary approach to produce high value vegetables like tomato, capsicum, cucumber and flowers like gerbera, rose and carnation. These crops have shown tremendous potential quantitatively and qualitatively, extend the growing season of crop and fetches good market price during off season. These technologies not only create avenues at higher level, but also keep the growers with the smaller landholdings at the higher productivity levels and retain economic relevance to agriculture. Controlled environment agriculture (CEA) is highly productive, conservative of resources and also protective of the environment like the temperature, humidity, light. By adopting protected cultivation technology, the growers can look forward to a better and additional remuneration for high quality produce (Ughade *et al*. 2016). At present, cultivation of regular tomato is a wide spread practice in Karnataka. But, the cultivation of cherry tomato on commercial scale under both open and protected conditions has not been practiced so far by the farmers due to lack of awareness about its nutritional and market values.

Fertigation is a new concept that is being recently adopted in several horticultural crops. Inorganic fertilizers were probably the first chemicals to be injected into the drip irrigation system. Fertigation means fertilizers combined with irrigation and is one of the most effective and convenient means of supplying nutrients and water, according to specific requirement of the crop, whenever required, resulting in higher productivity and better quality produce. Fertigation is an excellent method of optimizing the utilization of water and nutrients to improve the sustainability of both poly house and open field tomato. It allows frequent, uniform and precise application of nutrients through drip directly into the zone of maximum root activity as per the crop need. In fertigation nutrient use efficiency could be as high as 90 per cent as compared to 40 per cent in conventional methods. Despite these improvements in the efficiency of fertilizer, the timing and rate of fertigation for tomato is far from optimal. The concentration of NPK of the nutrient solutions and the application time and intervals are of vital importance for adequate uptake and optimal growth of tomato (Ughade *et al*., 2016).

Fertigation has been found to increase the efficiency in the application of fertilizers and water. Besides, reduce the amount of fertilizers applied; this in turn, reduces the cost of production and also lessens the ground water pollution which causes ecological disturbance and health risks by fertilizer leaching and accumulation of nitrates. As such use of fertigation could really prove as a blessing for Indian farming and may pave the way for another green revolution and provide coveted support to boost horticulture and agriculture exports. Adaptation of advanced and efficient method of application of water and fertilizers through drip irrigation system would go a long way in economizing the scarce inputs; thus, realizing increased productivity of tomato in the state and elsewhere. Fertigation being a new concept in India, not many studies have been carried out for many vegetables. Thus, there is a need for standardization of the technology.

Fertigation is becoming more popular because of availability of high-grade completely water-soluble fertilizer materials. Very few attempts have been made to work out the optimum fertigation schedules for cherry tomato under both polyhouse and open field conditions. It is a well-established fact that macro nutrients such as nitrogen, phosphorus and potassium have profound effect on crop productivity and quality. Among these three essential nutrients nitrogen is an integral part of chlorophyll (the only energy synthesizing apparatus of plants), protoplasm, proteins and nucleic acids. Consequently its deficiency checks the growth and reduces the yield significantly. Phosphorus on the other hand, participates in energy transfer, early and prolific flowering, stimulates root growth, seed and fruit development, whereas, potassium is essential for number of biological reactions.

Keeping these points in view, a study on "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" was carried out with the following objectives.

1. To study the effect of different levels of nitrogen and phosphorus fertigation under open field and polyhouse conditions and their interactions on growth, yield and quality of cherry tomato production.
2. To study the effect of different levels of nitrogen and phosphorus fertigation under open field and polyhouse conditions and their interactions on uptake of NPK and their balance in soil of cherry tomato raised plots.
3. To work out the cost economics of different treatment combinations of nitrogen and phosphorus fertigation on cultivation of cherry tomato under open field and polyhouse conditions.

II. REVIEW OF LITERATURE

The experiment on "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" was conducted during summer-2017. Since not much work has been done on fertigation of cherry tomato, an attempt has been made to collect the available literature on various aspects of drip irrigation and fertigation of tomato and other vegetables. The literature available on different aspects is summarized under the following headings:

2.1 Impact of growing conditions on growth, yield and quality of tomato.

2.2 Drip irrigation in tomato.

2.3 Effect of N, P and K on growth, yield and quality of tomato.

2.4 Fertigation studies in tomato grown under protected conditions.

2.5 Fertigation studies in tomato grown under open field conditions.

2.6 Effect of fertilizer application rates in tomato.

2.7 Water and fertilizer use efficiencies.

2.8 Economics of drip irrigation and fertigation.

2.1 Impact of growing conditions on growth, yield and quality of tomato

Dinar and Rudich (1985) reported that, higher temperatures in the greenhouse affect several physiological and biochemical processes of tomato crop associated with yield reduction.

Abdul-Baki (1991) observed that, heat stress is one of the most important constraints for tomato crop which adversely affected both vegetative and reproductive processes resulting in reduced yields and fruit quality.

Papadopoulos and Ormrod (1991) studied two cultivars Jumbo and Ohio CR-6 under greenhouse and found that Jumbo recorded significantly higher rate of fruit set (44.00%) and number of clusters (5.04) than Ohio CR-6.

The plant growth and development at earlier stages was faster in plants under shade than open place (Chowdhury and Bhuyan, 1992).

Nimje and Shyam (1993) observed that, the relative humidity was higher inside the greenhouse than in the open field condition which resulted in increased infestation of vegetable crops.

The effects of temperature on plant growth and yield of tomato in poly-greenhouses and open field condition were investigated. Poly-greenhouse with ventilation gaps in the triangular roof and four sidewalls was found more suitable for better plant growth and yield of tomato than those with the other ventilation gaps in poly-greenhouses and open field condition (Ganesan, 2002).

Harmanto *et al*. (2005) stated that, the microclimatic conditions inside the greenhouse in tropical climate may be temporarily less favorable as compared to unprotected cultivation, but by making certain modifications in the area of ventilation, favorable microclimate can be achieved.

Plants grown under shade exhibited better growth in terms of plant height and dry matter production compared to those in open field. The hybrid Naveen was taller tallest both under shade and in open field. In general, delayed flowering, days to first harvest and lower yield was noticed under shade during summer (Thangam and Thamburaj, 2008).

Parvej *et al*. (2010) reported that, the microclimate variability inside the polyhouse favoured the growth and development of tomato plant by increasing plant height, number of branches plant^{-1}, rate of leaf area expansion and leaf area index over the plants grown in open field.

2.2 Drip irrigation in tomato

Razi and Burrage (1991) explained that the reduction in tomato leaf growth at high salinity was attributed to water stress and transpiration reduction which limits the growth and transfer of nutrients into the plants.

Branthome *et al.* (1994) investigated tomato plants under drip-irrigation at 0.7, 1.0, or 1.3 kpc and concluded that higher amounts of quality components such as acidity, colour, and total soluble solids were recorded under 0.7 kpc.

Obreza *et al.* (1996) stated that, 15 and 30 per cent irrigation reductions would reduce gross revenue by 15 and 22 per cent, respectively and concluded that deficit irrigation of tomatoes may result in substantial economic loss through decreased marketable yield of crop.

Yohannes and Todesse (1998) studied two types of emitters, self-compensating and inline emitters with a discharge of 0.9 and 1.2 liters hour^{-1}, respectively. No significant yield difference was found between two emitters in one of the two years of study.

Shivashankar *et al.* (1998) suggested that, fertigation provides a variety of benefits to the users such as increased crop productivity with quality, resource use efficiency, environmental safety, flexibility in field operations, effective weed management and successful crop cultivation on fields with undulating topography.

Findings of Yong (2000) indicated that, drip irrigation produced the highest yield of 60.3 t ha^{-1}, with low rate of virus infection and navel rot, followed by furrow irrigation under plastic mulch.

Scholberg *et al.* (2000) studied the growth and canopy characteristics of field grown tomato. Maximum LAI values ranged from 3.19 to 6.00 with sub irrigation and from 1.54 to 2.99 in drip irrigated plots. Maximum fruit yields of tomato appeared to be attained with LAI values of 4 to 5. Lower LAI values would reduce light interruption. Fruit dry weights were about 600 g plant^{-1} and 400 g plant^{-1} with sub irrigated and drip irrigated crops respectively. Final harvest indices on dry weight basis ranged from 0.53 to 0.71 with an average of 0.58.

Alizadeh *et al.* (2001) reported that, the highest yield (51 t ha^{-1}) was obtained from trickle irrigation with 100 per cent water application on salty loam soils of Iran. Irrigation at 75 and 50 per cent reduced total yields by 34.70 and 67.95 per cent respectively in trickle irrigation and by 27.57 and 64.29 per cent in furrow irrigation, respectively. Water use efficiency in trickle irrigation was two times higher than that with furrow irrigation.

A case study reported by Tu *et al.* (2004) revealed that, drip irrigation and drip fertigation significantly increased tomato yield compared with the untreated control and the percentage of tomato fruits with blossom end rot was significantly reduced to negligible levels in these drip irrigation treatments.

Malash *et al.* (2005) revealed that, the highest yield was obtained (3.2 kg $plant^{-1}$) with the combination of drip system and mixed management practice using a ratio of 60 per cent fresh water with 40 per cent saline water.

The use of drip irrigation often resulted in undesirably low soluble solids concentration (Johnstone *et al.*, 2005). By contrast, soluble solids concentration increased significantly in response to soil moisture stress induced by deficit irrigation, with late maturing fruit as much as 1.6 °Brix higher than fruit maturing before significant soil moisture stress.

Drip irrigation of tomato found to produce higher yield than traditional surface irrigation and to reduce water consumption leading to higher water use efficiency than traditional methods (Gawad *et al.*, 2005).

Najafi (2006) indicated that, surface drip irrigation with treated waste water and subsurface drip irrigation at 15 cm with treated waste water could control environmental contamination and would be better than surface irrigation in decreasing pollution problems in the soil besides producing higher yield.

Drip irrigation at 0.5 E_{pan} irrespective of fertigation treatments recorded a saving of 48.1 per cent of irrigation water and resulted in 51.7 per cent higher fruit yield as compared to recommended practices inside the greenhouse (Mahajan and Singh, 2006).

Xiukang and Yingying (2016) evaluated the effect of irrigation and fertilization by drip fertigation on tomato yield and water use efficiency in greenhouse and reported that an increased irrigation level increased the fruit yield of tomatoes and decreased the WUE. The fruit yield and WUE increased with the increased fertilizer rate. WUE was more sensitive to irrigation than to fertilization.

2.3 Effect of N, P and K on growth, yield and quality of tomato

Hartz *et al.* (2005) evaluated the effect of K fertigation through subsurface irrigation lines on processing tomato (*Lycopersicon esculentum* Mill.) fruit yield and quality. Total and marketable fruit yield and color of the fruit were significantly increased by K fertigation but total soluble solids concentration did not differed significantly.

Parisi *et al.* (2006) studied the influence of nitrogen supply (from 0 to 250 kg N ha^{-1}) on yield and quality components of processing tomato. Nitrogen fertilizer application from 50 to 250 kg ha^{-1} increased total yield but not marketable yield. Higher nitrogen supply reduced some important processing characteristics such as pH, soluble solids, glucose, fructose content and sugar/total solids ratio.

Yan-cai *et al.* (2008) reported that, excessive P application (>0.53 g/kg) caused a high accumulated P in soil and plant, resulting in the salt toxicity, low soil enzyme activities, declined dry matter and low tomato yield.

El-Nemr *et al.* (2012) observed that, increased K levels in the nutrient solution resulted in increased contents of TSS, Vitamin C, titratable acidity and juice pH in tomato fruits. Higher yield was recorded with Floridat cultivar and high level of K concentration (350 ppm).

A field experiment was undertaken to evaluate different levels of phosphorus on growth, yield and yield components of chilli variety ‘Long Slim Cayenne’. The results showed that phosphorus application at 40 kg P/ha significantly increased plant height (28-59 per cent), leaf area (10-11 per cent), shoot (54-118 per cent) and root dry matter (37-59 per cent), number of fruit/plant (50-117), fruit length (8-9 per cent) and fruit yield/ha (92-178 per cent) compared to control plants (Emongor and Mabe, 2012).

Idowu *et al.* (2013) reported that, among different levels of phosphorus application, growth, yield and yield components of snake tomato (*Trichosanthes cucumerina* L.) were higher up to 30 kg P ha^{-1}, beyond which there was a reduction.

Nisar *et al.* (2015) investigated the effect of potassium levels (60, 90 and 120 kg ha^{-1}) and two application timings on tomato cv. Nagina. Results indicated that, potassium application @ 60 kg ha^{-1} either applied in single or in two splits, significantly increased the yield and improved the quality parameters of tomato over control, while higher levels of K (90 and 120 kg ha^{-1}) did not show further significant increase in the yield and quality subsequently.

Somapala *et al.* (2015) concluded that, application of higher doses of potassium improves plant growth parameters (height and stem thickness), fruit physical parameters (fruit length, width, fresh weight, firmness and cell wall thickness) and could have significant impact on reducing the post-harvest losses of capsicum.

Hasanuzzaman *et al.* (2016) reported that, higher dose of potassium (120 kg ha^{-1}) in combination with GA_3 (40 ppm) increased growth and produced the highest yield (59.45 t ha^{-1}) of tomato.

2.4 Fertigation studies in tomato grown under protected condition

In a greenhouse experiment conducted by Yomni *et al.* (1995), tomato plants supplied with equal amounts of N, P and K (150,300 or 450 kg ha^{-1}) or with 150 kg N ha^{-1} only and it was concluded that, increasing NPK application had no effects on fruit quality and shelf life, although yields were increased and no phytotoxic symptoms were observed even at the higher NPK application rate.

Chandra *et al*. (2003) studied the effects of N: P: K rate (200: 100: 150: 350: 200: 250 or 500: 300: 350 kg ha^{-1}) on the performance of 4 indeterminate tomato hybrids (Rakshita, Karnataka. Naveen and Sun-7611) in a multi-span greenhouse during 2000-2001 and 2001-2002. In both years, Karnataka hybrid and N: P: K at 350:200:250 kg ha^{-1} were superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit: cost ratio.

Findings of an investigation using tomato, chilli, and eggplant indicated that, fertigation twice a week with compound fertilizer NPK of 18-18-18 with 3% Mg and chelated forms of micronutrients Fe, Cu, Zn, Mn, B and Mo at a concentration of 0.75 g L^{-1} was the most efficient rate for higher yield per applied fertilizer in all three tested vegetables. (Al-Ghawas and Al-Mazidi, 2004).

Mahajan and Singh (2006) investigated the effect of irrigation and fertigation on greenhouse tomato. Drip irrigation with fertigation of 100 per cent recommended nitrogen resulted in an increased fruit yield by 59.5 per cent over control inside the greenhouse and by 116.2 per cent over control outside the greenhouse, respectively. Greenhouse tomato fruits were found superior than fruits of open field crop in view of fruit size, TSS content, ascorbic acid content and pH.

Fertigation of 100 per cent recommended dose of N and K recorded the higher vegetative growth, marketable fruit yield (122.59 t/ha) and the higher cost benefit ratio of 1:1.83 of tomato compared to fertigation of 75 per cent and 50 per cent recommended dose of N and K (Brahma *et al*., 2009).

A study was carried out to examine the morpho-physiological and yield of tomato influenced by different fertigation levels (Control, 60, 80 and 100 per cent RDF) under polyhouse condition. Results revealed that maximum yield was obtained with 80 per cent RDF (Tiwari *et al*., 2012).

Mane *et al*. (2015) found that, fertigation of 100 per cent recommended dose of fertilizers significantly improved tomato qualities in respect of the average fruit weight, total soluble salts and acidity of tomato. Whereas, higher residual nitrogen, phosphorous and potassium in soil after harvest of crop was observed with soil application of recommended dose of fertilizers with surface irrigation.

Fertigation of 100 per cent recommended dosage of N: P: K (300:150:150 N, P_2O_5, K_2O kg/ha) under polyhouse in 12 equal splits at every 9 days interval up to 120 DAT found significantly superior in case of growth, yield attributes and fruit yield of tomato (Ughade *et al*., 2016).

2.5 Fertigation studies in tomato grown under open field condition

Papadopoulos and Leena (2000) concluded that, only 50 per cent of recommended nitrogen through fertigation improved the yield of tomato compared to application of full amount of nitrogen through conventional method, suggesting that N is more efficiently utilized when applied with the irrigation water.

Qiao *et al*. (2003) evaluated various fertigation combinations for tomato production. They found that, the highest increment in yield (52.7 per cent), ascorbic acid content (8.6 per cent) and the highest cost benefit ratio (1:3.9) were obtained with $N:P_2O_5:K_2O$ at 1:1:1.5. Fertigation with N: $P_2O_5:K_2O$ at 1:1:1 and 1:1:2 also increased the yield (by 36.4 & 47.3 per cent, respectively).

Hebbar *et al*. (2003) stated that, WSF fertigation recorded significantly higher number of fruits per plant (56.9) and fertilizer-use efficiency (226.48 kg yield kg^{-1} NPK) compared to drip- and furrow-irrigated controls. Fertigation resulted in lesser leaching of NO_3-N and K to layer of soil.

Colla *et al*. (2003) carried out two field experiments to evaluate the impact of nitrogen fertigation rates (0, 40, 80, 120 and 160 kg per ha) on growth, yield and fruit quality of processing tomato hybrids. In both experiments, total above ground dry weight of aerial biomass, leaf area index (LAI) and yield increased with an increase in nitrogen rate.

Fertigation with 100 per cent water-soluble fertilizer increased the fruit yield of tomato significantly over furrow irrigation and drip irrigation. Subsurface drip fertigation, NK fertigation and 1/2 soil–1/2 fertigation was also found equally promising to WSF fertigation (Hebbar *et al*., 2003).

Tu *et al*. (2004) reported that, drip irrigation and drip fertigation significantly increased tomato yield compared to untreated control. The percentage of tomato fruits with blossom-end rot (BER) was significantly reduced to negligible levels in drip irrigated and drip fertigated treatments.

Intensive potassic nutrition is a prerequisite for quality parameters of tomato fruits, such as share of marketable yield, °Brix, DM, red colour, size, and lycopene content (Achilea and Kafkafi, 2003).

Application of liquid fertilization with complex fertilizers or nitrogen and potassium fertigation as well as drip irrigation in tomato cultivation caused increase of ascorbic acid, pectin, hemicellulos and lycopene content (Elkner *et al*., 2004).

Hebbar *et al*. (2005) conducted a field experiment to study the effect of drip fertigation on soil water, soil fertility and yield of field-grown tomato (*Lycopersicon esculentum* cv. Arka Abhijit) in the semi-arid tropics. Fertigation with 100 per cent water soluble fertilizers increased the marketable fruit yield and water use efficiency compared to soil application of fertilizer directly either with furrow or drip irrigation.

Frequent supplementation of nutrients with irrigation water increased the availability of N, P and K in the root zone and which in turn influenced the yield and quality of tomato (Shedeed *et al*., 2009).

Brahma *et al*. (2010) concluded that, drip fulfillment at 100 per cent evaporation replenishment throughout the crop season with cent per cent supplementation of recommended dose of N&K (75:60 kg/ha) through emitters of 2 l/h discharge rate with emission uniformity of 89-91 per cent corresponding to 27 drip cycle with the last drip coinciding at 15 days before harvest was found to be optimum for profitable cultivation of tomato with optimum quality and economic return.

Anoop *et al*. (2014) observed that, combination of starter and booster dose at 2 per cent along with RDF resulted in significantly increasing growth parameters of tomato like plant height (100.4 cm), number of branches per plant (23.4), leaf area index (4.16) and yield parameters like number of fruits per plant (38.6), yield per plant and per hectare (2.03 kg and 39.87 tons, respectively). However, early flowering and early harvest (27.25 days and 54.97 days, respectively) were recorded with application of water soluble fertilizers at 1.5 per cent along with RDF.

2.6 Effect of fertilizer application rates in tomato

Yield and fruit weight of tomato were higher at 1.0 evapotranspiration (ETM), but the most quality components (°Brix, acidity, colour, and TSS per cent) were best at 0.7 ETM. N fertilizer treatment had less significant effects on yield and quality (Branthome *et al*., 1994).

In a trial conducted by Lacatus *et al*. (1994) in Romania, processing tomatoes were supplied with N (as ammonium nitrate) at 100, 200 or 300 kg ha^{-1}, P_2O_5 (as concentrated super phosphate) at 75 or 150 kg ha^{-1}, K_2O (as potassium sulphate) at 75 or 150 kg ha^{-1} and half fermented FYM at 20, 40 or 60 t ha^{-1}. The best quality for processing were obtained with N, P and K rates of 300, 150 and 75 kg ha^{-1}, respectively with 20 t FYM ha^{-1}.

A field experiment conducted by Ashok Kumar *et al*. (2001) revealed that, fertigation level of 100 per cent recommended rate (150 kg N + 40 kg P_2O_5 + 50 kg K_2O ha^{-1}) was at par with 50 per cent RF + 10 t FYM ha^{-1} and produced the higher marketable yield.

Harikrishna *et al*. (2002) conducted an experiment at Dharwad and obtained the highest net returns (Rs. 78,565/ha) and benefit: cost ratio of 2.72 with FYM + 75 per cent recommended dose of nitrogen and recommended dose of phosphorus (P as rock phosphate + phosphate solubilizing bacteria) + recommended dose of potash + Azospirillum.

Haltlgl *et al*. (2002) found that for tomato, the per cent NUE was significantly increased by applying the N fertilizer through fertigation (53.9 per cent) as compared to the soil application (34.0 per cent) at 100 mg N litre^{-1}.

Balliu and Ibro (2002) reported the effect of different potassium fertilizer levels on yield and fruit quality. There were no significant differences in the crop yield. However, ascorbic content of the ripe fruits differed significantly in relation to potassium level applied.

Maximum fruit yield was (1.687 kg plant^{-1}) obtained with 160 kg N ha^{-1}, which was statistically different from the control. The effect of N level on agronomic efficiency was statistically significant, where the maximum agronomic efficiency was reached with 80 kg N ha^{-1}, superior to 240 kg N ha^{-1} by 209 per cent. The higher relative N recovery was found with 160 kg N ha^{-1} and was statistically equal to the rest of treatments (CRISTÓBAL *et al*., 2002).

Warner *et al*. (2004) examined the effects of nitrogen fertilization on fruit yield and quality of processing tomatoes and stated that, the response of marketable yield to N fertilizers may depend on water supply and with ample water, crop response to fertilizer N was enhanced.

Manoj Kumar *et al*. (2013) studied the effect of nitrogen, phosphorus and potassium fertilizers on the growth, yield and quality of tomato var. Azad T-6. The results revealed that significantly higher plant height, higher yield and yield attributing characters were recorded with the application of 100 per cent NPK *i.e*. 180 kg N/ha along with 80 kg P/ha and 75 kg K/ha.

Bielinski (2013) studied the effect of preplant potassium (K) fertilization rates and sources on the growth and yield of beef steak tomato. The results revealed that plots treated with MOP at rates higher than 300 lb/acre of K increased soil EC and caused a decline on extra-large and total marketable fruit weight of tomato.

Agyeman *et al*. (2014) examined the agronomic response of four tomato varieties (Shasta, Heinz, CRI POO and CRI 034) to fertilizers application. Results showed that using Winner fertilizer 6 g/plant at two weeks after transplanting (WAT) and Sulfan (3 g/plant at 4 WAT) CRI P00 produced the higher yield (26.4 t ha^{-1}) followed by chicken manure (250 g/plant at 2 and 4 WAT) (23.1 t ha^{-1}).

Urea fertilizer application at the rate of 108.6 kg urea/ha significantly increased plant height, number of leaves, number of fruits per plant and final fruit weight of tomato. However, this was not significantly better than plots with urea application at 54.8 kg/ha (Ogundare *et al*., 2015).

2.7 Water and fertilizer use efficiencies

Freeman *et al*. (1976) compared drip and furrow irrigation of tomatoes and found no significant difference in yield between the two irrigation methods but reported a reduced water usage with drip irrigation.

Drip irrigation gave a saving of 54 per cent irrigation water, which resulted in 40 per cent higher tomato fruit yield compared with surface irrigation (Raina *et al*., 1999).

Amma (1994) reported that, drip irrigation increased the water use efficiency compared with furrow irrigation (39.9 vs. 54.0 liters required to produce 1 kg marketable fruits). Water use efficiency under drip irrigation alone and surface irrigation was 0.34 and 0.16 t ha^{-1}, respectively.

Drip irrigation at every second day frequency with irrigation level 79 per cent of ET and fertigation at 96 per cent of recommended dose saved water to the tune of 21 per cent and increased yield up to 27 per cent (Dalvi *et al*., 1999).

Scholberg *et al*. (2000) reported that, with lower N supply (N<180 kg ha^{-1}), nitrogen use efficiency for field grown tomato was 0.4 Mg fresh fruit (kg N^{-1}) and average crop N accumulation increased from 37 to 210 kg N ha^{-1} as N fertilization increased from 0 to 333 kg N ha^{-1}. As a fraction of the fertilizer N applied, N fertilizer recovery ranged from 0.36 to 0.74 and 0.61 to 0.96 for drip irrigated and sub irrigated crops, respectively.

Armenta *et al*. (2001) stated that, N and K nutrient concentrations should be administered in accordance with phenological stage of the crop.

Sagheb and Hobbi (2002) reported that, the yield increase of the fertigation treatments enhanced the water use efficiency. Water use efficiency was lower for the conventional treatment (33.3 kg ha-cm^{-1}) and the higher for urea-0 mg litre^{-1} treatment (155.4 kg ha-cm^{-1}) and urea – 38 mg litre^{-1} (154.1 kg ha-cm^{-1}).

Fertigation with water soluble fertilizers recorded significantly higher water and fertilizer-use efficiency (226.48 kg yield kg^{-1} NPK) compared to drip- and furrow-irrigated controls (Hebbar *et al*., 2003).

The higher water use efficiency value of 67.5 kg m^{-3} was obtained from irrigation at 75 per cent of Class A pan evaporation with peat + ash (1: 1) in tomato (Sezen *et al*., 2006).

Drip irrigation at 0.5 E_{pan} irrespective of fertigation treatments giving a saving of 48.1 per cent of irrigation water and 51.7 per cent higher fruit yield as compared to recommended practices inside the Greenhouse (Mahajan and Singh, 2006).

Shedeed *et al*. (2009) reported that, even distribution of nutrients in fertigation improves fertilizer use efficiency and results in lesser leaching of NO_3 N and K to deeper soil layers.

Biswas *et al*. (2015) investigated the combined effects of drip irrigation and mulches on yield, water-use efficiency and economic return of tomato. The results indicated that, the highest water use efficiency of 592 kg/ha-mm, higher net return (US$ 7098/ha), and maximum yields of 81.12 and 79.49 t/ha were obtained under polyethylene and straw mulch, respectively, with water supply of 50 per cent crop water requirement through drip system.

Managing the crop using dynamic criteria allows the plant to take up less nitrogen and produces more fruit dry matter per gram of nitrogen (Battilani, 2006).

The drip fertigation method yielded 39 per cent higher tomato yield when compared to furrow irrigation combined with conventional fertilizer application and 24 per cent higher yield than drip irrigation combined with conventional fertilizer application (Vjekoslav *et al*., 2011).

A study conducted by Xiukang and Yingying (2016) showed, an increased irrigation level increased the fruit yield of tomatoes and decreased the WUE. The fruit yield and WUE increased with the increased fertilizer rate. WUE was more sensitive to irrigation than to fertilization.

2.8 Economics of drip irrigation and fertigation

Jadhav *et al*. (1990) reported higher cost: benefit ratio (5.15) for drip irrigated tomato compared to furrow methods (2.96).

In a study conducted by Pitts and Clark (1991) drip irrigation was compared to sub irrigation (seepage) and the reduction in pumping costs compensated to some extent for the additional cost of the drip irrigation system. The seasonal additional cost for drip irrigation (excluding labour) was \$ 328 ha^{-1}.

Yadav and Batra (1991) indicated that the tomato fruit yield was highest (318.6 q ha^{-1}) when irrigated at IW/CPE ratio 1.0 compared to 0.5 and 0.75.

Amarananjundeshwara *et al*. (1999) found that, the higher profit was obtained when 100 per cent water soluble fertilizers were drip fertigated, but B: C ratio was higher (2.24) when 100 per cent normal fertilizers were used for fertigation.

Hanson and May (2004) showed that the profits under drip irrigation were \$ 867 to \$ 493 ha^{-1} more compared to sprinkler irrigation, depending on the amount of yield increase and the interest used in the economic analysis.

Dunage *et al.* (2009) concluded that the payback period of the investment in net house cultivation of tomato using drip irrigation was found to be one and a half years (three seasons), by which time the system becomes beneficial.

Sivanappan (1998) reported that an extra income of Rs 49,280 per hectare could be obtained under drip irrigation in tomato over surface irrigation with a payback period of drip system cost was six months only.

Kavitha *et al*. (2007) conducted experiment on elucidate the effect of shade and fertigation on the growth, yield and quality of tomato hybrid 'Ruchi'. Application of 100 per cent water-soluble fertilizer under shade recorded the higher values for different growth, yield and quality parameters. However, application of 100 per cent dose of straight fertilizer under shade recorded the higher net returns and benefit: cost ratio.

Based on the exhaustive review presented, it is observed that there is a research gap with respect to fertigation of cherry tomato under open field and protected conditions keeping in view of economizing cost on fertigation, appropriate levels of nitrogen and phosphorus fertigation for achieving maximum productivity and highest return in cherry tomato. Hence, this present investigation has been systematically planned as indicated in material and methods.

III. MATERIALS AND METHODS

The present investigation "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" was conducted at the Horticulture Research Station, Department of Horticulture, University of Agricultural Sciences, Bangalore, Gandhi Krishi Vignana Kendra during the period between January to June-2017. The details of the materials used and the methods employed during the course of investigation are discussed in this chapter.

3.1 Location of the experiment

The experiment was conducted during summer-season (January to June) in the year 2017 at the Horticulture Research Station, Department of horticulture, University of Agricultural Sciences, Bangalore. The Horticulture research station is located at 12º 59" North latitude and 77º 34" East longitude. The station is at an altitude of 930 meters above mean sea level. The area represents Eastern Dry Zone of Karnataka (Zone-V) and is characterized by sub-tropical climate.

3.2 Soil of the experimental site and its previous history

The soil of the experimental site was red sandy loam. Composite soil samples drawn from the experimental site before planting and after the harvest of the crop were analyzed for mechanical composition and chemical properties and the data is presented in Table 3.2.1. Cabbage crop was grown as previous crop on the experimental polyhouse and under open field condition, there was no crop taken before this experiment for several years.

Table 3.2.1: Soil reactions and available N, P and K of soil in experimental plots before transplanting

Growing conditions	pH	EC (dS m^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
Polyhouse	6.76	0.4	288.51	30.85	273.12
Open field	7.13	0.3	263.42	39.48	234.00

3.3 Climatic conditions

Normal as well as actual weather data on total rainfall, maximum and minimum temperature, relative humidity, daily bright sunshine hours and open pan evaporation that prevailed during the period of experimentation are presented in Appendix- I.

3.3.1 Normal climatic conditions

The average data of forty one years (1972-2013) was considered to calculate normal climatic conditions of Zonal Agricultural Research Station, GKVK, Bangalore. The normal annual rainfall of the station was 922.0 mm and the major portion of rain was received during the months of July to October and maximum amount of rainfall was received during September and October months. The normal mean maximum air temperature ranged from 26.1 °C to 33.7 °C whereas, normal minimum mean air temperature ranged between 13.9 °C to 20.5 °C. The normal mean monthly maximum relative humidity ranged from 75.0 to 88.8 per cent and the normal mean sunshine hours varied from 4.4 to 9.5 hours.

3.3.2 Actual weather conditions

Actual average rainfall of the center during the period of study, between January-2017 to June-2017 was 53.9 mm, the major portion of which was received during May (246.6 mm) and June (65.4 mm). The mean maximum air temperature ranged between 27.3°C to 35.1°C and mean minimum air temperature ranged between 9.5°C to 21.9°C. The highest average temperature of 35.1°C was recorded during April followed by 33.0 °C during March and 32.7°C in May, 2017. Mean monthly relative humidity varied from 82.0 per cent in March to 88.9 per cent in January (Appendex-1).

3.4 Experimental site

Experiment was conducted in open field and naturally ventilated low cost poly house conditions. The dimension of open field and greenhouse area was 11 m x 18 m, with total area of 198 m^2 under each condition. The general view of experimental crop raised under open field and polyhouse conditions is shown in Plate 1a and 1b.

Plate 1a: General view of crop raised under polyhouse condition at flowering stage

Plate 1b: General view of crop raised under open field condition at flowering stage

3.5 Details of the experiment

- Crop and variety : Cherry tomato cv. Moscatel RZ F1 (74-104)
- Agro climatic zone : Eastern Dry Zone of Karnataka (Zone V)
- Location : Division of Horticulture, UAS (B), G.K.V.K
- Season : Summer-2017
- Date of planting : 4th January 2017
- Design : Factorial Randomized Complete Block Design
- Number of treatment combinations : 2x 3x 2= 12
- Number of replications : 3
- Spacing : 1.2m x 0.45m
- Individual plot size : 5.4 m x 1.2 m = 6.48 m^2
- Number of plants / plot / replication : 12

3.5.1 Description of cherry tomato cv. Moscatel RZ F1 (74-104)

The cherry tomato hybrid, Moscatel RZ F1 (74-104) has been released by Rijk Zwaan India Seeds Pvt. Ltd. It is large cherry tomato for single harvest with intense red coloured fruit, high brix level and sweet taste. It has an indeterminate growth with good plant vigour, compact plant type, well organized truss shape and resistance to tomato mosaic virus (ToMV) and *F. oxysporum f. sp. lycopersici* (Fol).

3.5.2 Design of the experiment

This was 2x3x2 factorial experiment, laid out in Randomized Complete Block Design (FRCBD) with two growing conditions *viz.,* open field and polyhouse, three levels of nitrogen and two levels of phosphorus with 12 treatment combinations and three replications.

3.6 Treatment details

The experiment consisted of two growing conditions, three different levels of nitrogen and two levels of phosphorus which are mentioned in Table 3.6.1 with alphabetic symbols. The details of the treatment combinations are given in Table 3.6.2.

Table 3.6.1: Treatment details

Growing conditions (Two conditions)	**Total nitrogen levels** (Three levels)	**Total phosphorus levels** (Two levels)
C_1: Open field condition	N_1-120 kg ha^{-1}	P_1-100 kg ha^{-1}
C_2: Protected condition	N_2-150 kg ha^{-1}	P_2-120 kg ha^{-1}
	N_3-180 kg ha^{-1}	

Note: Potassium was applied at 150 kg ha^{-1} for all fertilizer treatments.

Table 3.6.2 Treatment combinations

Polyhouse condition (C_1)		**Open field condition (C_2)**	
No.	**Treatment combinations**	**No.**	**Treatment combinations**
T_1	$C_1N_1P_1$-120:100 kg N & P_2O_5 ha^{-1}	T_7	$C_2N_1P_1$-120:100 kg N & P_2O_5 ha^{-1}
T_2	$C_1N_1P_2$-120:120 kg N & P_2O_5 ha^{-1}	T_8	$C_2N_1P_2$-120:120 kg N & P_2O_5 ha^{-1}
T_3	$C_1N_2P_1$-150:100 kg N & P_2O_5 ha^{-1}	T_9	$C_2N_2P_1$-150:100 kg N & P_2O_5 ha^{-1}
T_4	$C_1N_2P_2$-150:120 kg N & P_2O_5 ha^{-1}	T_{10}	$C_2N_2P_2$-150:120 kg N & P_2O_5 ha^{-1}
T_5	$C_1N_3P_1$-180:100 kg N & P_2O_5 ha^{-1}	T_{11}	$C_2N_3P_1$-180:100 kg N & P_2O_5 ha^{-1}
T_6	$C_1N_3P_2$-180:120 kg N & P_2O_5 ha^{-1}	T_{12}	$C_2N_3P_2$-180:120 kg N & P_2O_5 ha^{-1}

3.7 Fertilizer application

The basal dose of 20 per cent N, P and K of each treatment was applied in the form of urea (46 % N), single super phosphate (16 % P_2O_5) and muriate of potash (60 % K_2O) before transplanting. Remaining dose of 80 per cent NPK was applied through fertigation using water soluble fertilizer in the form of NPK mixtur (19:19:19 % NPK), calcium nitrite (15.5 and 18.8 % of N and Ca, respectively) and potassium sulfate (50 and 17.5 % K_2O and S, respectively) starting from 21th day after transplanting up to 129 days prior to final harvest. The details of fertilizers applied are given in Table 3.7.1.

3.8 Cultural practices

The seeds of cherry tomato cv. Moscatel RZ F1 (74-104) were sown in plastic pro trays by using cocopeat in naturally ventilated polyhouse on 4th January 2017 and the pro trays were watered by a rose can every day. Necessary plant protection and cultural operations were carried out from time to time to get healthy and disease free seedlings.

The main land was brought to fine tilth by repeated ploughing, harrowing and clod crushing. Full dose of FYM (25 t ha^{-1}) was applied commonly to all plots. Raised beds of 0.8 meter width and 17 meter length in both open field and polyhouse were prepared and the space between two beds was 40 cm. Twenty per cent basal soil fertilizer dose was applied and mixed with the soil. After laying of drip laterals, the planting beds were covered with polyethylene non-recycled mulch film.

One month old healthy tomato seedlings were transplanted in the field and polyhouse on 4th February 2017. Seedlings were transplanted in a single row per bed, the row to row and plant to plant spacing was kept at 1.20 m and 0.45 m, respectively. Each plot accommodated 12 plants in three rows. Gap filling was done within a week after transplanting to ensure optimum plant population. The beds were irrigated through drip irrigation system daily under both open field and polyhouse depending on the weather, soil and growth stage of the crop.

All beds were kept free of weeds by plastic mulch and manual weeding at regular intervals as when weeds appeared. Plant protection measures were taken up against damping off by drenching with 0.2% Captaf. Pest like leaf miner, trips and mites were controlled by removing the infested leaves manually and by spraying the plants with Dicofal (2 ml/L) + Confidar (0.5 ml/L).

Table 3.7.1: Quantity of fertilizers applied per plot (6.48 m^2) under open and polyhouse conditions

Treatment combinations		Fertilizer applied per plot					
		Basal soil application (20 %)			Fertigation (80 %)		
Polyhouse condition		**N (g/plot)**	**P_2O_5 (g/plot)**	**K_2O (g/plot)**	**N (g/plot)**	**P_2O_5 (g/plot)**	**K_2O (g/plot)**
T_1	120:100:150 kg N:P_2O_5:K_2O ha^{-1}	15.55	12.96	19.44	62.20	51.84	77.76
T_2	120:120:150 kg N:P_2O_5:$K_2O ha^{-1}$	15.55	15.55	19.44	62.20	62.20	77.76
T_3	150:100:150 kg N:P_2O_5:K_2O ha^{-1}	19.44	12.96	19.44	77.76	51.84	77.76
T_4	150:120:150 kg N:P_2O_5:K_2O ha^{-1}	19.44	15.55	19.44	77.76	62.20	77.76
T_5	180:100:150 kg N:P_2O_5: K_2O ha^{-1}	23.32	12.96	19.44	93.31	51.84	77.76
T_6	180:120:150 kg N:P_2O_5:K_2O ha^{-1}	23.32	15.55	19.44	93.31	62.20	77.76
Open field condition							
T_7	120:100:150 kg N:P_2O_5:K_2O ha^{-1}	15.55	12.96	19.44	62.20	51.84	77.76
T_8	120:120:150 kg N:P_2O_5:K_2O ha^{-1}	15.55	15.55	19.44	62.20	62.20	77.76
T_9	150:100:150 kg N:P_2O_5:K_2O ha^{-1}	19.44	12.96	19.44	77.76	51.84	77.76
T_{10}	150:120:150 kg N:P_2O_5:K_2O ha^{-1}	19.44	15.55	19.44	77.76	62.20	77.76
T_{11}	180:100:150 kg N:P_2O_5: K_2O ha^{-1}	23.32	12.96	19.44	93.31	51.84	77.76
T_{12}	180:120:150 kg N:P_2O_5:K_2O ha^{-1}	23.32	15.55	19.44	93.31	62.20	77.76

Note: Recommended dose of fertilizers (180:120:150 kg N: P_2O_5: K_2O ha^{-1})

The plants in polyhouse and open field were pruned to three stems per plant. When side suckers developed, they were removed and only main stems were allowed to grow. To train the plants straight upright in open condition, wooden sticks were provided as support at 2 m distance and GI wires were tied to these sticks at a height of 50, 90, 150 and 200 cm above the ground and the plants were tied with plastic twine to these wires. In polyhouse, the main stems of plant were tied with plastic twine to train along and tied to GI wire grid provided on the top of the plants. The tying operation was done periodically when plants grew different heights. The leaves which turned yellow and showed senescence were removed periodically. Fruits were harvested when they attained ripe red stage. A total of 11 harvests under open field condition and 8 harvests under polyhouse were done.

3.9 Fertigation schedule

Fertigation was commenced from 21 days after transplanting up to 129 days prior to final harvest. A Total of 37 fertigation were done at an interval of once in three days. The remaining 80 per cent of N, P and K was given through fertigation according to the age of the crop. At initial stage of growth, fertigation was given in lesser doses. Further, the quantity of fertilizers per fertigation increased as the growth of the plants increased at mid and late stages of plant life cycle.

First stage: 21- 37 days (6 fertigations)

- 20 per cent NPK mixture (19:19:19)

Middle stage: 39 - 57 days (7 fertigations)

- 30 per cent NPK mixture (19:19:19)
- 50 per cent calcium nitrate (15.5:00:00)
- 50 per cent Potassium sulphate (00:00:50)

Last stage: 60 – 129 days (24 fertigations)

- 50 per cent NPK mixture (19:19:19)
- 50 per cent calcium nitrate (15.5:00:00)
- 50 per cent Potassium sulphate (00:00:50)

3.10 Observations recorded

Five plants were selected at random and tagged in each replication for recording various biometric observations to assess the effect of treatments on growth, yield and quality of the cherry tomato. The details of observations recorded and the procedures followed are presented below.

3.10.1 Growth parameters

3.10.1.1 Plant height (cm)

Height of the tagged plants was recorded from the ground level up to the top most growing tip at 30, 60, 90 and 120 days after transplanting. The average of five plants at each stage was taken as mean plant height and expressed in centimeters (cm).

3.10.1.2 Number of leaves per plant

The leaves which were fully opened, matured and photosynthetically active were counted in each plant and recorded as number of leaves per plant at 30, 60, 90 and 120 days after transplanting.

3.10.1.3 Fresh and dry weights of plant (g)

Fresh weight of the plants was recorded from each plot. For dry weight, these uprooted plants were partitioned into stem, leaf, root and fruit and sundried first for a period of three days and then kept in hot air oven at 65 ºC till constant weight was obtained. Dry weight of different parts was recorded from destructive sampled plants at 90 days after transplanting.

3.10.1.4 Total leaf area per plant (cm^2)

Total leaf area per plant was measured at 90 days after transplanting by using leaf area meter in all fully opened and biologically active leaves. The values recorded were expressed in square centimeters. The process of recoding observation is shown in Plate 2a.

3.10.1.5 Nitrogen balance index, flavanols and total chlorophyll content (µg/cm^2)

Nitrogen balance index (NBI), flavanols and total chlorophyll contents were determined at 80 days after transplanting with the help of DUALEX SCIENTIFIC+™ Chlorophyll and Polyphenol-Meter and expressed as **µg**/cm^2 (Plate 2b).

3.10.2 Reproductive parameters

3.10.2.1 Days taken to first flowering

Number of days from transplanting to appearance of first flower cluster was counted and recorded as days taken for first flowering.

3.10.2.2 Number of flower clusters and flowers per plant

The number of inflorescences and flowers per plant were recorded at 50 and 70^{th} days after transplanting from the tagged plants.

3.10.2.3 Fruit set (%)

Fruit set percentage was estimated by the ratio of number of fruits to the number of flowers produced by each plant and was multiplied by 100. Fruit set percentage was worked out separately for bottom, middle and top positions and average of these positions for the whole plant expressed as fruit set per cent/ plant. The fruit set (%) was calculated with the following formula.

$$\text{Fruit set } (\%) = \frac{\text{Number of fruits}}{\text{Number of flowers}} \times 100$$

3.10.2.4 Days taken to first harvest

Number of days from transplanting to first picking of fruits was counted and recorded as days taken for first harvest. The stage of harvesting of fruits under open field and polyhouse conditions is depicted in Plate 3a and 3b.

3.10.3 Yield parameters

3.10.3.1 Number of fruits per plant

The total number of fruits harvested from five tagged plants in each plot was counted at each picking and total number of fruits per plant was computed by adding the number of fruits of all harvests and dividing it by the number of plants.

3.10.3.2 Mean fruit weight (g)

Mean fruit weight was worked out at 2^{nd}, 4^{th} and 7^{th} harvests from the yield of tagged plants by using the following formula and expressed in grams.

$$\text{Mean fruit weight (g)} = \frac{\text{weight of fruits(g)}}{\text{Number of fruits}}$$

3.10.3.3 Fruit yield per plant (kg)

The total weight of fruits harvested from five tagged plants in each plot of all the harvests were added and average yield per plant was worked out.

3.10.3.4 Fruit yield per hectare (t)

The fruit yield per hectare was estimated based on the fruit yield per plot from each harvest and was expressed in tonnes per hectare (t ha^{-1}).

$$\text{Fruit yield per hectare (t)} = \frac{\text{Fruit yield per plot}}{\text{Net plot area}} \times 10{,}000$$

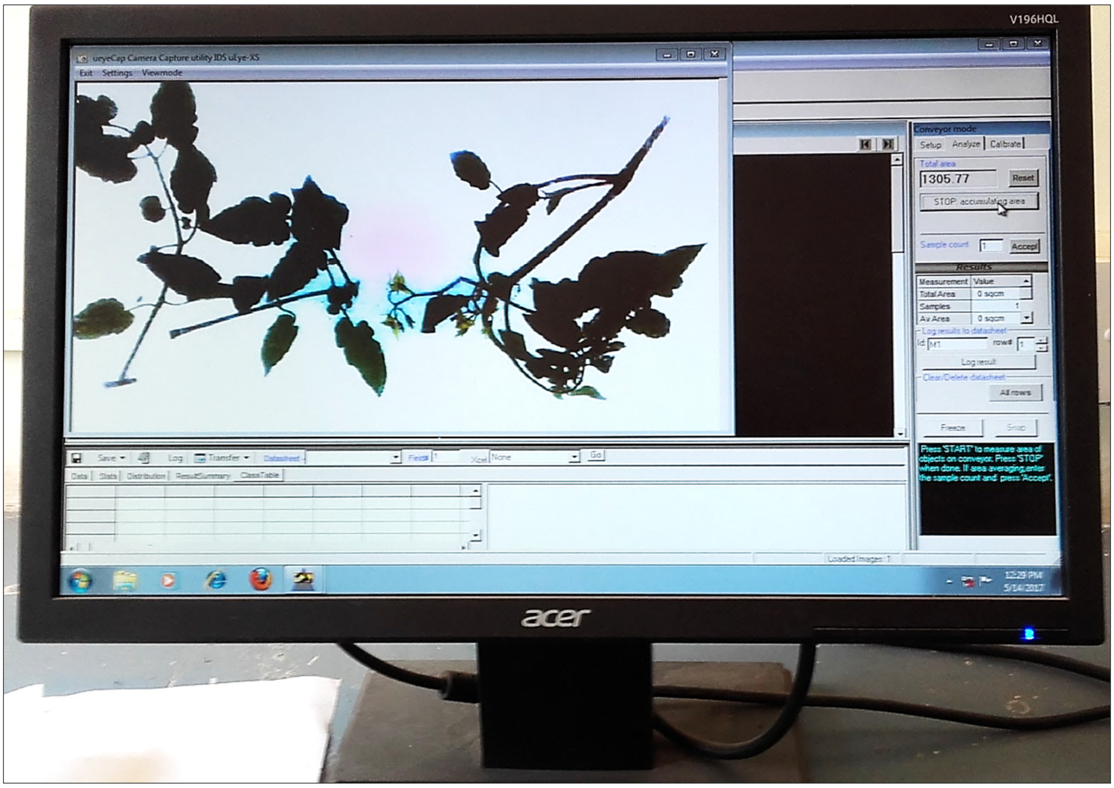

Plate 2a: BIO-VIS leaf area meter used for measuring leaf area of the experimental crop

Plate 2b: DUALEX SCIENTIFIC+™ chlorophyll and polyphenol meter used for measuring total chlorophyll content, flavanol content and nitrogen balance index

Plate 3a: General view of crop raised under polyhouse condition at 1st harvest stage

Plate 3b: General view of crop raised under open field condition at 1st harvest stage

3.10.4 Quality parameters

3.10.4.1 Total soluble solids (TSS)

The total soluble solids content was determined with the help of "Erma Portable Refractometer" at initial and middle stages (2nd and 7th harvest, respectively) under ambient conditions (25 °C) by putting a drop of juice on the prism and taking the reading (Plate 4a). The values recorded were expressed as degrees Brix (°B).

3.10.4.2 Shelf life (days)

To study the shelf life of fruits, 500 g fruits were collected after harvest from each plot and kept at room temperature. The fruits were observed for their retention of freshness, firmness, moisture loss and spoilage. Days taken from harvest up to the stage of consumer preference (*i.e.,* 10 per cent loss) were recorded as shelf life of fruits (Plate 4b and 4c).

3.11 Soil analysis

3.11.1 Preparation of soil samples

Soil samples before and after the experiment were collected for nutrient analysis using screw auger. The samples were air dried in shade, powdered with wooden mallet and passed through 2 mm sieve. The sieved samples were bagged in PE bag, labelled and stored for further laboratory analysis.

3.11.2 Soil pH and EC

The soil pH was determined in 1:2.5 soil water suspension using pH meter. The clear surpenatant solution of the above soil water suspension was taken out and was measured using conductivity bridge (Jackson, 1973).

3.11.3 Available nitrogen (kg ha^{-1})

Ten grams of soil was distilled in 25 ml of 0.32 per cent $KMnO_4$ and 25 ml of 2.5 per cent NaOH. The ammonia released was trapped in 4 per cent boric acid containg mixed indicator and titrated against standard sulfuric acid solution (Subbiah and Asija, 1956).

3.11.4 Available phosphorus (kg ha^{-1})

Available phosphorus was extracted with Brays No.1 extractant and was estimated by chloro stannous phosphoric acid blue colour method (Jackson, 1973).

3.11.5 Available potassium (kg ha^{-1})

Extraction was done by shaking the medium with ammonium acetate (pH=7) (1:5-medium: extractant ratio) for 5 minutes and K in the filtrate was estimated using flame photometer (Jackson, 1973).

3.12 Plant analysis

3.12.1 Sample preparation

Plant samples collected at final stage from the respective treatments were washed and shade dried for three days then dried in an oven at 60 ºC till a constant weight and ground in to fine powder in micro willey mill. The ground samples were stored in butter paper bags for chemical analysis.

3.12.2 Estimation of total nitrogen content (%)

The nitrogen content in the plant samples was estimated by Micro Kjeldahl-distillation method as per the procedure described by Jackson (1973).

3.12.3 Digestion of plant samples for P and K

The plant samples were wet ashed using diacid (HNO_3: HCL-9:4). The digest was diluted using double distilled water, filtered through pre watered Whatman No-1 filter paper.

Plate 4a: Fruit samples harvested for measuring TSS content

Plate 4b: Fruit samples of polyhouse raised crop for keeping quality studies

Plate 4c: Fruit samples of open field raised crop for keeping quality studies

3.12.4 Estimation of phosphorus content (%)

The phosphorus content was estimated by Vanadomybdate yellow colour method as suggested by the Jackson (1973).

3.12.5 Estimation of potassium content (%)

Potassium content in plant was estimated by the flame photometer as outlined by the Jackson (1973).

3.12.6 Uptake of primary nutrients by the plant (kg ha^{-1})

Nitrogen, phosphorus and potassium content were used to work out the uptake by the plant. The uptake of nitrogen, phosphorus and potassium were calculated by the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Dry weight (kg ha}^{-1})}{100}$$

3.13 Cost economics

The prices of all the inputs and the labour cost that were prevailing at the time of their use were considered to work out the cost of cultivation. The details of cost of cultivation are furnished in Appendix-II. The gross income was worked out based on the prevailing market price (Rs.20 kg^{-1}) when the produce was ready to harvest and market. Net income per hectare was calculated on the basis of gross income and cost of cultivation per hectare. The benefit cost ratio was calculated by dividing the net income by cost of cultivation as shown below:

$$\begin{matrix}\text{Benefit: cost ratio '} \\ \text{Output/Input ratio}\end{matrix} = \frac{\text{Net return (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

3.14 Statistical Analysis

The data pertaining to the present investigation was subjected to statistical analysis using 2x3x2 Factorial Randomized Complete Block Design. The significant treatment effect was judged with the help of F-test and to judge the significant difference between treatments, the critical difference was worked out (Panse and Sukhatme, 1984). The ANOVA of 2x3x2 Factorial RCBD is given below.

Table 3.14.1: Analysis of Variance (ANOVA)

SOURCE	**DF**	**SS**	**MSS**	**F-cal**	**F-tab** at 0.05
R	(R-1)=2	R.SS	R.MSS	R.MSS/ E.MSS	$F_{(2@ 22)}$=3.44
A	(A-1)=1	A.SS	A.MSS	A.MSS/ E.MSS	$F_{(1@ 22)}$=4.30
B	(B-1)=2	B.SS	B.MSS	B.MSS/E.MSS	$F_{(2@ 22)}$=3.44
C	(C-1)=1	C.SS	C.MSS	C.MSS/E.MSS	$F_{(1@ 22)}$=4.30
AXB	(A-1) (B-1)=2	AxBss	AB.MSS	AB.MSS/ E.MSS	$F_{(2@ 22)}$=3.44
AXC	(A-1)(C-1)=1	AxCss	AC.MSS	AC.MSS/ E.MSS	$F_{(1@ 22)}$=4.30
BXC	(B-1)(C-1)=2	BxCss	BC.MSS	BC.MSS/ E.MSS	$F_{(2@ 22)}$=3.44
AXBXC	(A-1)(B-1)(C-1)=2	AxBxCss	ABC.MSS	ABC.MSS/E.MSS	$F_{(2@ 22)}$=3.44
ERROR	(R-1) (ABC-1)=22	E.SS	E.MSS		
TOTAL	(RxAxBxC-1)=35	TSS			

R=Replication A= Growing conditions B=Nitrogen levels C= Phosphorus levels

IV. EXPERIMENTAL RESULTS

The results of investigation entitled "Performance of cherry tomato [*Solanum lycopersicum* L.var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse growing conditions with varied levels of nitrogen and phosphorus fertigation" carried out at the Department of Horticulture, University of Agricultural Sciences, Bangalore during the summer season of 2017 are presented in this chapter.

4.1 Growth parameters

4.1.1 Plant height (cm)

Data pertaining to the effect of different growing conditions, nitrogen and phosphorus levels and interaction effects of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P), nitrogen and phosphorus (N×P) and growing conditions, nitrogen and phosphorus levels (CxNxP) on plant height of cherry tomato at 30, 60, 90 and 120 days after transplanting is furnished in Table 1a, 1b and 1c.

A perusal of data (Table 1a) revealed that, the plant height under open and polyhouse conditions differed significantly from each other. Polyhouse condition recorded significantly taller plants (99.76, 239.69, 342.93 and 352.59 cm, respectively) at 30, 60, 90 and 120 after transplanting and lower plant height (73.36, 175.64, 270.00 and 275.77 cm, respectively) was observed under open field condition.

Plant height was significantly influenced by N fertigation levels at 30, 60, 90 and 120 DAT (Table 1a). Application of 180 kg N ha^{-1} (N_3) recorded significantly higher plant height (89.45, 323.58, 328.76 cm, respectively) at 30, 90 and 120 DAT, followed N_2 i.e., 150 kg N ha^{-1} (84.41, 301.45 and 309.20 cm, respectively) at 30, 90 and 120 DAT whereas at 60 days after transplanting, application of 150 kg N ha^{-1} (N_2) recorded significantly taller plants (211.09 cm) and it was on par with N_3 (209.1 cm) at 60 DAT. Lower plant height (83.83, 202.89, 294.36 and 304.69 cm, respectively) at 30, 60, 90 and 120 DAT was recorded with N_1 (120 kg N ha^{-1}).

Table 1a: Effect of different growing conditions, nitrogen and phosphorus levels on plant height of cherry tomato at different stages after transplanting

Treatments		Plant height (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
Growing conditions (C)					
C_1	Polyhouse	99.76	239.69	342.93	352.59
C_2	Open field	73.36	175.64	270.00	275.77
F-test (p=0.05)		*	*	*	*
S.Em.±		0.49	0.91	1.35	1.44
C.D. (p=0.05)		1.46	2.67	3.97	4.25
Nitrogen levels (N)					
N_1	120 kg ha^{-1}	83.83	202.89	294.36	304.69
N_2	150 kg ha^{-1}	86.41	211.09	301.45	309.20
N_3	180 kg ha^{-1}	89.45	209.10	323.58	328.76
F-test (p=0.05)		*	*	*	*
S.Em.±		0.61	1.11	1.65	1.77
C.D. (p=0.05)		1.79	3.27	4.88	5.20
Phosphorus levels (P)					
P_1	100 kg ha^{-1}	86.72	207.38	301.14	308.97
P_2	120 kg ha^{-1}	86.35	207.95	311.78	319.39
F-test (p=0.05)		NS	NS	*	*
S.Em.±		0.49	0.11	1.33	1.44
C.D. (p=0.05)		-	-	3.97	4.25

*= Significant. NS = Non-significant. DAT= Days after transplanting

Table 1b: Interaction effect of different growing conditions and nitrogen levels (C×N), growing conditions and phosphorus levels (C×P) and nitrogen and phosphorus levels (N×P) on plant height of cherry tomato at different stages after transplanting

Treatments		Plant height (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
Growing conditions x Nitrogen levels (C×N)					
C_1N_1	Polyhouse + 120 kg N ha^{-1}	98.60	238.33	328.40	340.04
C_1N_2	Polyhouse + 150 kg N ha^{-1}	99.66	242.30	334.90	344.88
C_1N_3	Polyhouse + 180 kg N ha^{-1}	101.03	238.46	365.50	372.86
C_2N_1	Open field + 120 kg N ha^{-1}	69.06	167.46	260.33	269.34
C_2N_2	Open field + 150 kg N ha^{-1}	72.99	179.90	268.00	273.31
C_2N_3	Open field + 180 kg N ha^{-1}	77.86	179.56	281.66	284.66
F-test (p=0.05)		*	*	*	*
S.Em.±		0.86	1.57	2.34	2.51
C.D. (p=0.05)		2.53	4.63	6.87	7.36
Growing condition x phosphorus levels (C×P)					
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	99.39	240.68	336.53	346.71
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	100.13	238.71	349.33	358.48
C_2P_1	Open field +100 kg P_2O_5 ha^{-1}	74.04	174.08	265.75	271.24
C_2P_2	Open field +120 kg P_2O_5 ha^{-1}	72.57	177.19	274.24	280.30
F-test ($p\leq0.05$)		NS	NS	NS	NS
S.Em.±		0.70	1.28	1.91	2.05
C.D. (p=0.05)		-	-	-	-
Nitrogen levels x Phosphorus levels (N×P)					
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	83.36	199.13	295.13	305.96
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	84.29	206.66	293.60	303.42
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	85.73	212.53	293.76	301.81
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	86.93	209.66	309.13	316.38
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	91.06	210.49	314.53	319.15
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	87.83	207.53	332.63	338.37
F-test ($p\leq0.05$)		*	*	*	*
S.Em.±		0.86	1.57	2.34	2.51
C.D. (p=0.05)		2.53	4.63	6.87	7.36

*= Significant. NS = Non-significant. DAT= Days after transplanting

Table 1c: Interaction effect of different growing conditions, nitrogen and phosphorus levels (CxNxP) on plant height of cherry tomato at different stages after transplanting

Treatments		Plant height (cm)			
		30 DAT	60 DAT	90 DAT	120 DAT
Growing conditions x Nitrogen levels x Phosphorus levels (CxNxP)					
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	97.93	233.46	325.33	337.42
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	99.26	243.20	331.46	342.66
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	99.53	251.66	330.13	341.38
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	99.80	232.93	339.66	348.38
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	100.73	236.93	354.13	361.34
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	101.33	240.00	376.86	384.39
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	68.80	164.80	264.93	274.50
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	69.33	170.13	255.73	264.18
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	71.93	173.40	257.40	262.24
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	74.06	186.40	278.60	284.38
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	81.40	184.06	274.93	276.97
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	74.33	175.06	288.40	292.35
F-test (p=0.05)		*	*	*	*
S.Em.±		2.12	3.87	5.75	6.15
C.D. (p=0.05)		3.59	6.55	9.73	10.41

C_1 = Polyhouse condition — DAT= Days after transplanting

C_2 = Open field condition — *= Significant

Phosphorus fertigation levels also had significant influence on plant height at 90 and 120 DAT (Table 1a). Application of 120 kg P_2O_5 ha^{-1} (P_2) recorded significantly higher plant height (311.78 and 319.39 cm, respectively) at 90 and 120 DAT. Lower plant height (301.14 and 308.97 cm, respectively) at 90 and 120 DAT was recorded with P_1 (100 kg P_2O_5 ha^{-1}).

Plant height was significantly influenced by the interaction between growing conditions and nitrogen levels at 30, 60, 90 and 120 DAT (Table 1b). Interaction combination of C_1N_3 (polyhouse with 180 kg N ha^{-1}) recorded significantly higher plant height (101.03, 365.50 and 372.86 cm, respectively) at 30, 90 and 120 DAT. C_1N_3 was *on par* with treatment combinations of C_1N_1 and C_1N_2 (98.60 and 99.66 cm, respectively) at 30 DAT. At 60 DAT, treatment combination of C_1N_2 (polyhouse with 150 kg N ha^{-1}) resulted in higher plant height (242.30 cm) and it was *at par* with C_1N_1 and C_1N_3 (238.33 and 238.46 cm, respectively). Lower plant height (69.06, 167.46, 260.33 and 269.34 cm, respectively) at 30, 60, 90 and 120 DAT was recorded with C_2N_1 (open field with 120 kg N ha^{-1}).

Plant height was significantly influenced by the interaction between nitrogen and phosphorus levels at 30, 60, 90 and 120 DAT (Table 1b). Significantly higher plant height (91.06 cm) was recorded in interaction combination of N_3P_1 (180: 100 kg N: P_2O_5 ha^{-1}) followed by N_3P_2 and N_2P_2 (87.83 and 86.93 cm, respectively) at 30 DAT and lower plant height (83.36 cm) was recorded in N_1P_1 (120:100 kg N: P_2O_5 ha^{-1}) at 30 DAT.

Significantly higher plant height (212.53 cm) was recorded in N_2P_1 (150:100 N: P_2O_5 kg ha^{-1}) at 60 DAT, which was *on par* with N_2P_2 and N_3P_1 (209.66 and 210.49 cm, respectively) and lower plant height (199.13) was recorded in N_1P_1 (120:100 kg N: P_2O_5 ha^{-1}) at 60 DAT.

Significantly higher plant height (332.63) was recorded in N_3P_2 (180:120 N: P_2O_5 kg ha^{-1}) at 90 DAT, followed by N_3P_1 and N_2P_2 (314.53 and 309.13 cm, respectively) and lower plant (295.13 cm) was recorded under interaction combination of N_1P_1 (120:100 kg N: P_2O_5 ha^{-1}).

Similarly, significantly higher plant height (338.37 cm) was recorded in N_3P_2 (180:120 N: P_2O_5 kg ha^{-1}) at 120 DAT, followed by N_3P_1 and N_2P_2 (319.15 and 316.38 cm, respectively) and lower plant height (305.96 cm) was recorded with interaction combination of N_1P_1 (120:100 kg N: P_2O_5 ha^{-1}) at 120 DAT.

Plant height was also affected significantly by the interaction between conditions, nitrogen and phosphorus at 30, 60, 90 and 120 DAT (Table 1c). Treatment combination of $C_1N_3P_2$ (180:120 kg N: P_2O_5 ha^{-1} under polyhouse condition) recorded significantly higher plant height (101.33, 240.00, 376.86 and 384.39 cm, respectively) at 30, 60, 90 and 120 DAT, which was *on par* with $C_1N_2P_2$ (99.80 and 232.93 cm, respectively) at 30 and 60 DAT. Lower plant height (68.80, 164.80, 255.73 and 262.24 cm, respectively) at 30, 60, 90 and 120 DAT was observed in treatment combination of $C_2N_1P_1$, $C_2N_1P_2$ and $C_2N_2P_1$.

Plant height did not differ significantly due to phosphorus levels at 30 and 60 DAT and due to interaction effects of growing conditions and phosphorus at 30, 60, 90 and 120 DAT.

4.1.2 Number of leaves per plant

Data pertaining to effects of different growing conditions, nitrogen and phosphorus levels and interaction effects of conditions and nitrogen (C×N), conditions and phosphorus (C×P), nitrogen and phosphorus (N×P) and conditions, nitrogen and phosphorus levels (CxNxP) on number of leaves per plant of cherry tomato at 30, 60, 90 and 120 days after transplanting is furnished in Table 2a, to 2c.

The data on number of leaves per plant (Table 2a) revealed that growing conditions had significant influence on the number of leaves per plant at 30, 60 and 90 DAT. Polyhouse condition (C_1) recorded significantly higher number of leaves per plant (28.67, 66.71 and 57.50, respectively) at 30, 60 and 90 DAT. Open field condition (C_2) recorded significantly least number of leaves per plant (26.58, 60.36 and 53.11, respectively).

Number of leaves per plant was significantly influenced by N fertigation levels at 60 and 90 DAT. Application of 150 kg N ha^{-1} (N_2) recorded significantly higher number of leaves per plant (65.28) at 60 DAT and it was *on par* with N_3 *i.e.,* 180 kg N ha^{-1} (63.96). Lower number of leaves per plant (61.36) was recorded with N_1 (120 kg N ha^{-1}).

At 90 DAT, significantly higher number of leaves per plant (62.95) was recorded with N_3 (180 kg N ha^{-1}) followed by N_2 (54.88) and lower number of leaves per plant (48.08) with N_1 (120 kg N ha^{-1}) at 90 DAT.

Number of leaves per plant was significantly influenced by the interaction between growing conditions and nitrogen levels at 30 and 90 DAT (Table 2b and Fig.1). Interaction combination of C_1N_1 (polyhouse with 120 kg N ha^{-1}) recorded significantly higher number of leaves per plant (31.70) at 30 DAT whereas at 90 DAT, the number of leaves per plant was significantly higher (66.70) in C_1N_3 (polyhouse with 120 kg N ha^{-1}) followed by C_1N_2 *i.e.,* polyhouse with 150 kg N ha^{-1} (57.30) and C_2N_3 *i.e.,* open field with 180 kg N ha^{-1} (59.20). Lower number of leaves per plant (47.66) was observed in C_2N_1 (open field with120 kg N ha^{-1}).

The data presented in Table 2c and Fig.2 showed that the number of leaves per plant differed significantly by the interaction of growing conditions, nitrogen and phosphorus levels at 60 DAT. Interaction combination of $C_1N_2P_1$ (polyhouse with 150:100 kg N:P_2O_5 ha^{-1}) recorded significantly higher number of leaves (71.86) per plant followed by $C_1N_3P_1$, $C_1N_3P_2$ and $C_1N_2P_2$ (66.80, 66.60 and 65.13, respectively) at 60 DAT. Lower number of leaves per plant (56.13) was recorded in $C_2N_1P_2$ (open field with 120: 120 kg N :P_2O_5 ha^{-1}).

Number of leaves per plant was also significantly influenced by the interaction effects of growing conditions, nitrogen and phosphorus levels at 120 DAT. Treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher number of leaves per plant (49.33) and it was *on par* with $C_1N_2P_2$, $C_2N_3P_1$ and $C_2N_2P_2$ (44.66, 44.26 and 43. 13 respectively). Lower number of leaves (39.66) per plant was observed in treatment combination of $C_2N_3P_2$ (open field with 180: 120 kg N: P_2O_5 ha^{-1}).

Table 2a: Effect of different growing conditions, nitrogen and phosphorus levels on number of leaves per plant of cherry tomato at different stages after transplanting

Treatments		Number of leaves per plant			
		30 DAT	60 DAT	90 DAT	120 DAT
Growing conditions (C)					
C_1	Polyhouse	28.67	66.71	57.50	43.81
C_2	Open field	26.58	60.36	53.11	41.40
F-test (p=0.05)		*	*	*	NS
S.Em.±		0.55	0.63	0.62	1.01
C.D. (p=0.05)		1.62	1.86	1.84	-
Nitrogen levels (N)					
N_1	120 kg ha^{-1}	28.37	61.36	48.08	41.43
N_2	150 kg ha^{-1}	27.53	65.28	54.88	47.75
N_3	180 kg ha^{-1}	26.98	63.96	62.95	43.70
F-test (p=0.05)		NS	*	*	NS
S.Em.±		0.68	0.77	0.76	1.24
C.D. (p=0.05)		-	2.28	2.25	-
Phosphorus levels (P)					
P_1	100 kg ha^{-1}	27.21	64.44	54.98	41.37
P_2	120 kg ha^{-1}	28.05	62.63	55.62	43.21
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		0.55	0.63	0.62	1.01
C.D. (p=0.05)		-	-	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 2b: Interaction effect of different growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on number of leaves per plant of cherry tomato at different stages after transplanting

Treatments		Number of leaves per plant			
		30 DAT	60 DAT	90 DAT	120 DAT
Growing conditions x Nitrogen levels (C×N)					
C_1N_1	Polyhouse + 120 kg N ha^{-1}	31.70	64.93	48.50	41.66
C_1N_2	Polyhouse + 150 kg N ha^{-1}	27.80	68.50	57.30	42.66
C_1N_3	Polyhouse + 180 kg N ha^{-1}	26.53	66.70	66.70	45.23
C_2N_1	Open field + 120 kg N ha^{-1}	25.05	57.80	47.66	41.20
C_2N_2	Open field + 150 kg N ha^{-1}	27.26	62.06	52.46	40.83
C_2N_3	Open field + 180 kg N ha^{-1}	27.43	61.23	59.20	42.16
F-test (p=0.05)		*	NS	*	NS
S.Em.±		0.96	1.10	1.08	1.75
C.D. (p=0.05)		2.81	-	3.18	-
Growing conditions x phosphorus levels (C×P)					
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	28.28	67.64	57.42	41.91
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	28.97	65.77	57.57	44.46
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	26.13	61.24	52.55	40.84
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	27.03	59.48	53.66	41.95
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		0.78	0.89	0.88	1.43
C.D. (p=0.05)		-	-	-	-
Nitrogen x Phosphorus levels (N×P)					
N_1P_1	120:100 kg $N:P_2O_5$ ha^{-1}	27.83	61.86	48.00	41.43
N_1P_2	120:120 kg $N:P_2O_5$ ha^{-1}	28.91	60.86	48.16	41.43
N_2P_1	150:100 kg $N:P_2O_5$ ha^{-1}	27.20	66.76	54.40	39.80
N_2P_2	150:120 kg $N:P_2O_5$ ha^{-1}	27.86	63.80	55.36	43.70
N_3P_1	180:100 kg $N:P_2O_5$ ha^{-1}	26.60	64.70	62.56	42.90
N_3P_2	180:120 kg $N:P_2O_5$ ha^{-1}	27.36	63.23	63.33	44.50
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		0.95	1.10	1.08	1.75
C.D. (p=0.05)		-	-	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 2c: Interaction effect of different growing conditions, nitrogen and phosphorus levels (CxNxP) on number of leaves per plant of cherry tomato at different stages after transplanting

Treatments		**Number of leaves per plant**			
		30 DAT	**60 DAT**	**90 DAT**	**120 DAT**
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)					
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	29.93	64.26	48.66	42.40
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	33.46	65.60	48.33	40.93
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	28.53	71.86	57.26	42.20
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	27.06	65.13	57.33	43.13
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	26.40	66.80	66.33	41.13
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	26.66	66.60	67.06	49.33
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	25.73	59.46	47.33	40.46
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	24.36	56.13	48.00	41.93
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	25.86	61.66	51.53	37.40
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	28.66	62.46	53.40	44.26
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	26.80	62.60	58.80	44.66
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	28.06	59.86	59.60	39.66
F-test (p=0.05)		NS	*	NS	*
S.Em.±		2.35	2.70	2.66	4.30
C.D. (p=0.05)		-	4.57	-	7.29

C_1 = Polyhouse condition NS= Non –significant C_2 = Open field condition
*= Significant DAT= Days after transplanting

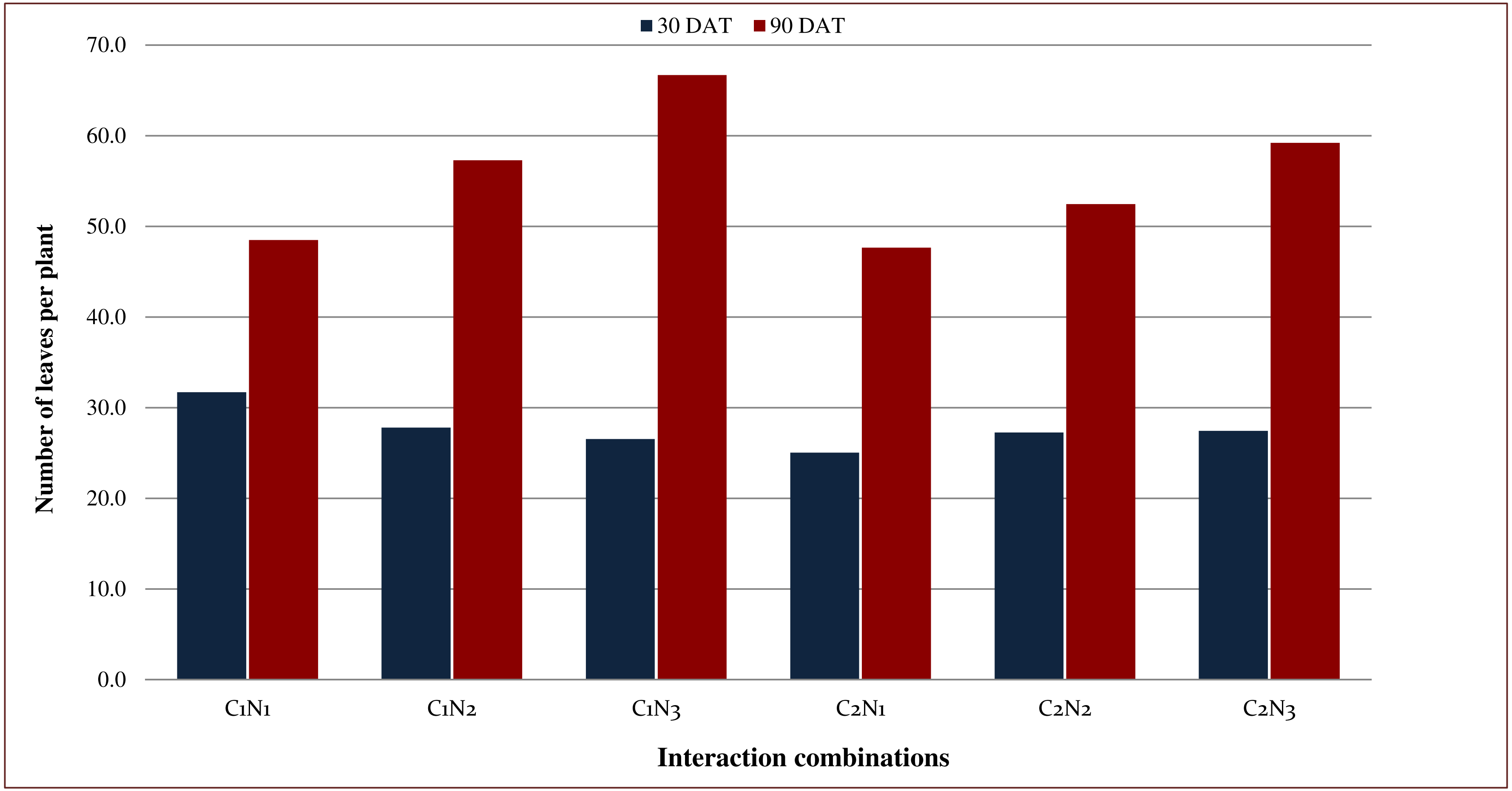

Fig. 1: Interaction effect of growing conditions and nitrogen fertigation levels on number of leaves per plant at 30 and 90 DAT

C_1N_1 = Polyhouse + 120 kg N ha^{-1}

C_1N_2 = Polyhouse + 150 kg N ha^{-1}

C_1N_3= Polyhouse + 180 kg N ha^{-1}

C_2N_1= Open field + 120 kg N ha^{-1}

C_2N_2= Open field + 150 kg N ha^{-1}

C_2N_3= Open field + 180 kg N ha^{-1}

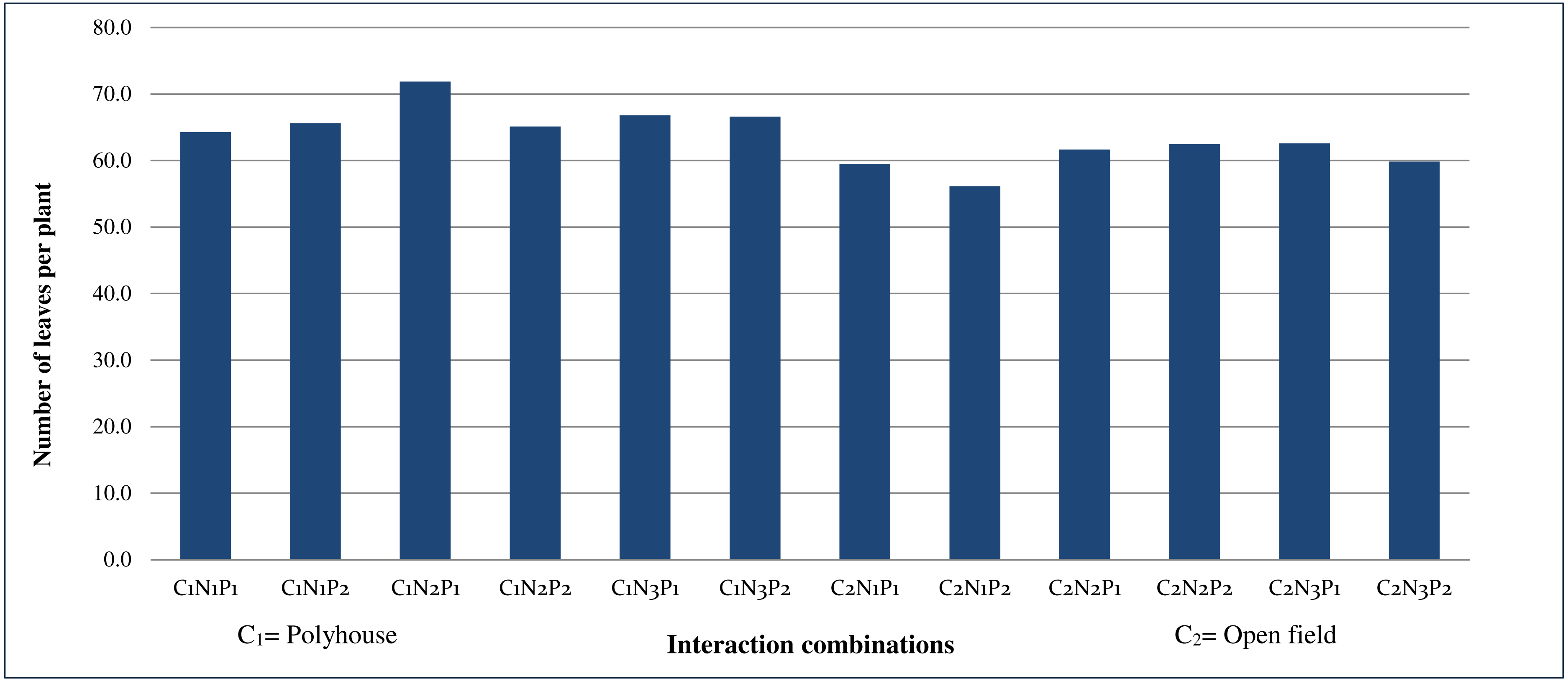

Fig. 2: Interaction effect of different growing conditions, nitrogen and phosphorus fertigation levels on number of leaves per plant at 60 days after transplanting

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}
$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}
$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}
$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-[1]
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}
$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

Number of leaves per plant did not differ significantly due to different growing conditions at 120 DAT and due to nitrogen levels at 30 and 120 DAT.

Number of leaves per plant did not differ significantly due to phosphorus levels and interaction effect of growing conditions and phosphorus levels (CxP) at 30, 60, 90 and 120 DAT.

Number of leaves per plant also did not differ significantly due to interaction effects of growing conditions and nitrogen levels (CxN) at 60 and 120 DAT and due to interaction effects of different growing conditions, nitrogen and phosphorus levels (CxNxP) at 30 and 90 DAT.

4.1.3 Total chlorophyll content, flavanol content and nitrogen balance index (NBI) at 90 days after transplanting

The data on total chlorophyll content, flavanol content and nitrogen balance index (NBI) as affected by different growing conditions, nitrogen and phosphorus fertigation levels and their interactions have been summarized in Table 3a to 3c.

4.1.3.1 Total chlorophyll content (μg/cm^2) at 90 DAT

It can be construed from the data (Table 3a) that growing conditions had significant effect on total chlorophyll content at 90 DAT. Significantly higher total chlorophyll content (27.80 μg/cm^2) was recorded under open field condition (C_2) at 90 DAT and lower chlorophyll content (26.11 μg/cm^2) was observed under polyhouse condition (C_1) at 90 DAT.

Chlorophyll content was significantly influenced by the interaction between nitrogen and phosphorus levels at 90 DAT. Significantly higher chlorophyll content (28.88 μg/cm^2) was observed in the interaction combination of N_1P_1 (120:100 kg P_2O_5 ha^{-1}) and it was *at par* with the treatment combination of N_2P_2, N_3P_1 and N_3P_2 (28.55, 28.20 and 26.67 μg/cm^2, respectively). Lower chlorophyll content (26.03 μg/cm^2) was observed in interaction combination of N_1P_2 (120: 120 kg N: P_2O_5 ha^{-1}) at 90 DAT (Table 3b and Fig.3).

Table 3a: Effect of different growing conditions, nitrogen and phosphorus levels on total chlorophyll content, flavanol content and nitrogen balance index (NBI) of cherry tomato at 90 DAT

Treatments		Total chlorophyll content (µg/cm^2)	Flavanol content (µg/cm^2)	Nitrogen Balance Index
		90 DAT	90 DAT	90 DAT
Growing conditions (C)				
C_1	Polyhouse	26.11	0.559	44.73
C_2	Open field	27.80	0.797	33.78
F-test (p=0.05)		*	*	*
S.Em.±		0.43	0.022	0.93
C.D. (p=0.05)		1.41	0.064	2.74
Nitrogen levels (n)				
N_1	120 kg ha^{-1}	27.46	0.670	40.75
N_2	150 kg ha^{-1}	27.00	0.665	38.78
N_3	180 kg ha^{-1}	26.41	0.699	38.24
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.58	0.027	1.14
C.D. (p=0.05)		-	-	-
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	27.37	0.664	39.49
P_2	120 kg ha^{-1}	26.55	0.692	39.02
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.48	0.022	0.93
C.D. (p=0.05)		-	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 3b: Interaction effect of different growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on total chlorophyll content, flavanols and nitrogen balance index (NBI) of cherry tomato at 90 DAT

Treatments		Total chlorophyll content (µg/cm²)	Flavanol content (µg/cm²)	Nitrogen Balance Index
		90 DAT	90 DAT	90 DAT
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	26.37	0.565	45.36
C_1N_2	Polyhouse + 150 kg N ha^{-1}	25.81	0.570	44.00
C_1N_3	Polyhouse + 180 kg N ha^{-1}	26.16	0.543	44.84
C_2N_1	Open field + 120 kg N ha^{-1}	28.55	0.775	36.14
C_2N_2	Open field + 150 kg N ha^{-1}	28.20	0.761	33.57
C_2N_3	Open field + 180 kg N ha^{-1}	26.67	0.855	31.65
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.83	0.038	1.62
C.D. (p=0.05)		-	-	-
Growing condition x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	26.49	0.548	43.62
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	25.73	0.570	45.85
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	28.24	0.780	35.36
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	27.37	0.814	32.20
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.68	0.031	1.32
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	28.88	0.655	41.84
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	26.03	0.685	39.66
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	26.16	0.700	38.29
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	28.55	0.631	39.27
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	28.20	0.638	38.34
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	26.67	0.760	38.14
F-test (p=0.05)		*	NS	NS
S.Em.±		0.83	0.038	1.62
C.D. (p=0.05)		2.44	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 3c: Interaction effect of different growing conditions, nitrogen and phosphorus levels (CxNxP) on total chlorophyll, flavanols and nitrogen balance index (NBI) of cherry tomato at 90 DAT

Treatments		Total chlorophyll content (µg/cm^2)	Flavanol content (µg/cm^2)	Nitrogen Balance Index
		90 DAT	90 DAT	90 DAT
Conditions x Nitrogen x Phosphorus levels (CxNxP)				
$C_1N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	28.13	0.586	45.65
$C_1N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	24.61	0.543	45.07
$C_1N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	25.45	0.563	44.08
$C_1N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	26.18	0.576	43.92
$C_1N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	25.91	0.495	41.13
$C_1N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	26.41	0.590	48.56
$C_2N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	29.64	0.723	38.03
$C_2N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	27.46	0.826	34.25
$C_2N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	27.03	0.836	32.50
$C_2N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	29.37	0.886	34.63
$C_2N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	28.07	0.780	35.56
$C_2N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	25.28	0.930	27.73
F-test (p=0.05)		NS	NS	*
S.Em.±		2.04	0.090	3.97
C.D. (p=0.05)		-	-	6.72

C_1 = Polyhouse condition NS= Non–significant C_2 = Open field condition
DAT= Days after transplanting *= Significant

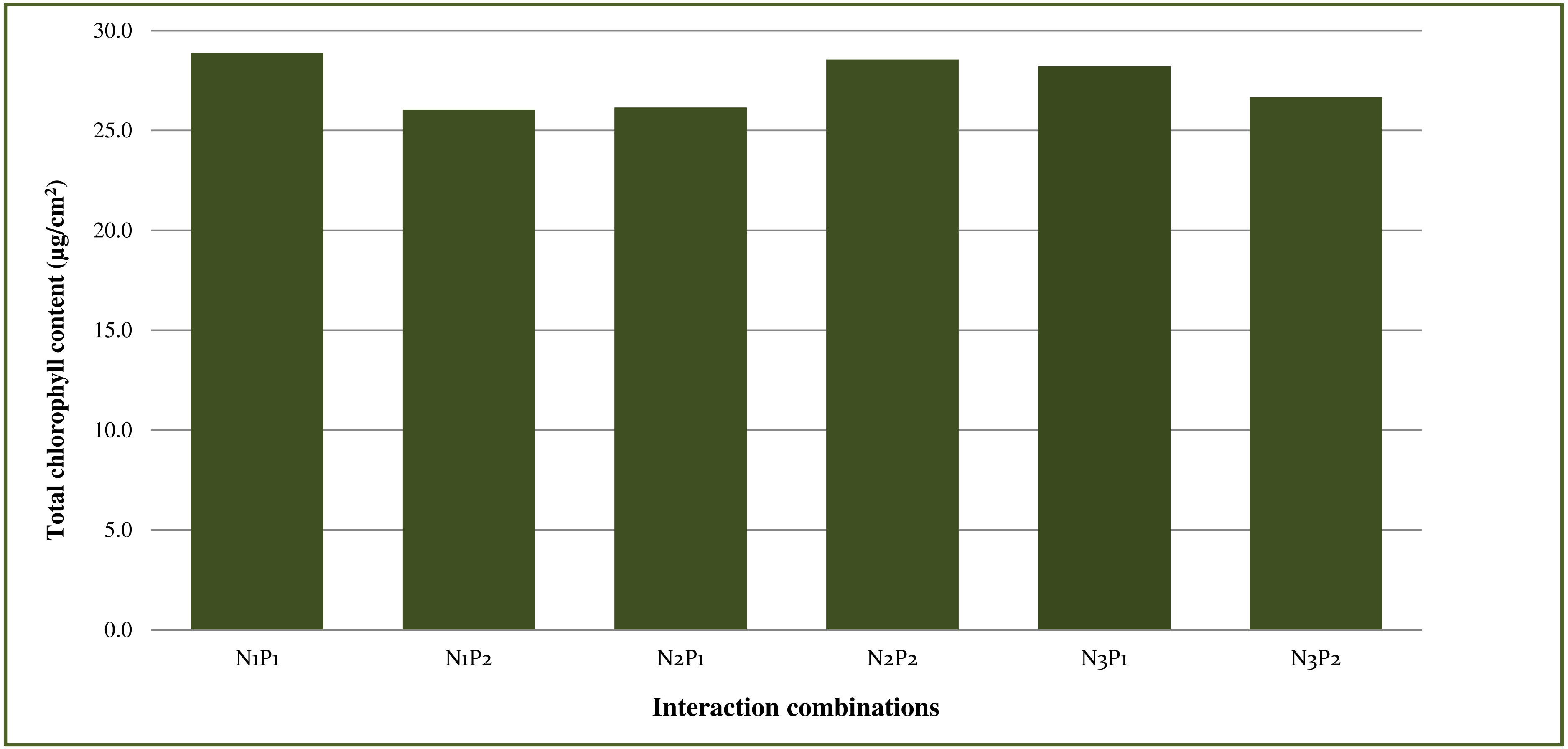

Fig. 3: Interaction effect of nitrogen and phosphorus fertigation levels on total chlorophyll content of cherry tomato at 90 DAT

N_1P_1 = 120:100 kg N:P_2O_5 ha^{-1} N_1P_2 = 120:120 kg N:P_2O_5 ha^{-1} N_2P_1= 150:100 kg N:P_2O_5 ha^{-1}
N_2P_2= 150:120 kg N:P_2O_5 ha^{-1} N_3P_1= 180:100 kg N:P_2O_5 ha^{-1} N_3P_2= 180:120 kg N:P_2O_5 ha^{-1}

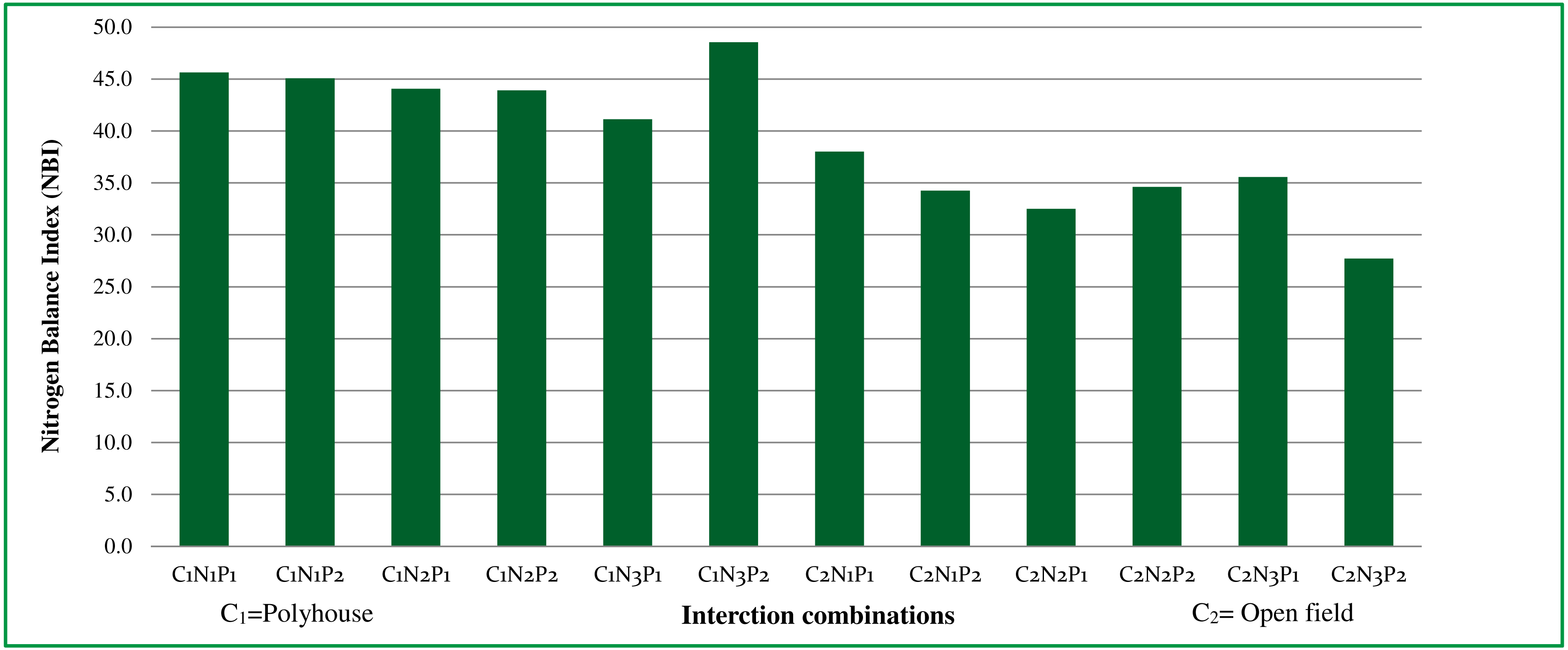

Fig. 4: Interaction effect of different growing conditions, nitrogen and phosphorus fertigation levels on nitrogen balance index (NBI) of cherry tomato at 60 days after transplanting

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1} $C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1} $C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}

$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1} $C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1} $C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1} $C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1} $C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}

$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1} $C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1} $C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

Total chlorophyll content did not differ significantly due to nitrogen and phosphorus fertigation levels at 90 DAT (Table 3a). The interaction combinations of growing conditions x nitrogen (NxP), growing conditions x phosphorus (CxP) and growing conditions, nitrogen and phosphorus levels (CxNxP) also had non- significant effect on total chlorophyll content at 90 DAT (Table 3b).

4.1.3.2 Flavanol content (μg/cm^2) at 90 DAT

It is apparent from the data (Table 3a) that growing conditions had significant influence on flavanols content at 90 DAT. Maximum flavanol content (0.797 μg/cm^2) was recorded under open field condition at 90 DAT. Lower flavanol content (0.559 μg/cm^2) was observed under polyhouse conditions (C_1).

Flavanol content did not differ significantly due to nitrogen and phosphorus levels at 90 DAT (Table 3a). Interaction combinations of growing conditions x nitrogen (CxN) , growing conditions x phosphorus (CxP), nitrogen and phosphorus levels (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP) also had no significant effect on flavanol content at 90 DAT (Table 3b and 3c).

4.1.3.4 Nitrogen balance index (NBI) at 90 DAT

The data pertaining to nitrogen balance index (NBI) as influenced by different growing conditions, nitrogen and phosphorus levels and their interactions have been summarized in Table 3a, 3b and 3c.

A perusal of data in Table 3a showed that nitrogen balance index (NBI) was significantly influenced by different growing conditions at 90 DAT. Significantly higher nitrogen balance index (44.73) was recorded under polyhouse condition (C_1) at 90 DAT and lower nitrogen balance index (33.78) was observed under polyhouse conditions (C_2).

Nitrogen balance index (NBI) was also influenced significantly by the interaction between growing conditions, nitrogen and phosphorus levels at 90 DAT (Table 3c and Fig.4). Treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher nitrogen balance index (48.56) and it was *on par* with

$C_1N_1P_1$, $C_1N_1P_2$, $C_1N_2P_1$ and $C_1N_2P_2$ (45.65, 45.07, 44.08 and 43.92, respectively). Lower nitrogen balance index (27.73) was recorded in treatment combination of $C_2N_3P_2$ (open field with 180: 120 kg N: P_2O_5 ha^{-1}).

Nitrogen balance index (NBI) did not differ significantly due to nitrogen and phosphorus levels, Interactions of growing conditions x nitrogen (NxP), growing conditions and phosphorus (CxP) and nitrogen x phosphorus levels (NxP) at 90 DAT (Table 3b).

4.1.4 Fresh and dry weights and total leaf area per plant at 90 DAT

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on fresh weight, dry weight and total leaf area per plant at 90 days after transplanting is furnished in Table 4a to 4c.

4.1.4.1 Fresh weight per plant (kg)

A keen observation of the data (Table 4a) revealed that fresh weight per plant at 90 DAT was significantly influenced by phosphorus fertigation levels. Application of 120 kg ha^{-1} P_2O_5 (P_2) recorded significantly higher fresh weight per plant (2.28 kg) at 90 DAT. Lower fresh weight/plant (2.04 kg) was recorded with P_1 (100 P_2O_5 kg ha^{-1}) at 90 DAT.

Fresh weight per plant was significantly affected by the interaction between different growing conditions and nitrogen fertigation levels at 90 DAT (Table 4b). Significantly higher fresh weight per plant (2.57 kg) was observed in C_1N_3 (polyhouse with 180 kg N ha^{-1}) and it was *on par* with C_2N_2 *i.e.,* open field with 150 kg N ha^{-1} (2.35 kg). Lower fresh weight per plant (1.90 kg) was recorded in C_2N_1 (open field condition with 120: 100 kg N ha^{-1}).

Fresh weight per plant at 90 DAT was significantly influenced by the interaction between nitrogen and phosphorus fertigation levels (Table 4b). Significantly higher fresh weight per plant (2.66 kg) was observed in interaction combination of N_3P_2 (180: 120 kg

N: P_2O_5 ha^{-1}) and it was *on par* with N_2P_2 *i.e.,* 150: 120 kg N: P_2O_5 ha^{-1} (2.26 kg). Lower fresh weight per plant (1.91 kg) was recorded in N_3P_1 (180: 100 kg N: P_2O_5 ha^{-1}).

Treatment combination of different growing conditions, nitrogen and phosphorus levels (CxNxP) also had significant effect on fresh weight per plant at 90 DAT (Table 4c and Fig.5). Significantly higher fresh weight per plant (3.00 kg) was recorded in treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) and it was *on par* with $C_2N_2P_2$ (2.69 kg). Lower fresh weight per plant (1.78 kg) was observed in $C_2N_1P_2$ (open field with 120:120 kg N: P_2O_5 ha^{-1}) at 90 DAT.

Fresh weight per plant did not differ significantly due to different growing conditions and nitrogen fertigation levels. Interaction effects of growing conditions and phosphorus levels (CxP) also had non-significant influence on fresh weight per plant at 90 DAT (Table 4a and 4b).

4.1.4.2 Dry weight per plant at 90 DAT (g)

A perusal of data (Table 4b) showed that dry weight per plant was significantly influenced by the interaction between growing conditions and nitrogen levels at 90 DAT. Significantly higher dry weight per plant (401.49 g) was recorded in C_1N_3 (polyhouse with 180 kg N ha^{-1}) and it was *on par* with C_2N_2 (355.41 g). Lower dry weight (284.56 g) was observed in C_2N_1 (open field with 120 kg N ha^{-1}).

Dry weight per plant was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels at 90 DAT. Significantly higher dry weight per plant (446.51 g) was recorded in polyhouse condition when supplied with 180: 120 kg N:P_2O_5 ha^{-1}($C_1N_3P_2$) and it was *on par* with $C_2N_2P_2$ (411.38 g). Lower dry weight (275.88 g) was observed in $C_2N_1P_2$ (275.88 g) at 90 DAT.

Dry weight per plant did not differ significantly due to different growing conditions, nitrogen and phosphorus fertigation levels and interaction effects of growing conditions and phosphorus levels (CxP) and interaction effects of nitrogen and phosphorus levels (NxP) at 90 DAT.

Table 4a: Effect of different growing conditions, nitrogen and phosphorus levels on fresh weight, dry weight and total leaf area of cherry tomato at 90 DAT

Treatments		Fresh weight per plant (kg)	Dry weight per plant (g)	Total leaf area per plant (cm^2)
		90 DAT	90 DAT	90 DAT
Growing conditions (C)				
C_1	Polyhouse	2.24	343.83	5244
C_2	Open field	2.08	312.63	5187
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.08	11.53	106.69
C.D. (p=0.05)		-	-	-
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	2.00	300.98	4718
N_2	150 kg ha^{-1}	2.20	334.01	5058
N_3	180 kg ha^{-1}	2.29	349.70	5871
F-test (p=0.05)		NS	NS	*
S.Em.±		0.09	14.12	130.67
C.D. (p=0.05)		-	-	383.22
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	2.04	315.77	5162
P_2	120 kg ha^{-1}	2.28	340.69	5269
F-test (p=0.05)		*	NS	NS
S.Em.±		0.08	11.53	106.69
C.D. (p=0.05)		0.23	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 4b: Interaction effect of different growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on fresh weight, dry weight and total leaf area of cherry tomato at 90 DAT

Treatments		Fresh weight per plant (kg)	Dry weight per plant (g)	Total leaf area per plant (cm^2)
		90 DAT	90 DAT	90 DAT
Growing condition x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	2.09	317.40	4653
C_1N_2	Polyhouse + 150 kg N ha^{-1}	2.06	312.60	5008
C_1N_3	Polyhouse + 180 kg N ha^{-1}	2.57	401.49	6071
C_2N_1	Open field + 120 kg N ha^{-1}	1.90	284.56	4782
C_2N_2	Open field + 150 kg N ha^{-1}	2.35	355.41	5107
C_2N_3	Open field + 180 kg N ha^{-1}	2.00	297.92	5671
F-test (p=0.05)		*	*	NS
S.Em.±		0.14	19.97	184.80
C.D. (p=0.05)		0.41	58.58	-
Growing condition x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	1.17	339.18	5244
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	2.30	348.48	5245
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	1.90	292.46	5080
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	2.26	332.90	5294
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.11	16.31	150.89
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	2.05	309.24	4881
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	1.94	292.72	4554
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	2.15	317.64	4697
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	2.26	350.37	5419
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	1.91	320.43	5907
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	2.66	378.97	5836
F-test (p=0.05)		*	NS	*
S.Em.±		0.14	19.97	184.80
C.D. (p=0.05)		0.41	-	541.95

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 4c: Interaction effect of different growing conditions, nitrogen and phosphorus levels (CxNxP) on fresh weight, dry weight and total leaf area per plant at 90 DAT

Treatments		Fresh weight per plant (kg)	Dry weight per plant (g)	Total leaf area per plant (cm^2)
		90 DAT	90 DAT	90 DAT
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	2.09	325.24	4994
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	2.09	309.56	4313
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	2.29	335.85	4888
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	1.82	289.36	5129
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	2.14	356.46	5849
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	3.00	446.51	6293
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	2.02	293.23	4769
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	1.78	275.88	4795
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	2.01	299.44	4506
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	2.69	411.38	5708
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	1.69	284.49	5964
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	2.32	311.43	5378
F-test (p=0.05)		*	*	*
S.Em.±		0.34	48.93	452.67
C.D. (p=0.05)		0.58	82.85	766.44

C_1 = Polyhouse condition
C_2 = Open field condition
DAT= Days after transplanting
*= Significant

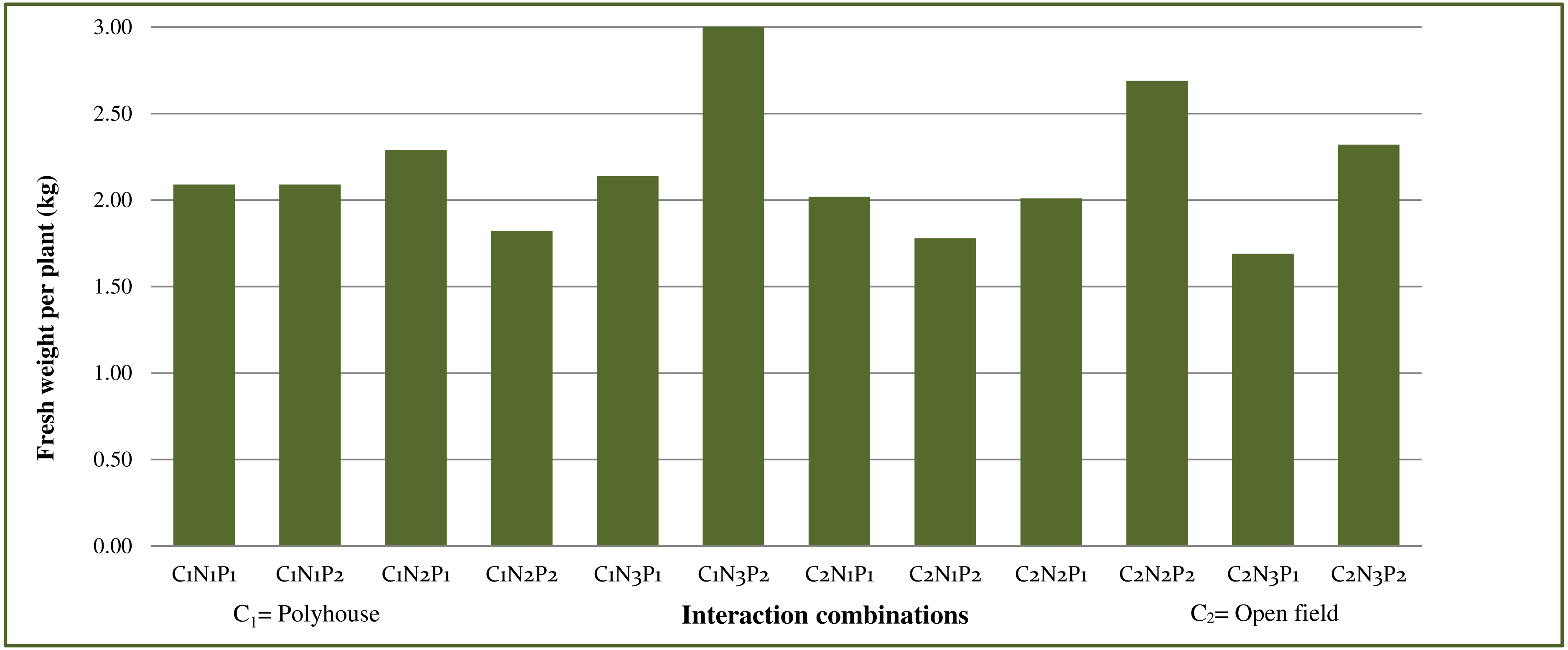

Fig. 5: Interaction effect of different growing conditions, nitrogen and phosphorus fertigation levels on fresh weight per plant at 90 days after transplanting

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}	$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}	$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}	$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-[1]
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}	$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

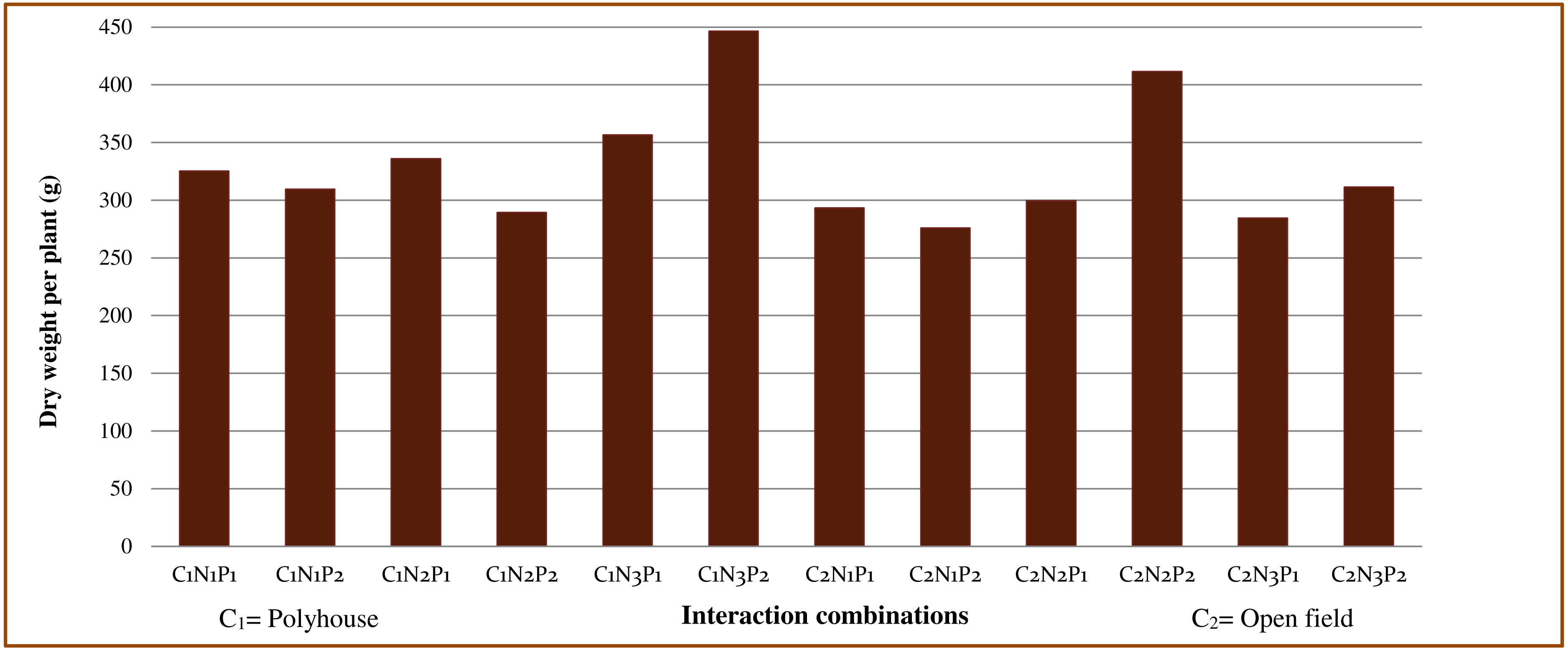

Fig. 6: Interaction effect of different growing conditions, nitrogen and phosphorus fertigation levels on dry weight per plant at 90 days after transplanting

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}
$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}
$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}
$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}
$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

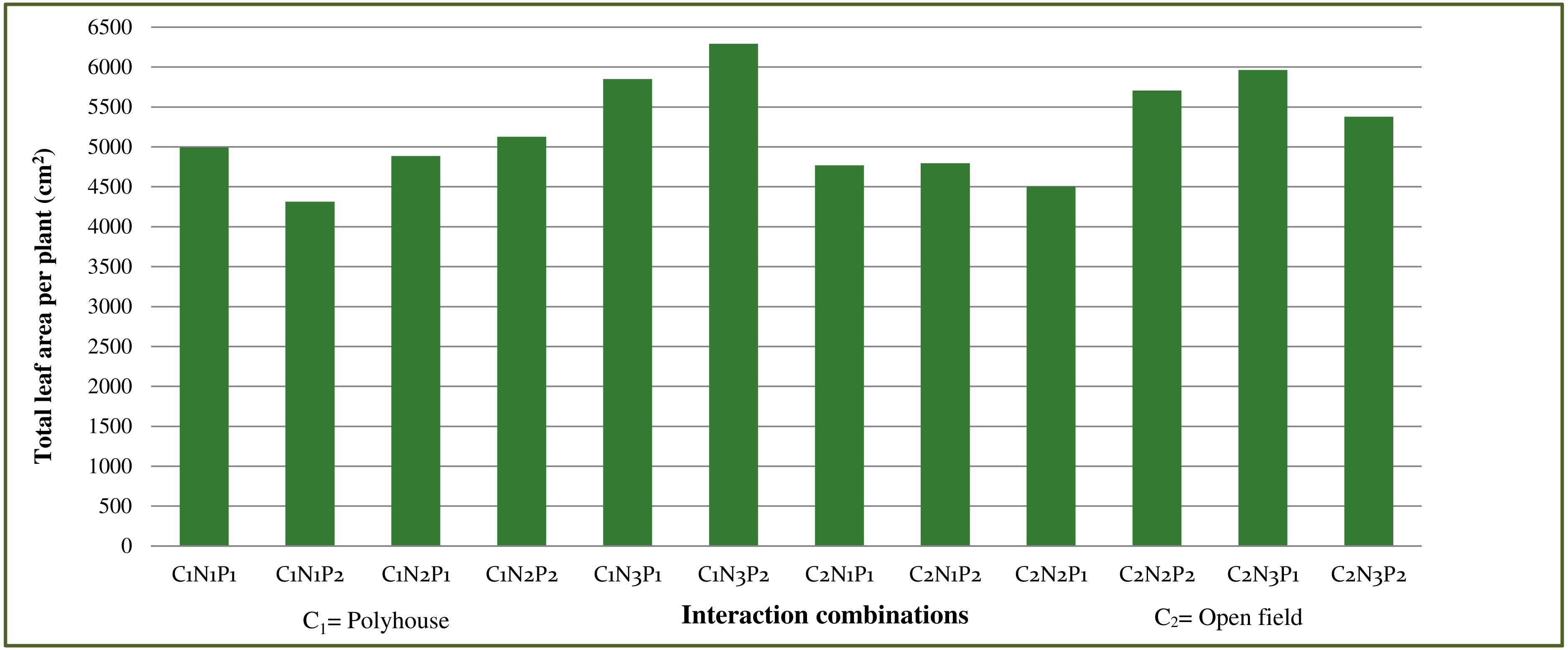

Fig. 7: Interaction effect of different growing conditions, nitrogen and phosphorus fertigation levels on total leaf area per plant at 90 days after transplanting

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}	$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}	$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}	$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}	$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

4.1.4.2 Total leaf area per plant (cm^2) at 90 DAT

An examination of data (Table 4a) showed that leaf area per plant was significantly influenced by different nitrogen fertigation levels at 90 DAT. Application of 180 kg N ha^{-1} (N_3) recorded significantly higher leaf area per plant (5871 cm^2) followed N_2 (5058 $cm^{2)}$ at 90 DAT. Lower total leaf area per plant (4718 cm^2) was observed in N_1 (120 kg N ha^{-1}).

Total leaf area per plant was significantly influenced by the interaction between nitrogen and phosphorus fertigation levels at 90 DAT (Table 4b). The interaction combination of N_3P_1 (180: 100 kg N: P_2O_5 ha^{-1}) recorded significantly higher total leaf area per plant (5907 cm^2) and it was *on par* with N_3P_2 and N_2P_2 (5836 and 5419 cm^2, respectively). Lower total leaf area per plant (4554 cm^2) was recorded under interaction combination of N_1P_2 (120: 120 kg N: P_2O_5 ha^{-1}) at 90 DAT.

Total leaf area per plant was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels at 90 DAT (Table 4c and Fig.7). Treatment combination of $C_1N_3P_2$ (polyhouse with 180: 120 kg N: P_2O_5 ha^{-1}) recorded significantly higher leaf area per plant (6293 cm^2) and it was *on par* with $C_2N_3P_1$, $C_1N_3P_1$ and $C_2N_2P_2$ (5964, 5849 and 5708 cm^2, respectively). Lower total leaf area per plant (4313 cm^2) was recorded in $C_1N_1P_2$ (polyhouse with 120: 120 kg N: P_2O_5 ha^{-1}) at 90 DAT.

Total leaf area per plant did not differ significantly due to different conditions (C), phosphorus fertigation levels (P), interaction effects of growing conditions and nitrogen levels (CxN) and interaction effects of growing conditions and phosphorus levels (CxP) at 90 DAT.

4.2 Reproductive parameters

4.2.1 Days taken to first flowering

The data on days taken to first flowering as influenced by different growing conditions, nitrogen and phosphorus fertigation levels and their interactions is presented in Table 5a to 5c.

An examination of the data (Table 5a) revealed that, the days taken to first flowering were significantly influenced by different growing conditions. Polyhouse condition (C_1) recorded significantly minimum number of days (21.61 days) to first flowering. Maximum number of days to first flowering (21.88 days) was recorded under open field condition (C_2).

Days taken to first flowering were significantly influenced by nitrogen fertigation levels (Table 5a). Application of 150 kg N ha^{-1} (N_2) recorded significantly lower number of days to first flowering (21.50 days) and it was *on par* with N_1 (21.58 days). Maximum number of days to first flowering (22.16 days) was recorded with N_3 (180 kg N ha^{-1}).

Phosphorus fertigation levels also had significant influence on days taken to first flowering (Table 5a). Application of 100 kg P_2O_5 ha^{-1} (P_1) recorded significantly minimum number of days to first flowering (21.55 days). Maximum number of days to first flowering (21.94 days) was recorded with P_2 (120 kg P_2O_5 ha^{-1}).

Days taken to first flowering were significantly influenced by the interaction between growing conditions and nitrogen levels (Table 5b). Interaction combination of C_1N_2 (polyhouse with 150 kg N ha^{-1}) recorded significantly minimum number of days to first flowering (21.33 days) and it was *on par* with C_2N_1, C_1N_1 and C_2N_2 (21.50, 21.66 and 21.66 days, respectively). Maximum number of days to first flowering (22.50 days) was recorded under open field when supplied 180 kg N ha^{-1} (C_2N_3).

Days taken to first flowering were significantly influenced by the interaction between growing conditions and phosphorus levels (Table 5b). Interaction combinations of C_1P_1 (polyhouse with 100 kg P_2O_5 ha^{-1}) and C_2P_1 (open field with 100 kg P_2O_5 ha^{-1}) recorded significantly lesser number of days to first flowering (21.55 days). Interaction combinations of C_1P_1 and C_2P_1 were *on par* with C_1P_2 (21.66 days). Maximum number of days to first flowering (22.22 days) was observed in interaction combination of C_2P_2 (open field with 120 kg ha^{-1}).

Days taken to first flowering were significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels (Table 5b). Treatment combination of $C_1N_2P_2$ (polyhouse with 150:120 kg N:P_2O_5 ha^{-1}) recorded significantly lesser number of days to first flowering (21.00 days) and it was *on par* with $C_1N_1P_1$, $C_2N_1P_1$, $C_2N_2P_1$, $C_1N_2P_1$, $C_2N_1P_2$ and $C_1N_3P_1$ (21.33, 21.33, 21.33, 21.66, 21.66 and 21.66 days, respectively). Maximum number of days to first flowering (23.00 days) was recorded with treatment combinations of $C_2N_3P_2$ (open field 180: 120 kg N: P_2O_5 ha^{-1}).

Days taken to first flowering did not differ significantly due to interaction between nitrogen and phosphorus levels (NxP).

4.2.2 Days taken to first harvest

The data on days taken to first harvest as influenced by different growing conditions, nitrogen and phosphorus fertigation levels and their interactions is presented in Table 5a to 5c.

A perusal of data (Table 5a) revealed that days taken to first harvest was significantly influenced by nitrogen fertigation levels. Application of 120 kg N ha^{-1} (N_1) recorded significantly lower number of days to first harvest (60.83 days) and it was *on par* with N_2 (61.58 days). Maximum number of days to first harvest (62.33 days) was observed with N_3 (180 kg N ha^{-1}).

Days taken to first harvest did not differ significantly due to different growing conditions, phosphorus levels, interaction effects of growing conditions and nitrogen (CxN), growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP).

4.2.3 Fruit set (%)

A perusal of data (Table 5a) revealed that fruit set was significantly influenced by the interaction effects between growing conditions and phosphorus levels. Significantly higher fruit set (52.56 per cent) was observed in interaction combination of C_2P_1 (open field with 100 kg P_2O_5 ha^{-1}) and it was par on with C_1P_2 and C_1P_1 (52.20 and 51.12 per cent, respectively). Minimum fruit set (50.29 per cent) was recorded with interaction combination of C_2P_2 (open field with 120 kg P_2O_5 ha^{-1}).

Table 5a: Effect of different growing conditions, nitrogen and phosphorus levels on days to first flowering, days taken to first harvest and per cent fruit set

Treatments		Days taken to first flowering (Days)	Days taken to first harvest (Days)	Fruit set (%)
Growing conditions (C)				
C_1	Polyhouse	21.61	61.55	51.66
C_2	Open field	21.88	61.61	51.43
F-test (p=0.05)		*	NS	NS
S.Em.±		0.09	0.23	0.45
C.D. (p=0.05)		0.26	-	-
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	21.58	60.83	51.60
N_2	150 kg ha^{-1}	21.50	61.58	51.50
N_3	180 kg ha^{-1}	22.16	62.33	51.53
F-test (p=0.05)		*	*	NS
S.Em.±		0.11	0.29	0.53
C.D. (p=0.05)		0.33	0.85	-
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	21.55	61.55	51.84
P_2	120 kg ha^{-1}	21.94	61.61	51.24
F-test (p=0.05)		*	NS	NS
S.Em.±		0.09	0.23	0.43
C.D. (p=0.05)		0.26	-	-

*= Significant. NS = Non-significant.

Table 5b: Interaction effect of different growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on days taken to first flowering, days to first harvest and per cent fruit set

Treatments		Days taken to first flowering (Days)	Days taken to first harvest (Days)	Fruit set (%)
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	21.66	60.33	51.77
C_1N_2	Polyhouse + 150 kg N ha^{-1}	21.33	61.83	51.41
C_1N_3	Polyhouse + 180 kg N ha^{-1}	21.83	62.50	51.80
C_2N_1	Open field + 120 kg N ha^{-1}	21.50	61.33	51.43
C_2N_2	Open field + 150 kg N ha^{-1}	21.66	61.33	51.59
C_2N_3	Open field + 180 kg N ha^{-1}	22.50	62.16	51.27
F-test (p=0.05)		*	NS	NS
S.Em.±		0.15	0.41	0.75
C.D. (p=0.05)		0.46	-	-
Growing conditions x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	21.55	61.66	51.12
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	21.66	61.44	52.20
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	21.55	61.44	52.56
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	22.22	61.77	50.29
F-test (P=0.05)		*	NS	*
S.Em.±		0.13	0.33	0.61
C.D. (P=0.05)		0.38	-	1.80
Nitrogen levels x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	21.33	60.66	52.16
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	21.83	61.00	51.04
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	21.50	61.50	52.40
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	21.50	61.66	50.60
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	21.83	62.50	50.97
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	22.50	62.16	52.10
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.15	0.41	0.75
C.D. (P=0.05)		-	-	-

*= Significant. NS = Non-significant.

Table 5c: Interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) on days taken to first flowering, days to first harvest and per cent fruit set

Treatments		Day to taken first flowering (Days)	Days taken to first harvest (Days)	Fruit set (%)
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	21.33	60.66	51.37
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	22.00	60.00	52.17
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	21.66	61.66	51.12
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	21.00	62.00	51.70
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	21.66	62.66	50.88
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	22.00	62.33	52.73
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	21.33	60.66	52.95
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	21.66	62.00	49.91
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	21.33	61.33	53.69
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	22.00	61.33	49.49
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	22.00	62.33	51.06
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	23.00	62.00	51.47
F-test (p=0.05)		*	NS	NS
S.Em.±		0.39	1.01	1.84
C.D. (p=0.05)		0.66	-	-

C_1 = Polyhouse condition NS= Non –significant C_2 = Open field condition

Fruit set did not differ significantly due to different growing conditions, nitrogen and phosphorus fertigation levels, interaction effects of growing conditions and nitrogen (CxN), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP).

4.2.4 Number of flower clusters per plant at 50 and 70 DAT

The data on number of flower clusters per plant as influenced by different growing conditions, nitrogen and phosphorus fertigation levels and their interactions is presented in Table 6a to 6c.

An examination of the data (Table 6a) revealed that, number of flower clusters per plant was significantly influenced by different growing conditions. Polyhouse condition (C_1) recorded significantly higher number of flower clusters per plant (12.62 and 11.77) at both 50 and 70 DAT. Lower number of flower clusters per plant (10.68 and 10.79) was recorded under open field condition (C_2) at both 50 and 70 DAT.

Number of clusters per plant was significantly influenced by different nitrogen fertigation levels at both 50 and 70 DAT (Table 6a and Fig.7). Application of 150 kg N ha^{-1} (N_2) recorded significantly higher number of flower clusters per plant (12.27 and 12.02) at 50 and 70 DAT, respectively and it was *at par* with N_3 (11.66 and 11.60) at both 50 and 70 DAT. Lower number of flower clusters per plant (11.02 and 10.22, respectively) at 50 and 70 DAT was recorded in N_1 (120 kg N ha^{-1}).

Number of flower clusters per plant was also affected significantly by the interaction between growing conditions and nitrogen levels at 50 and 70 DAT (Table 6b and Fig.9). Interaction combination of C_1N_2 (polyhouse with 150 N kg N ha^{-1}) recorded significantly higher number of flower clusters per plant (13.72 and 13.38, respectively) and it was *on par* with C_1N_3 (12.88 and 12.55) at both 50 and 70 DAT. Lower number of flower clusters per plant (10.44) at 50 DAT was observed in C_2N_3 (open field with 180 kg N ha^{-1}) and at 70 DAT, lower number of flower clusters per plant (9.33) was noticed in Polyhouse when supplied with 120 kg N ha^{-1} (C_1N_1).

Number of flower clusters was significantly influenced by the interaction between nitrogen and phosphorus levels at 50 DAT (Table 6b). Interaction combination of N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher number of flower clusters per plant (13.72) and it was *at par* with N_2P_1 (12.88) at 50 DAT. Lower number of flower clusters per plant (10.44) was observed in interaction combination of N_3P_2 (180:120 kg N: P_2O_5 ha^{-1}).

Number of flower clusters per plant did not differ significantly due to phosphorus levels, interaction effects of growing conditions and phosphorus (CxP) and interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) at 50 and 70 DAT. Interaction between nitrogen and phosphorus levels (NxP) also had no significant influence on number of flower clusters per plant 70 DAT.

4.2.5 Number flowers per plant at 50 and 70 DAT

The data on number of flowers per plant as influenced by different growing conditions, nitrogen and phosphorus fertigation levels and their interactions is presented in Table 6a to 6c.

A perusal of data (Table 6a) revealed that number of flowers per plant differed significantly due to different growing conditions at 50 and 70 DAT. Higher number of flowers per plant (202.60 and 185.94, respectively) at 50 and 70 DAT was recorded under polyhouse condition (C_1) and lower number of flowers per plant (160.60 and 167.43 respectively) was observed under open field condition at both 50 and 70 DAT.

Number of flowers per plant was significantly influenced by different nitrogen fertigation levels at 50 and 70 DAT (Table 6a and Fig.10). Application of 150 kg N ha^{-1} (N_2) recorded significantly higher number of flowers per plant (196.80 and 189.77, respectively) at 50 and 70 DAT. N_2 was *on par* with N_3 (180.44 flowers plant) at 70 DAT. Lower number of flowers per plant (171.33 and 159.85, respectively) was recorded with N_1 (120 kg N ha^{-1}) at both 50 and 70 DAT.

Table 6a: Effect of different growing conditions, nitrogen and phosphorus levels on number flower clusters and number of flowers per plant of cherry tomato at different stages after transplanting

Treatments		Number of flower clusters/plant		Number of flowers/plant	
		50 DAT	70 DAT	50 DAT	70 DAT
Growing conditions (c)					
C_1	Polyhouse	12.62	11.77	202.60	185.94
C_2	Open field	10.68	10.79	160.60	167.43
F-test (p=0.05)		*	*	*	*
S.Em.±		0.24	0.22	4.80	4.33
C.D. (p=0.05)		0.72	0.66	14.08	12.71
Nitrogen levels (N)					
N_1	120 kg ha^{-1}	11.025	10.22	171.33	159.85
N_2	150 kg ha^{-1}	12.27	12.02	196.80	189.77
N_3	180 kg ha^{-1}	11.66	11.60	176.69	180.44
F-test (p=0.05)		*	*	*	*
S.Em.±		0.30	0.28	5.88	5.30
C.D. (p=0.05)		0.89	0.82	17.24	15.56
Phosphorus levels (P)					
P_1	100 kg ha^{-1}	11.77	11.18	178.88	174.64
P_2	120 kg ha^{-1}	11.53	11.38	184.33	178.73
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		0.24	0.22	4.80	4.33
C.D. (p=0.05)		-	-	-	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

Table 6b: Interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on number of flower clusters and number of flowers per plant of cherry tomato at different stages after transplanting

Treatments		Number of flower clusters per plant		Number of flowers per plant	
		50 DAT	70 DAT	50 DAT	70 DAT
Growing onditions x Nitrogen levels (C×N)					
C_1N_1	Polyhouse + 120 kg N ha^{-1}	11.27	9.38	180.49	147.94
C_1N_2	Polyhouse + 150 kg N ha^{-1}	13.72	13.38	224.77	215.94
C_1N_3	Polyhouse + 180 kg N ha^{-1}	12.88	12.55	202.55	193.94
C_2N_1	Open field + 120 kg N ha^{-1}	10.77	11.05	162.16	171.77
C_2N_2	Open field + 150 kg N ha^{-1}	10.83	10.66	168.83	163.60
C_2N_3	Open field + 180 kg N ha^{-1}	10.44	10.66	150.82	165.94
F-test (p=0.05)		*	*	NS	*
S.Em.±		0.42	0.39	8.31	7.50
C.D. at 5%		1.25	1.16	-	22.01
Growing conditions x phosphorus levels (C×P)					
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	12.51	11.66	197.51	185.25
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	12.74	11.88	207.70	186.62
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	11.034	10.70	160.25	164.03
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	10.32	10.88	160.95	170.84
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		0.35	0.32	6.79	6.13
C.D. (p=0.05)		-	-	-	-
Nitrogen x Phosphorus levels (N×P)					
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	11.27	9.77	157.77	151.10
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	13.72	10.66	184.88	168.60
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	12.88	12.33	193.94	195.55
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	10.77	11.71	199.66	183.99
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	10.83	11.44	184.94	177.27
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	10.44	11.77	168.44	183.60
F-test (p=0.05)		*	NS	*	NS
S.Em.±		0.42	0.39	8.31	7.50
C.D. (p=0.05)		1.25	-	24.39	-

*= Significant. NS = Non-significant. DAT= Days after transplanting.

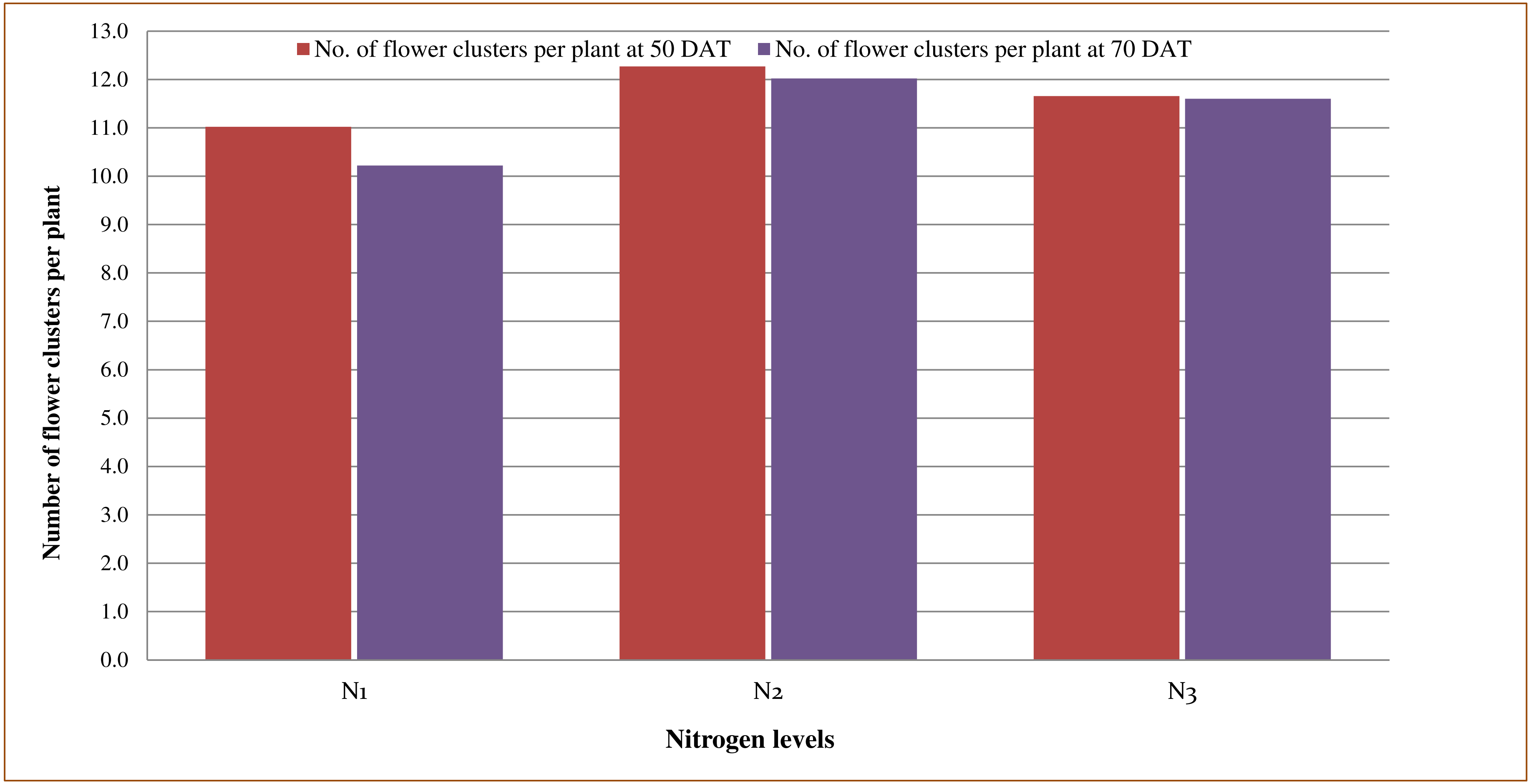

Fig. 8: Effect of different nitrogen fertigation levels on number of flower clusters per plant at 50 and 70 DAT

N_1 = 120 kg N ha^{-1} N_2 = 150 kg N ha^{-1} N_3= 180 kg N ha^{-1}

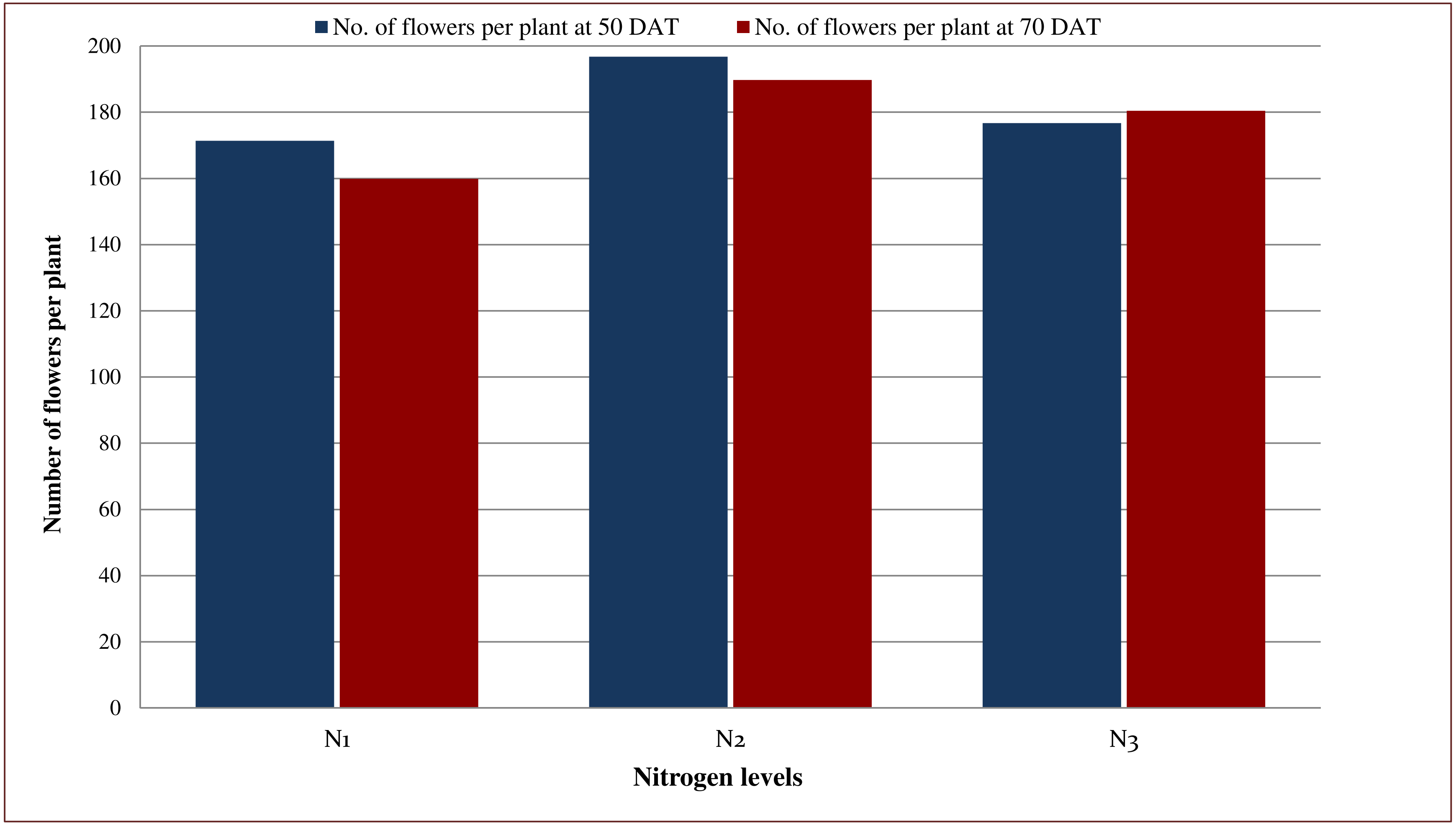

Fig. 9: Effect of different nitrogen fertigation levels on number of flowers per plant at 50 and 70 DAT

N_1 = 120 kg N ha^{-1} N_2 = 150 kg N ha^{-1} N_3= 180 kg N ha^{-1}

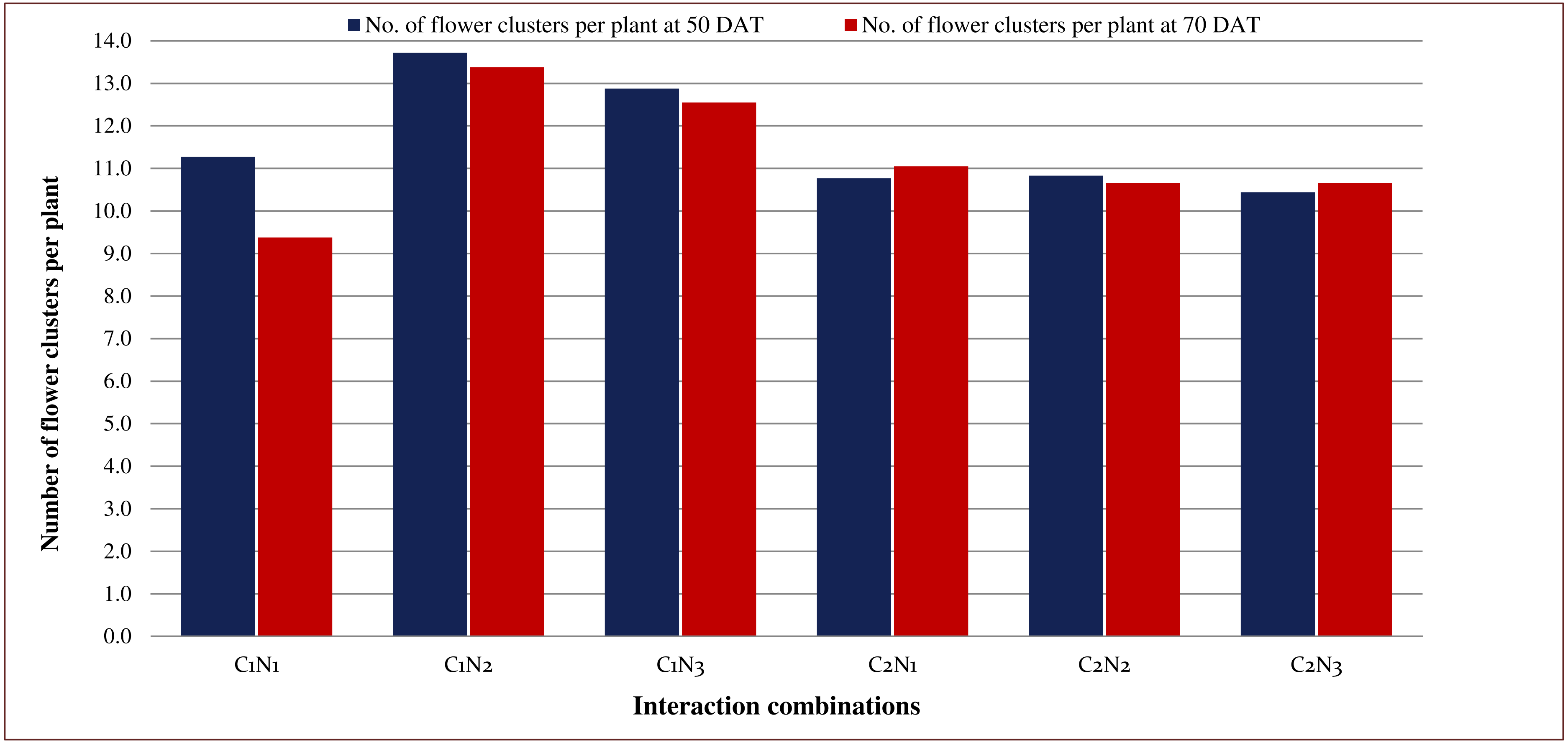

Fig. 10: Interaction effect of growing conditions and nitrogen fertigation levels on number of flower clusters per plant at 50 and 70 days after transplanting

C_1N_1 = Polyhouse + 120 kg N ha^{-1} C_1N_2 = Polyhouse + 150 kg N ha^{-1} C_1N_3= Polyhouse + 180 kg N ha^{-1}

C_2N_1= Open field + 120 kg N ha^{-1} C_2N_2= Open field + 150 kg N ha^{-1} C_2N_3= Open field + 180 kg N ha^{-1}

Table 6c: Interaction effect of different growing conditions, nitrogen and phosphorus levels (CxNxP) on number of flower clusters and number of flowers per plant of cherry tomato at different stages after transplanting

Treatments		Number of flower clusters per plant		Number of flowers per plant	
		50 DAT	70 DAT	50 DAT	70 DAT
Growing conditions x Nitrogen x Phosphorus (CxNxP)					
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	10.22	8.55	160.88	132.10
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	12.33	10.22	200.10	163.77
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	14.22	13.55	227.10	221.55
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	13.22	13.22	222.44	210.33
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	13.10	12.88	204.55	202.11
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	12.66	12.22	200.55	185.77
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	10.33	11.00	154.66	170.10
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	11.22	11.10	169.66	173.44
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	11.11	11.11	160.77	169.55
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	10.55	10.21	176.88	157.66
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	11.66	10.00	165.33	152.44
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	9.21	11.33	136.32	181.44
F-test (p=0.05)		NS	NS	NS	NS
S.Em.±		1.05	0.97	20.37	18.39
C.D. (p=0.05)		-	-	-	-

C_1 = Polyhouse condition DAT= Days after transplanting
C_2 = Open field condition NS= Non-significant

Number of flower per plant was also affected significantly by the interaction between growing conditions and nitrogen levels at 70 DAT (Table 6b). Interaction combination of C_1N_2 (polyhouse with 150 kg N ha^{-1}) recorded significantly higher number of flowers per plant (215.77) and it was *on par* with C_1N_3 (193.94) at 70 DAT. lower number of flowers per plant (147.94) was noticed in polyhouse when supplied with 120 kg N ha^{-1} (C_1N_1) at 70 DAT.

Number of flower per plant was significantly influenced by the interaction between nitrogen and phosphorus levels at 50 DAT (Table 6b). Interaction combination of N_2P_2 (150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher number of flowers per plant (199.66) and it was *at par* with N_2P_1, N_3P_1 and N_3P_1 (193.94, 184.88 and 184.94, respectively) at 50 DAT. Lower number of flowers per plant (157.77) was observed in interaction combination of N_1P_1 (120:100 kg N: P_2O_5 ha^{-1}) at 50 DAT.

Number of flowers per plant did not differ significantly due to different phosphorus levels, interaction effects of growing conditions and phosphorus (CxP) and interaction effects of growing conditions, nitogen and phosphorus levels (CxNxP) at both 50 and 70 DAT. The interaction effects of growing condition and nitrogen (CxN) at 50 DAT and nitrogen and phosphorus (NxP) at 70 DAT also had no-significant influence on number of flowers per plant.

4.3 Yield parameters

4.3.1 Mean fruit weight at 2nd, 4th and 7th harvest (g)

Data pertaining to Effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on mean fruit weight of cherry tomato at 2nd, 4th and 7th harvest is furnished in Table 7a to 7c.

An examination of data (Table 7a) revealed that, the mean fruit weight was significantly influenced by N fertigation levels at 4th and 7th harvest. Application of 180 kg N ha^{-1} recorded significantly higher mean fruit weight (15.86 and 15.68 g, respectively) followed by N_2 (1487 and 14.73 g, respectively) at both 4th and 7th harvest. Lower mean fruit weight (13.43 and 12.96 g, respectively) at 4th and 7th harvests was recorded with N_1 (120 kg N ha^{-1}).

Mean fruit weight affected significantly due to interaction between nitrogen and phosphorus levels at 4th harvest (Table 7b). Interaction combination of N_2P_2 (180: 120 N: P_2O_5 kg ha^{-1}) recorded significantly higher mean fruit weight (15.98 g) and it was *on par* with N_3P_1 and N_2P_2 (15.74 and 15.60 g, respectively) at 4th harvest. Lower mean fruit (13.02 g) was noticed in N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}).

Mean fruit weight was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels at 7th harvest (Table 7c). Treatment combination of $C_2N_3P_1$ (open condition with 180: 100 kg N: P_2O_5 ha^{-1}) recorded significantly higher mean fruit weight (15.98 g) and it was *on par* with $C_1N_3P_1$, $C_2N_3P_2$, $C_2N_2P_2$, $C_1N_3P_1$, $C_1N_2P_1$ and $C_2N_2P_1$(15.84, 15.76, 15.48, 15.14, 15.13 and 14.53 g, respectively). Lower mean fruit (11.69 g) was noticed in treatment combination of $C_2N_1P_1$ (open field with 120: 100 kg N: P_2O_5 ha^{-1}) at 7th harvest.

Mean fruit weight did not differ significantly due to growing conditions at 2nd, 4th and 7th harvest. Mean fruit weight was also affected non-significantly by different nitrogen fertigation levels at 2nd harvest and due to phosphorus levels at 2nd, 4th and 7th harvest.

Mean fruit weight did not differ significantly due to interaction effects of growing conditions and nitrogen (CxN), growing conditions and phosphorus levels (CxP) at 2nd , 4th and 7th harvest. likewise, mean fruit weight did not differ significantly due to interaction effects of nitrogen and phosphorus levels (NxP) at 2nd and 7th harvest and due to interaction effects of growing conditions, nitrogen and phosphorus levels (CxNxP) at 2nd and 4th harvest.

Table 7a: Effect of different growing conditions, nitrogen and phosphorus levels on mean fruit weight of cherry tomato at different harvests

Treatments		Mean fruit weight (g)		
		2nd harvest	4th harvest	7th harvest
Growing conditions (C)				
C_1	Polyhouse	15.09	14.73	14.40
C_2	Open field	14.59	14.71	14.51
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.31	0.22	0.21
C.D. (p=0.05)		-	-	-
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	15.05	13.43	12.96
N_2	150 kg ha^{-1}	15.14	14.87	14.73
N_3	180 kg ha^{-1}	14.33	15.86	15.68
F-test (p=0.05)		NS	*	*
S.Em.±		0.39	0.27	0.26
C.D. (p=0.05)		-	0.81	0.78
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	15.13	14.57	14.18
P_2	120 kg ha^{-1}	14.55	14.87	14.73
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.31	0.22	0.21
C.D. (p=0.05)		-	-	-

*= Significant. NS = Non-significant.

Table 7b: Interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on mean fruit weight of cherry tomato at different harvests

Treatments		Mean fruit weight (g)		
		2nd harvest	4th harvest	7th harvest
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	15.80	13.65	13.26
C_1N_2	Polyhouse + 150 kg N ha^{-1}	15.43	14.79	14.46
C_1N_3	Polyhouse + 180 kg N ha^{-1}	14.05	15.75	15.49
C_2N_1	Open field + 120 kg N ha^{-1}	14.31	13.20	12.66
C_2N_2	Open field + 150 kg N ha^{-1}	14.85	14.96	15.00
C_2N_3	Open field + 180 kg N ha^{-1}	14.61	15.97	15.87
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.55	0.39	0.37
C.D. (p=0.05)		-	-	-
Growing conditions x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	15.73	14.56	14.30
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	14.46	14.91	14.51
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	14.53	14.59	14.07
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	14.65	14.83	14.96
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.45	0.32	0.30
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	15.18	13.83	12.83
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	14.92	13.02	13.09
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	15.56	14.15	14.16
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	14.72	15.60	15.31
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	14.64	15.74	15.56
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	14.02	15.98	15.80
F-test (p=0.05)		NS	*	NS
S.Em.±		0.55	0.39	0.37
C.D. (p=0.05)		-	1.15	-

*= Significant. NS = Non-significant.

Table 7c: Interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) on mean fruit weight of cherry tomato at different harvests

Treatments		Mean fruit weight (g)		
		2nd harvest	4th harvest	7th harvest
Growing conditions x Nitrogen x Phosphorus (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	16.26	14.01	13.97
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	15.33	13.30	12.56
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	16.70	14.23	13.79
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	14.15	15.36	15.13
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	14.22	15.44	15.14
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	13.88	16.07	15.84
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	14.11	13.65	11.69
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	14.51	12.75	13.63
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	14.43	14.08	14.53
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	15.28	15.84	15.48
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	15.06	16.04	15.98
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	14.16	15.89	15.76
F-test (p=0.05)		NS	NS	*
S.Em.±		1.35	0.96	0.92
C.D. (p=0.05)		-	-	1.56

C_1 = Polyhouse condition NS= Non -significant
C_2 = Open field condition

4.3.2 Total number of fruits per plant

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on total number of fruits per plant of cherry tomato is furnished in Table 8a to 8c.

A perusal of data (Table 8a) revealed that total number of fruits per plant was significantly affected by different growing conditions. Total number of fruits per plant was significantly higher (258.07) in polyhouse compared to open field (142.98 fruits per plant).

Total number of fruits per plant affected significantly with different levels of nitrogen. Application of 150 kg N ha^{-1} (N_2) recorded significantly higher number of fruits per plant (219.28) followed by N_3 (194.47). Lower total number of fruits per plant (187.82) was recorded with N_1 (120 kg N ha^{-1}).

Total number of fruits per plant was influenced significantly by the interaction between nitrogen and phosphorus levels (Table 8b). Interaction combination of N_2P_2 (150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher total number of fruits per plant (241.95) followed by N_1P_1 (196.74). Lower total number of fruits per plant (178.90) was recorded in interaction combination of N_1P_2 (120: 120 kg N: P_2O_5 ha^{-1}).

Total number of fruits per plant was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels (Table 8c and Fig.11). Treatment combination of $C_2N_2P_2$ (open field with 150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher total number of fruits per plant (316.63) followed by $C_2N_3P_1$ and $C_2N_2P_1$ (262.13 and 259.32, respectively). Lower total number of fruits per plant (128.27) was observed under polyhouse conditions when supplied with 180:100 kg N: P_2O_5 ha^{-1} ($C_1N_3P_1$).

Total number of fruits per plant did not differ significantly due to different phosphorus levels, interaction effects of growing conditions and nitrogen levels and growing conditions and phosphorus.

4.3.3 Fruit yield per plant (kg)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on yield per plant of cherry tomato is furnished in Table 8a to 8c.

A keen observation of the data (Table 8a) indicated that, fruit yield per plant differed significantly due to different growing conditions. Significantly higher yield per plant (3.60 kg) was recorded in open field condition. Lower yield per plant (2.03 kg) was noticed in polyhouse condition.

Yield per plant was significantly influenced by different nitrogen fertigation levels. Application of 150 kg N ha^{-1} (N_2) recorded significantly higher yield per plant (3.00 kg) followed by N_3 (2.75 kg $plant^{-1}$). Lower yield (2.70 kg) per plant was observed with N_1 (120 kg N ha^{-1}).

Yield per plant was significantly influenced by the interaction between growing conditions and nitrogen levels (Table 8b). Interaction combination of C_2N_2 (open field with 150 kg N ha^{-1}) recorded significantly higher yield per plant (4.01 kg) followed by C_2N_3 (3.48 kg) and lower yield (1.98 kg) per plant was observed in C_1N_2 (polyhouse with 150 kg N ha^{-1}).

Yield per plant was significantly influenced by the interaction between nitrogen and phosphorus fertigation levels (Table 8b). Interaction combination of N_2 P_2 (150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher yield per plant (3.25 kg) and it was *on par* with N_3P_1 and N_1P_1 (2.88 and 2.74 kg per plant, respectively). Lower yield per plant (2.56 kg) was recorded in interaction combination of N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}).

Yield per plant was also affected significantly by the interaction between growing conditions, nitrogen and phosphorus levels (Table 8c). Treatment combination of $C_2N_2P_2$ (open field with 150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher yield per plant (4.46. kg) followed by $C_2N_3P_1$ (3.79 kg $plant^{-1}$). Lower yield per plant (1.80 kg) was observed in treatment combination of $C_1N_1P_2$ (polyhouse with 120:120 kg N: P_2O_5 ha^{-1}).

Table 8a: Effect of different growing conditions, nitrogen and phosphorus levels on number of fruits per plant, yield per plant and yield per hectare of cherry tomato

Treatments		Number of fruits per plant	Yield per plant (kg)	Yield per hectare (t)
Growing conditions (C)				
C_1	Polyhouse	142.98	2.03	36.74
C_2	Open field	258.07	3.60	63.79
F-test (p=0.05)		*	*	*
S.Em.±		5.83	0.08	1.22
C.D. (p=0.05)		17.09	0.23	3.60
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	187.82	2.70	48.71
N_2	150 kg ha^{-1}	219.28	3.00	53.18
N_3	180 kg ha^{-1}	194.47	2.75	48.92
F-test (p=0.05)		*	NS	NS
S.Em.±		7.14	0.09	1.50
C.D. (p=0.05)		20.94	-	-
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	196.18	2.82	50.57
P_2	120 kg ha^{-1}	204.87	2.81	49.96
F-test (p=0.05)		NS	NS	NS
S.Em.±		5.83	0.08	1.22
C.D. (p=0.05)		-	-	-

*= Significant. NS = Non-significant.

Table 8b: Interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus (N×P) on number of fruits per plant, yield per plant and yield per hectare of cherry tomato

Treatments		No. of fruits per plant	Yield per plant (kg)	Yield per hectare (t)
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	136.77	2.09	37.65
C_1N_2	Polyhouse + 150 kg N ha^{-1}	150.58	1.98	35.85
C_1N_3	Polyhouse + 180 kg N ha^{-1}	141.60	2.03	36.73
C_2N_1	Open field + 120 kg N ha^{-1}	238.87	3.32	59.76
C_2N_2	Open field + 150 kg N ha^{-1}	287.98	4.01	70.50
C_2N_3	Open field + 180 kg N ha^{-1}	247.33	3.48	61.11
F-test (p=0.05)		NS	*	*
S.Em.±		10.09	0.13	2.12
C.D. (p=0.05)		-	0.40	6.23
Growing conditions x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	139.85	2.08	37.63
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	146.11	1.98	35.86
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	252.51	3.56	63.51
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	263.62	3.64	64.06
F-test (p=0.05)		NS	NS	NS
S.Em.±		8.24	0.11	1.73
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg $N:P_2O_5$ ha^{-1}	196.74	2.85	51.94
N_1P_2	120:120 kg $N:P_2O_5$ ha^{-1}	178.90	2.56	45.47
N_2P_1	150:100 kg $N:P_2O_5$ ha^{-1}	196.60	2.74	48.72
N_2P_2	150:120 kg $N:P_2O_5$ ha^{-1}	241.95	3.25	57.63
N_3P_1	180:100 kg $N:P_2O_5$ ha^{-1}	195.20	2.88	51.05
N_3P_2	180:120 kg $N:P_2O_5$ ha^{-1}	193.75	2.63	46.79
F-test (p=0.05)		*	*	*
S.Em.±		10.09	0.13	2.12
C.D. (p=0.05)		29.61	0.40	6.23

*= Significant. NS = Non-significant.

Table 8c: Interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) on number of fruits per plant, yield per plant and yield per hectare of cherry tomato

Treatments		No. of fruit per plant	Yield per plant (kg)	Yield per hectare (t)
Growing conditions x Nitrogen x Phosphorus (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	157.41	2.38	42.73
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	116.13	1.80	32.57
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	133.88	1.91	34.59
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	167.27	2.05	37.11
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	128.27	1.96	35.55
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	154.93	2.10	37.91
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	236.08	3.32	61.16
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	241.66	3.31	58.36
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	259.32	3.57	62.84
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	316.63	4.46	78.16
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	262.13	3.79	66.54
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	232.58	3.16	55.87
F-test (p=0.05)		*	*	*
S.Em.±		24.74	0.34	5.21
C.D. (p=0.05)		41.88	0.57	8.82

C_1 = Polyhouse condition C_2 = Open field condition
*= Significant

Yield per plant did not differ significantly due to different phosphorus levels and interaction effects of growing conditions and phosphorus levels (CxP).

4.3.4 Fruit yield per hectare (t)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on yield per hectare of cherry tomato is furnished in Table 8a to 8c.

An examination of data (Table 8a) indicated that, yield per hectare was significantly affected by different growing conditions. Significantly higher yield per hectare (63.79 t) was recorded in open field condition. Lower yield per hectare (36.74 t) was noticed in polyhouse condition.

Yield per hectare was significantly influenced by the interaction between growing conditions and nitrogen levels (Table 8b). Interaction combination of C_2N_2 (open field with 150 kg N ha^{-1}) recorded significantly higher yield per hectare (70.50 t) followed by C_2N_3 and C_2N_1 (61.11 and 59.76 t ha^{-1}, respectively) and lower yield per hectare (35.85 t) was observed in C_1N_2 (polyhouse with 150 kg N ha^{-1}).

Yield ha^{-1} was significantly influenced by the interaction between nitrogen and phosphorus fertigation levels (Table 8b). Interaction combination of N_2P_2 (150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher yield per hectare (57.63 t) followed by N_1P_1 and N_3P_1 (51.94 and 51.05 t ha^{-1}, respectively). Lower yield (45.47 t ha^{-1}) was recorded in interaction combination of N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}).

Yield per hectare was also affected significantly by the interaction between growing conditions, nitrogen and phosphorus levels (Table 8c and Fig.12). Treatment combination of $C_2N_2P_2$ (open field with 150:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher yield per hectare (78.16 t) followed by $C_2N_3P_1$ (66.54 t ha^{-1}). Lower yield (32.57 t ha^{-1}) was observed in treatment combination of $C_1N_1P_2$ (polyhouse with 120:120 kg N: P_2O_5 ha^{-1}).

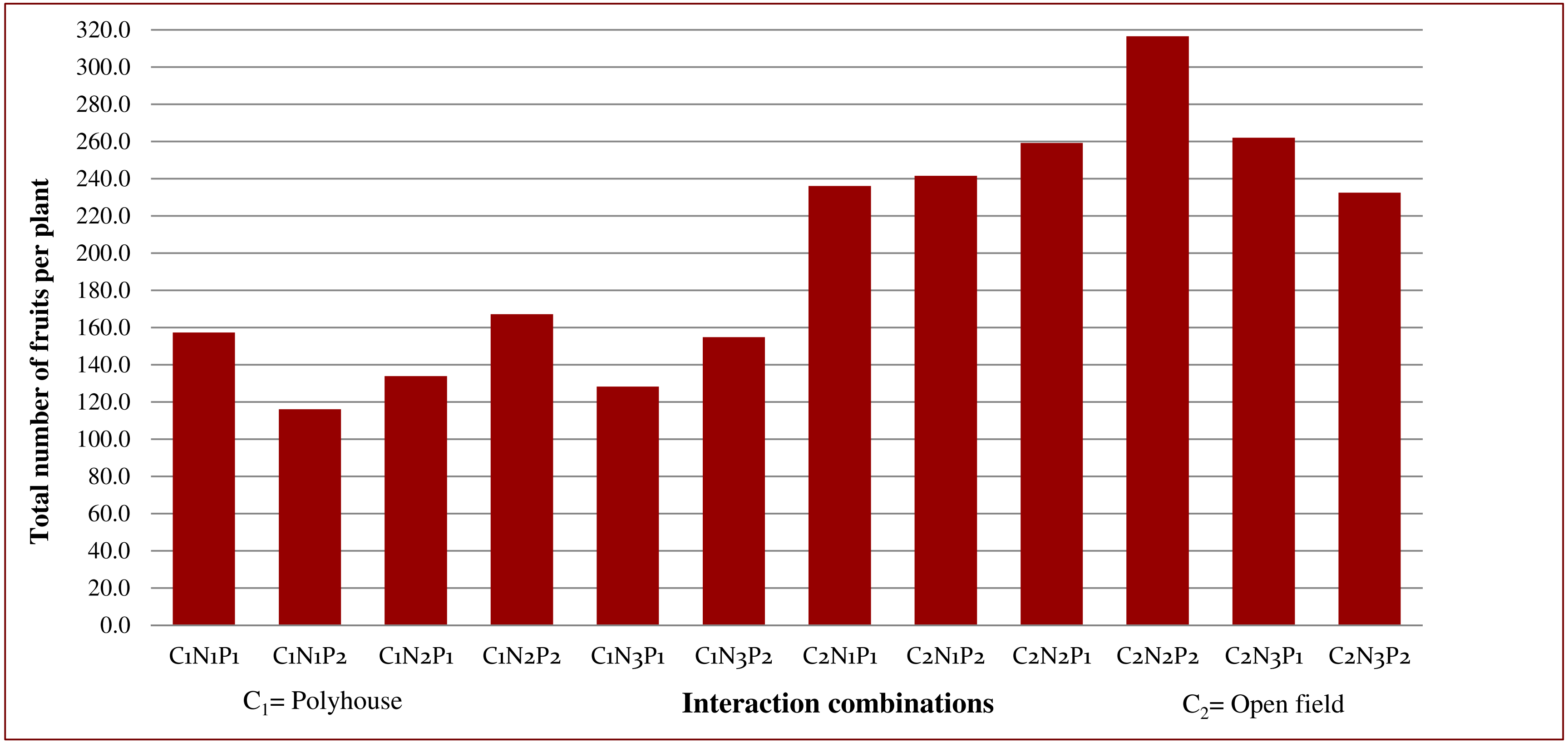

Fig. 11: Interaction effect of growing conditions, nitrogen and phosphorus fertigation levels on total number of fruits per plant

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}
$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}
$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}
$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}
$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

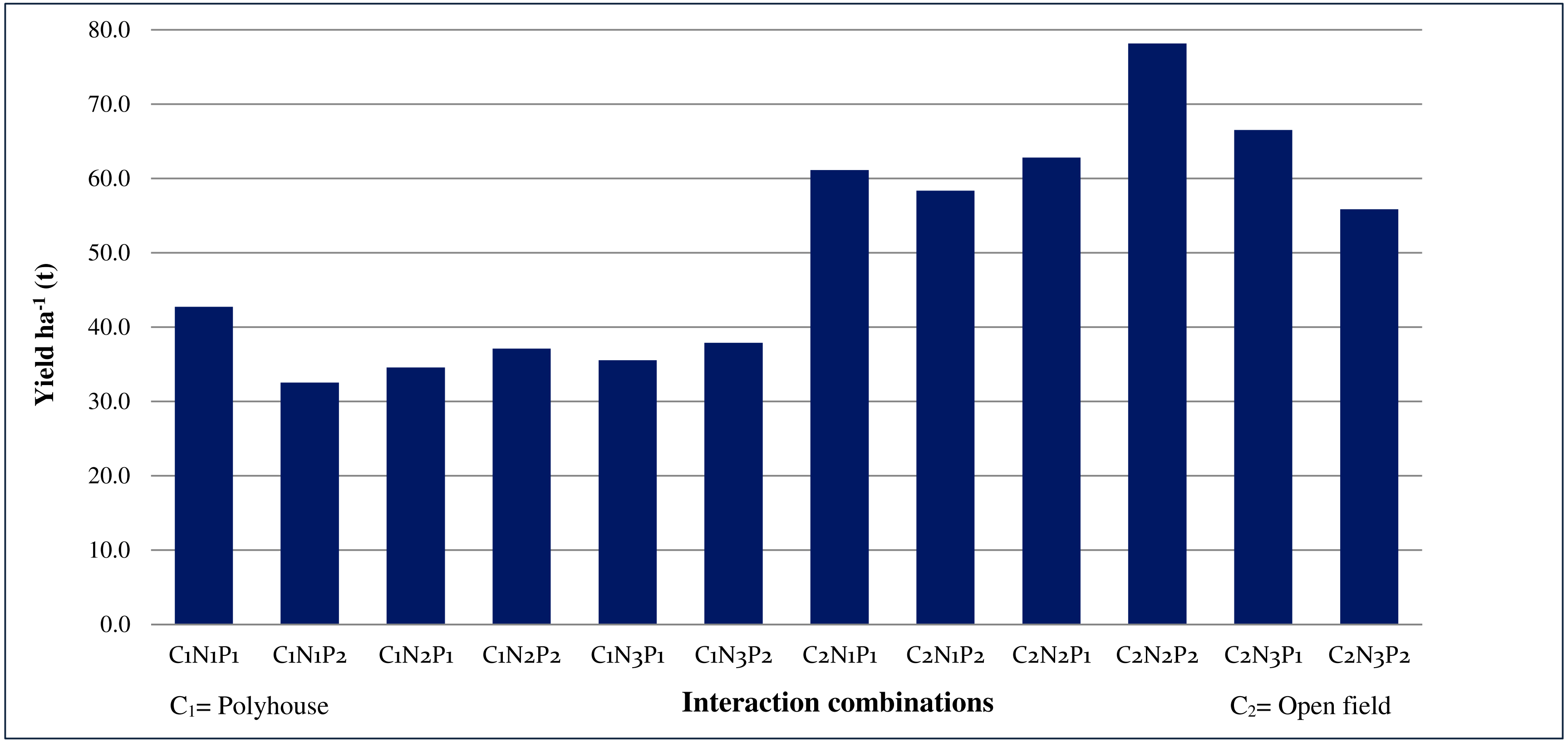

Fig. 12: Interaction effect of growing conditions, nitrogen and phosphorus fertigation levels on fruit yield ha^{-1} of cherry tomato

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}	$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}	$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}	$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}	$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

Yield per hectare did not differ significantly due to different nitrogen and phosphorus levels and interaction effects of growing conditions and phosphorus levels (CxP).

4.4 Quality parameters

4.4.1 Total soluble of solid content (TSS) at initial and middle stage (ºB)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on TSS content of cherry tomato at initial and middle stages is furnished in Table 9a to 9c.

The data (Table 9a) showed that TSS content was significantly influenced by different growing conditions at both initial and middle stages. Polyhouse condition (C_1) recorded significantly higher TSS content (4.84 and 5.07 ºB) at both initial and middle stages. Lower TSS contents (4.11 and 4.74 ºB) were recorded under open field condition at both initial and middle stages, respectively.

Total soluble of solid content (TSS) was significantly influenced by different nitrogen fertigation levels at initial and middle stages (Table 9a). Application of 180 kg N ha^{-1} (N_3) recorded significantly higher TSS (4.75 and 5.37 ºB, respectively) at both initial and middle stages, followed by N_2 (4.39 and 4.79 ºB, respectively) at both initial and middle stages. Lower TSS content (4.28 and 4.55 ºB, respectively) at initial and middle stages was observed in lower levels of nitrogen *i.e.,* N_1 (120 kg N ha^{-1}).

TSS content was significantly influenced by the interaction between growing conditions and nitrogen levels at middle stages (Table 9b). Interaction combination of C_1N_3 (polyhouse with 180 kg N ha^{-1}) recorded significantly higher TSS content (5.70 ºB), followed by C_2N_3 (5.05 ºB) at middle stage. Lower TSS content (4.33 ºB) at middle stage was recorded under open field condition when supplied with 120 kg N ha^{-1} (C_2N_1).

TSS content was also affected significantly by the interaction between nitrogen and phosphorus levels at middle stage. Interaction combination of N_3P_2 (180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher TSS content (5.71 ºB), followed N_3P_1 (5.03 ºB).

Table 9a: Effect of different growing conditions, nitrogen and phosphorus levels on and TSS content and shelf life of cherry tomato at different stages

Treatments		TSS Content (ºB)		Shelf life (Days)
		Initial stage (2^{nd} Harvest)	Middle stage (7^{th} Harvest)	
Growing conditions (C)				
C_1	Polyhouse	4.84	5.07	14.44
C_2	Open field	4.11	4.74	13.94
F-test (p=0.05)		*	*	NS
S.Em.±		0.10	0.07	0.21
C.D. (p=0.05)		0.30	0.22	-
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	4.28	4.55	13.00
N_2	150 kg ha^{-1}	4.39	4.79	14.16
N_3	180 kg ha^{-1}	4.75	5.37	15.41
F-test (p=0.05)		*	*	*
S.Em.±		0.12	0.09	0.26
C.D. (p=0.05)		0.36	0.27	0.78
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	4.41	4.81	13.94
P_2	120 kg ha^{-1}	4.53	5.00	14.44
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.10	0.07	0.21
C.D. (p=0.05)		-	-	-

*= Significant. NS = Non-significant.

Table 9b: Interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on TSS content and shelf life of cherry tomato at different stages

Treatments		TSS Content (°B)		Shelf life (Days)
		Initial stage (2nd Harvest)	Middle stage (7th Harvest)	
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	4.63	4.78	13.66
C_1N_2	Polyhouse + 150 kg N ha^{-1}	4.73	4.73	14.16
C_1N_3	Polyhouse + 180 kg N ha^{-1}	5.16	5.70	15.50
C_2N_1	Open field + 120 kg N ha^{-1}	3.93	4.33	12.33
C_2N_2	Open field + 150 kg N ha^{-1}	4.05	4.85	14.16
C_2N_3	Open field + 180 kg N ha^{-1}	4.35	5.05	15.33
F-test (p=0.05)		NS	*	NS
S.Em.±		0.17	0.13	0.37
C.D. (p=0.05)		-	0.39	-
Growing conditions x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	4.76	4.94	14.11
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	4.92	5.20	14.77
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	4.06	4.68	13.77
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	4.15	4.80	14.11
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.14	0.10	0.30
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	4.18	4.61	13.33
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	4.38	4.50	12.66
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	4.33	4.80	13.16
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	4.45	4.78	15.16
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	4.73	5.03	15.33
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	4.78	5.71	15.50
F-test (p=0.05)		NS	*	*
S.Em.±		0.17	0.13	0.37
C.D. (p=0.05)		-	0.39	1.11

*= Significant. NS = Non-significant.

Table 9c: Interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) on TSS content and shelf life of cherry tomato at different stages

Treatments		TSS Content (ºB)		Shelf life (Days)
		Initial stage (2^{nd} Harvest)	Middle stage (7^{th} Harvest)	
Growing conditions x Nitrogen x Phosphorus (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	4.33	4.90	13.33
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	4.93	4.66	14.00
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	4.66	4.83	13.66
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	4.80	4.63	14.66
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	5.30	5.10	15.33
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	5.03	6.30	15.66
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	4.03	4.33	13.33
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	3.83	4.33	11.33
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	4.00	4.76	12.66
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	4.10	4.93	15.66
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	4.16	4.96	15.33
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	4.53	5.13	15.33
F-test (p=0.05)		NS	*	*
S.Em.±		0.43	0.33	0.93
C.D. (p=0.05)		-	0.56	1.57

C_1 = Polyhouse condition *= Significant
C_2 = Open field condition NS= Non-significant

Lower TSS content (4.50 ºB) was noticed in interaction combination of N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}) at middle stage.

TSS content was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus levels at middle stage (Table 9c). Treatment combination of $C_1N_3P_2$ (polyhouse with 180: 120 N: P_2O_5 ha^{-1}) recorded significantly higher TSS content (6.30 ºB) followed by $C_2N_3P_2$ and $C_1N_3P_1$ (5.13 and 5.10 ºB, respectively) at middle stage. Lower TSS content (4.33 ºB) was noticed in treatment combination of $C_2N_1P_1$ (open field with 120: 120 kg N: P_2O_5 ha^{-1}) at middle stage.

TSS content did not differ significantly due to different phosphorus levels and interaction effects of growing conditions and phosphorus levels (CxP) at both initial and middle stages.

TSS content also did not differed significantly due to interaction effects growing conditions and nitrogen (CxN), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP) at initial stage.

4.4.1 Shelf life (days)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and their interactions on shelf life of cherry tomato is furnished in Table 9a to 9c.

An examination of data (Table 9a) indicated that shelf life of cherry tomato fruits was significantly affected by different nitrogen fertigation levels. Application of 180 kg N ha^{-1} (N_3) recorded significantly higher shelf life (15.41 days), followed N_2 (14.16 days) and lower shelf life (13.00 days) was recorded with N_1 (120 kg N ha^{-1}).

Shelf life was significantly influenced by the interaction between nitrogen and phosphorus levels (Table 9b). Interaction of N_3P_2 (180: 120 kg N: P_2O_5 ha^{-1}) recorded significantly higher shelf life of fruits (15.50 days) and it was *on par* with N_3P_1 and N_2P_2

(15.33 and 15.16 days, respectively). Lower shelf life (12.66 days) was recorded with N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}).

Shelf life was also affected significantly by the interaction between growing conditions, nitrogen and phosphorus levels (Table 9c). Treatment combinations of $C_1N_3P_2$ (polyhouse with 180: 120 kg N: P_2O_5 ha^{-1}) and $C_2N_2P_2$ (open field with 150: 120 kg N: P_2O_5 ha^{-1}) recorded significantly highest shelf life (15.66 days) which were *on par* with $C_1N_3P_1$, $C_2N_3P_1$ and $C_2N_3P_2$ (15.33 days). Minimum shelf life (11.33 days) was observed under open field when supplied with 120:120 kg N: P_2O_5 ha^{-1} ($C_2N_2P_2$).

Shelf life did not differed significantly due to different growing conditions, phosphorus levels, interaction effects of condition and nitrogen (CXN) and condition and phosphorus (CXP).

4.4 Plant analysis

Data pertaining to effect of different growing conditions, nitrogen and phosphorus levels and interactions of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P), nitrogen and phosphorus (N×P) and growing conditions, nitrogen and phosphorus levels (CxNxP) on nutrients concentration (N, P and K %) of cherry tomato is furnished in Table 10a to 10c .

4.5.1 Nitrogen content in plant (%)

An examination of data (Table 10a) indicated that growing conditions showed significant effect on nitrogen content in plant. Higher nitrogen content in plant (2.50 %) was observed under open field condition (C_2). Lower nitrogen concentration (2.26%) was noticed in polyhouse condition (C_2).

Nitrogen content in plant was also significantly influenced by different nitrogen fertigation levels (Table 10a). Application of 180 kg N ha^{-1} (N_3) recorded significantly higher nitrogen content in plant (2.73 %) followed N_2 (2.30 %). Lower plant nitrogen concentration (2.12 %) was observed with N_1 (120 kg N ha^{-1}).

Plant nitrogen concentration was also significantly affected by the interaction between growing conditions and nitrogen levels (Table 10b). The combined effect of C_2N_3 (open field with 180 kg h^{-1}) recorded significantly higher plant nitrogen content (3.10 %) followed by C_1N_3 (2.37 %). Lower nitrogen content in plant (2.11 %) was observed with C_2N_1 (open field with 120 kg N ha^{-1}).

Nitrogen content in plant did not differ significantly due to different levels of phosphorus, interaction effects of growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP).

4.5.2 Phosphorus content in plant (%)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus levels and their interaction on phosphorus content (%) in cherry tomato plant is furnished in Table 10a to 10c.

An examination of data (Table 10a) indicated that phosphorus content in plant was significantly influenced by different phosphorus fertigation levels. Application of 120 kg P ha^{-1} (P_2) recorded significantly higher phosphorus content (0.37 %). Lower phosphorus content in plant (0.34 %) was observed with P_1 (100 kg P_2O_5 ha^{-1}).

Phosphorus content in plant did not differ significantly due to different growing conditions, nitrogen levels, Interaction effects of growing conditions and nitrogen (CxP), growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus (CxNxP).

4.5.3 Potassium content in plant (%)

Data pertaining to effect of different growing conditions, nitrogen and phosphorus levels and their interaction on phosphorus content (%) in cherry tomato plant is furnished in Table 10a to 10c.

Table 10a: Effect of different growing conditions, nitrogen and phosphorus levels on plant nutrient contents (N, P and K %) of cherry tomato

Treatments		Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Growing conditions (C)				
C_1	Polyhouse	2.26	0.351	1.85
C_2	Open field	2.50	0.366	2.10
F-test (p=0.05)		*	NS	*
S.Em.±		0.06	0.010	0.03
C.D. (p=0.05)		0.18	-	0.09
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	2.12	0.342	1.97
N_2	150 kg ha^{-1}	2.30	0.366	1.88
N_3	180 kg ha^{-1}	2.73	0.367	2.06
F-test (p=0.05)		*	NS	*
S.Em.±		0.07	0.013	0.04
C.D. (p=0.05)		0.23	-	0.12
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	2.45	0.339	2.01
P_2	120 kg ha^{-1}	2.32	0.378	1.94
F-test (p=0.05)		NS	*	NS
S.Em.±		0.06	0.010	0.03
C.D. (p=0.05)		-	0.030	-

*= Significant. NS = Non-significant.

Table 10b: Interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P) on plant nutrient content (N, P and K %) of cherry tomato

Treatments		Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	2.14	0.346	1.86
C_1N_2	Polyhouse + 150 kg N ha^{-1}	2.28	0.356	1.78
C_1N_3	Polyhouse + 180 kg N ha^{-1}	2.37	0.353	1.91
C_2N_1	Open field + 120 kg N ha^{-1}	2.11	0.339	2.09
C_2N_2	Open field + 150 kg N ha^{-1}	2.31	0.376	1.98
C_2N_3	Open field + 180 kg N ha^{-1}	3.10	0.382	2.22
F-test (p=0.05)		*	NS	NS
S.Em.±		0.11	0.018	0.05
C.D. (p=0.05)		0.32	-	-
Growing conditions x phosphorus (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	2.30	0.328	1.88
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	2.22	0.375	1.81
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	2.59	0.350	2.14
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	2.42	0.381	2.06
F-test (p=0.05)		*	NS	NS
S.Em.±		0.09	0.015	0.04
C.D. (p=0.05)		0.26	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	2.08	0.316	2.07
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	2.17	0.369	1.88
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	2.38	0.341	1.91
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	2.22	0.391	1.86
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	2.89	0.359	2.05
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	2.57	0.376	2.07
F-test (p=0.05)		*	NS	*
S.Em.±		0.11	0.018	0.05
C.D. (p=0.05)		0.32	-	0.17

*= Significant. NS = Non-significant.

Table 10c: Interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP) on plant nutrient contents (N, P and K %) of cherry tomato

Treatments		Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Growing conditions x Nitrogen x Phosphorus (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	2.11	0.325	1.97
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	2.18	0.366	1.74
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	2.27	0.325	1.79
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	2.29	0.388	1.77
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	2.53	0.333	1.89
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	2.20	0.372	1.93
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	2.05	0.306	2.17
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	2.16	0.371	2.01
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	2.48	0.358	2.02
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	2.14	0.394	1.95
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	3.25	0.385	2.22
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	2.95	0.379	2.22
F-test (p=0.05)		NS	NS	NS
S.Em.±		0.27	0.040	0.14
C.D. (p=0.05)		-	-	-

C_1 = Polyhouse condition C_2 = Open field condition
*= Significant

Potassium content in plant differed significantly due to different growing conditions (Table 10a). Open field condition (C_2) recorded significantly higher potassium content in plant (2.10 %) and lower potassium content in plant (1.85 %) was recoded under polyhouse condition.

Potassium content in plants was affected significantly by different nitrogen fertigation levels (Table 10a). Application of 180 kg N ha^{-1} (N_3) recorded significantly higher potassium content in plant (2.06 %), followed by N_1 (1.97 %). Lower potassium content in plant (1.88 %) was observed with N_2 (150 kg N ha^{-1}).

Potassium content in plant did not differ significantly due to different growing conditions, phosphorus levels, interaction effects of growing conditions and nitrogen (CxP), growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP).

4.6 Nutrient uptake

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and interactions of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P), nitrogen and phosphorus (N×P) and growing conditions, nitrogen and phosphorus levels (CxNxP) on uptake of nitrogen, phosphorus and potassium by cherry tomato is furnished in Table 11a to 11c and depicted in Fig.14.

4.6.1 Nitrogen uptake (kg ha^{-1})

The data (Table 11a) showed that nitrogen uptake by cherry tomato was significantly influenced by nitrogen fertigation levels. Application of 180 kg N ha^{-1} (N_3) recorded significantly higher nitrogen uptake (171.36 kg ha^{-1}), followed by N_2 (139.79 kg ha^{-1}). Lower nitrogen uptake (115.18 kg ha^{-1}) was recorded with application of 120 kg N ha^{-1} (N_2).

Nitrogen uptake was also affected significantly by the interaction between growing conditions and nitrogen fertigation levels (Table 11b and Fig.13). Interaction combination of C_1N_3 (polyhouse with 180 kg N ha^{-1}) recorded significantly higher nitrogen uptake (174.33 kg ha^{-1}) and it was *on par* with C_2N_3 (168.39 kg ha^{-1}). Lower nitrogen uptake (111.02 kg ha^{-1}) was noticed under open field condition when supplied with 120 kg N ha^{-1} (C_2N_1).

Nitrogen uptake by cherry tomato plants was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus fertigation levels (Table 11c and Fig.14). Treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher nitrogen uptake (181.41 kg ha^{-1}) and it was *on par* with $C_2N_3P_1$, $C_1N_3P_1$, $C_2N_3P_2$ and $C_2N_2P_2$ (171.71, 167.26, 165.07 and 163.18 kg h^{-1}, respectively). Lower nitrogen uptake (110.68 kg ha^{-1}) was observed in treatment combination of $C_2N_1P_2$ (open field with 120:120 kg N: P_2O_5 ha^{-1}).

Nitrogen uptake did not differ significantly due to different growing conditions, phosphorus levels, interaction effects of growing conditions and phosphorus (CxP) and nitrogen and phosphorus (NxP).

4.6.2 Phosphorus uptake (kg ha^{-1})

The data (Table 11a) indicated that, phosphorus uptake by cherry tomato was significantly influenced by nitrogen fertigation levels. Application of 180 kg N ha^{-1} (N_3) recorded significantly higher phosphorus uptake (23.71 kg ha^{-1}) and it was *on par* with N_2 (22.73 kg ha^{-1}). Lower phosphorus uptake (19.66 kg ha^{-1}) was observed with N_1 (120 kg N ha^{-1}).

Phosphorus uptake by cherry tomato plants was significantly influenced by phosphorus fertigation levels (Table 11a). Application 120 kg P_2O_5 ha^{-1} (P_2) recorded significantly higher phosphorus uptake (23.85 kg ha^{-1}). Lower phosphorus uptake (20.22 kg ha^{-1}) was recorded with P_1 (100 kg P_2O_5 ha^{-1}).

Phosphorus uptake was also affected significantly by the interaction between growing conditions and nitrogen fertigation levels (Table 11b and Fig.13). Interaction combination of C_1N_3 (polyhouse with 180 kg N ha^{-1}) recorded significantly higher phosphorus uptake (26.36 kg ha^{-1}) and it was *on par* with C_2N_2 (24.76 kg ha^{-1}). Lower phosphorus uptake (19.02 kg ha^{-1}) was noticed under open field condition when supplied with 120 kg N ha^{-1} (C_2N_1).

Phosphorus uptake by cherry tomato was significantly influenced by the interaction between growing conditions, nitrogen and phosphorus fertigation levels (Table 11c and Fig.14). Treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher phosphorus uptake (30.72 kg ha^{-1}) and it was *on par* with $C_2N_2P_2$ (29.69 kg ha^{-1}). Lower phosphorus uptake (18.92 kg ha^{-1}) was recorded in treatment combination of $C_2N_1P_1$ (open field with 120:100 kg N: P_2O_5 ha^{-1}). However, phosphorus uptake did not differ significantly due to different growing conditions, interaction effects of growing conditions and phosphorus (CxP) and nitrogen and phosphorus levels (NxP).

4.6.3 Potassium uptake (kg ha^{-1})

The data (Table 11a) revealed that potassium uptake by cherry tomato was significantly influenced by nitrogen fertigation levels. Application of 180 kg N ha^{-1} (N_3) recorded significantly higher potassium uptake (132.55 kg ha^{-1}) followed by N_2 (116.35 kg ha^{-1}). Lower potassium nitrogen uptake (109.86 kg ha^{-1}) was recorded with application of 120 kg N ha^{-1} (N_2).

Potassium uptake was also affected significantly by the interaction between growing conditions and nitrogen fertigation levels (Table 11b and Fig.13). Interaction combination of C_1N_3 (polyhouse with 180 kg N ha^{-1}) recorded significantly higher potassium uptake (142.33 kg ha^{-1}) and it was *on par* with C_2N_2 and C_2N_3 (130.68 and 122.77 kg ha^{-1}, respectively). Lower potassium uptake (102.01kg ha^{-1}) was noticed under polyhouse condition when supplied with 150 kg N ha^{-1} (C_2N_1).

Potassium uptake was influenced significantly by the interaction between nitrogen and phosphorus fertigation levels (Table 11b). Interaction combination of N_3P_2 (180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher potassium uptake (144.17 kg ha^{-1}) followed by N_2P_2 and N_3P_1 (121.98 and 120.94 kg ha^{-1}, respectively). Lower potassium uptake (101.20 kg ha^{-1}) was recorded with interaction combination of N_1P_2 (120:120 kg N: P_2O_5 ha^{-1}).

Table 11a: Uptake of nitrogen, phosphorus and potassium by cherry tomato as influenced by different growing conditions, nitrogen and phosphorus fertigation levels

Treatments		Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
Growing conditions (C)				
C_1	Polyhouse	141.04	22.45	117.90
C_2	Open field	143.18	21.61	121.27
F-test (p=0.05)		NS	NS	NS
S.Em.±		3.17	0.91	3.85
C.D. (p=0.05)		-	-	-
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	115.18	19.66	109.86
N_2	150 kg ha^{-1}	139.79	22.73	116.35
N_3	180 kg ha^{-1}	171.36	23.71	132.55
F-test (p=0.05)		*	*	*
S.Em.±		3.88	1.12	4.71
C.D. (p=0.05)		11.39	3.28	13.83
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	141.33	20.22	116.73
P_2	120 kg ha^{-1}	142.89	23.85	122.45
F-test (p=0.05)		NS	*	NS
S.Em.±		3.17	0.91	3.85
C.D. (p=0.05)		-	2.68	-

*= Significant. NS = Non-significant.

Table 11b: Uptake of nitrogen, phosphorus and potassium by cherry tomato as influenced by the interaction of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P)

Treatments		Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
Growing conditions x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	119.34	20.31	109.37
C_1N_2	Polyhouse + 150 kg N ha^{-1}	129.44	20.69	102.01
C_1N_3	Polyhouse + 180 kg N ha^{-1}	174.33	26.36	142.33
C_2N_1	Open field + 120 kg N ha^{-1}	111.02	19.02	110.35
C_2N_2	Open field + 150 kg N ha^{-1}	150.14	24.76	130.68
C_2N_3	Open field + 180 kg N ha^{-1}	168.39	21.05	122.77
F-test (p=0.05)		*	*	*
S.Em.±		5.49	1.58	6.67
C.D. (p=0.05)		16.11	4.64	19.56
Growing condition x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	142.60	20.74	117.57
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	139.47	24.17	118.23
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	140.05	19.69	115.88
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	146.31	23.53	126.66
F-test (p=0.05)		NS	NS	NS
S.Em.±		4.48	1.29	5.44
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	117.81	19.34	118.52
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	112.54	19.98	101.20
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	136.69	20.14	110.72
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	142.89	25.31	121.98
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	169.48	21.16	120.94
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	173.24	26.25	144.17
F-test (p=0.05)		NS	NS	*
S.Em.±		5.49	1.58	6.67
C.D. (p=0.05)		-	-	19.56

*= Significant. NS = Non-significant.

Table 11c: Uptake of nitrogen, phosphorus and potassium by cherry tomato as influenced by the interaction of growing conditions, nitrogen and phosphorus (CxNxP)

Treatments		Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)				
$C_1N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	124.27	19.77	119.10
$C_1N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	114.40	20.85	99.64
$C_1N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	136.28	20.45	108.84
$C_1N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	122.60	20.94	95.18
$C_1N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	167.26	22.00	124.78
$C_1N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	181.41	30.72	159.88
$C_2N_1P_1$	120:100 kg $N:P_2O_5$ ha^{-1}	111.35	18.92	117.94
$C_2N_1P_2$	120:120 kg $N:P_2O_5$ ha^{-1}	110.68	19.12	102.76
$C_2N_2P_1$	150:100 kg $N:P_2O_5$ ha^{-1}	137.10	19.83	112.59
$C_2N_2P_2$	150:120 kg $N:P_2O_5$ ha^{-1}	163.18	29.69	148.77
$C_2N_3P_1$	180:100 kg $N:P_2O_5$ ha^{-1}	171.71	20.33	117.10
$C_2N_3P_2$	180:120 kg $N:P_2O_5$ ha^{-1}	165.07	21.78	128.45
F-test (p=0.05)		*	*	*
S.Em.±		13.46	3.88	16.34
C.D. (p=0.05)		22.79	6.57	27.67

C_1 = Polyhouse condition C_2 = Open field condition
*= Significant

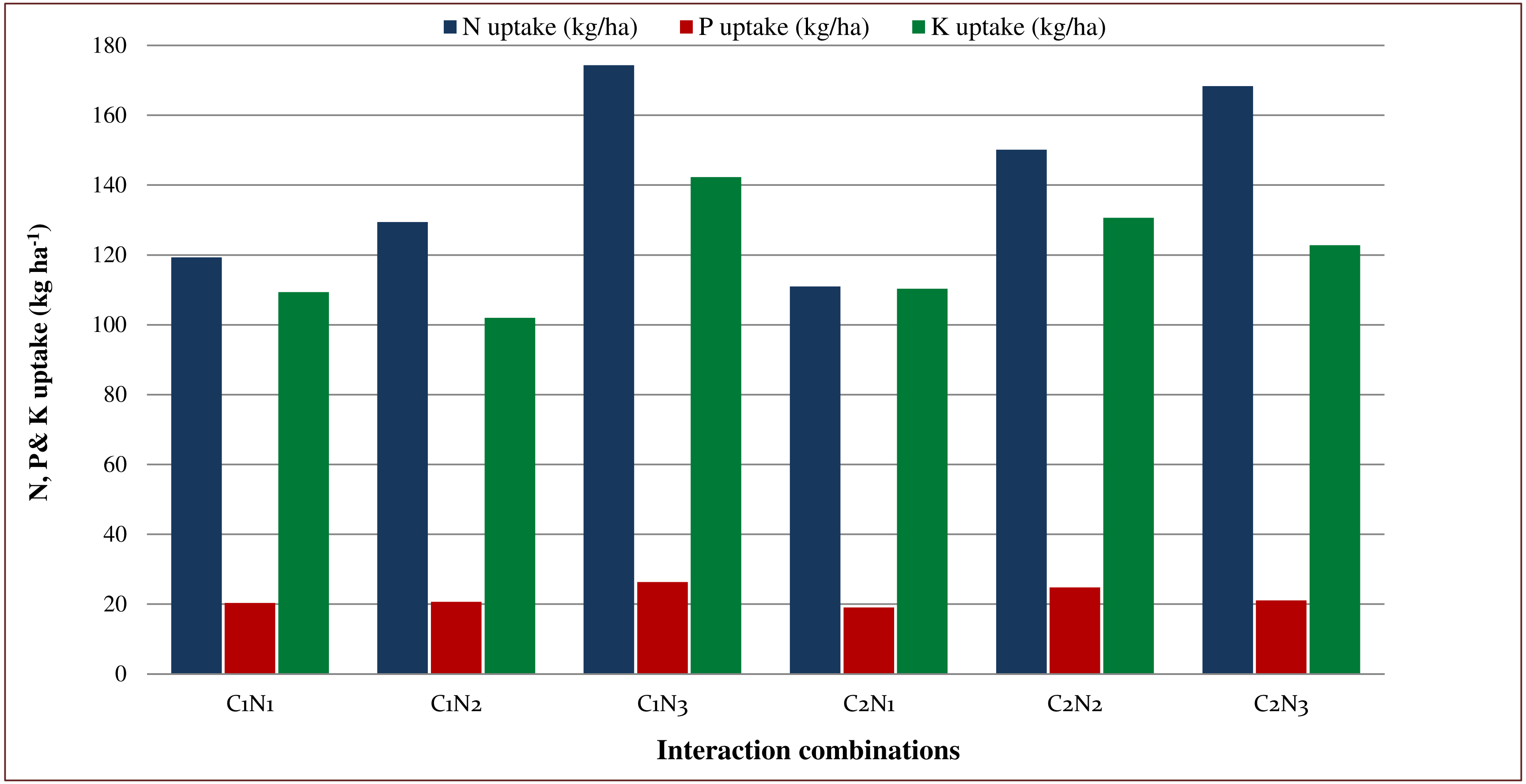

Fig. 13: Interaction effect of growing conditions and nitrogen fertigation levels on N, P and K uptake by cherry tomato

C_1N_1 = Polyhouse + 120 kg N ha^{-1} C_1N_2 = Polyhouse + 150 kg N ha^{-1} C_1N_3= Polyhouse + 180 kg N ha^{-1}

C_2N_1= Open field + 120 kg N ha^{-1} C_2N_2= Open field + 150 kg N ha^{-1} C_2N_3= Open field + 180 kg N ha^{-1}

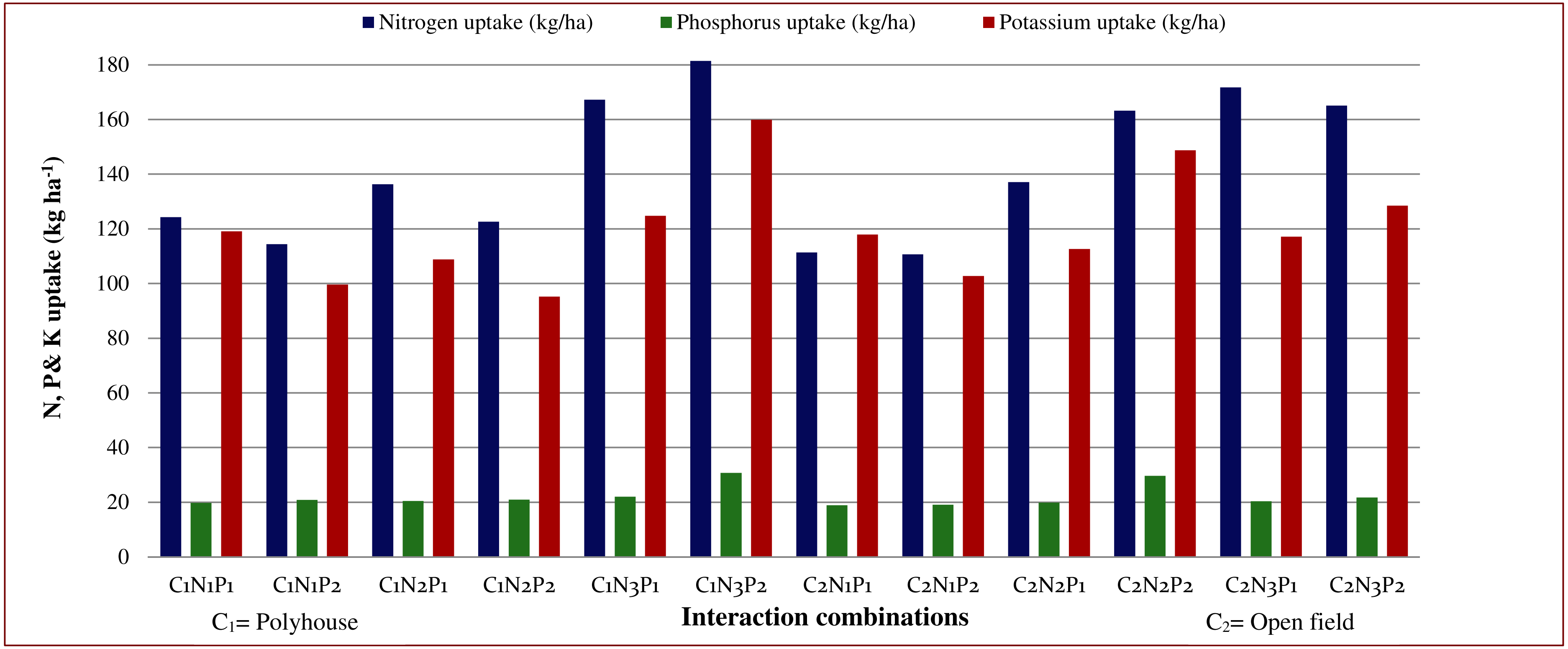

Fig. 14: Uptake of N, P & K by cherry tomato as influenced by different growing conditions, nitrogen and phosphorus fertigation levels

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}	$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}	$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}	$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}	$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}	$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}	$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

Potassium uptake by cherry tomato plants was also significantly influenced by the interaction between growing conditions, nitrogen and phosphorus fertigation levels (Table 11c and Fig.14). Treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher potassium uptake (159.88 kg ha^{-1}) and it was *on par* with $C_2N_2P_2$ (148.77 kg ha^{-1}). Lower potassium uptake (95.18 kg ha^{-1}) was recorded in treatment combination of $C_1N_2P_2$ (polyhouse with 150:200 kg N: P_2O_5 ha^{-1}).

Potassium uptake by cherry tomato plants did not differ significantly due to different growing conditions, phosphorus levels and interaction effects of growing conditions and phosphorus levels (CxP).

4.7.3 Soil analysis

Data pertaining to effect of different growing conditions, nitrogen and phosphorus fertigation levels and interactions of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P), nitrogen and phosphorus (N×P) and growing conditions, nitrogen and phosphorus levels (CxNxP) on soil reaction (pH and EC), available nitrogen, phosphorus and potassium in cherry tomato plots is furnished in Table 12a to 12c and 13a to13c.

4.7.1 Available nitrogen (kg ha^{-1})

It is apparent from the data (Table 12a) that available nitrogen content of soil was significantly influenced due to different growing conditions. Polyhouse condition (C_1) recorded significantly higher available nitrogen of soil (310.96 kg ha^{-1}). Lower available nitrogen (294.58 kg ha^{-1}) was recorded under open field condition (C_2).

Available nitrogen content of soil did not differ significantly due to nitrogen and phosphorus fertigation levels and interaction effects of growing conditions and nitrogen (CxP), condition and phosphorus (CxP), nitrogen and phosphorus (NxP) and interaction effects of growing conditions, nitrogen and phosphorus levels (CxNxP).

4.7.2 Available phosphorus (kg ha^{-1})

An examination of data (Table 12a) indicated that available phosphorus of soil was significantly influenced by different growing conditions. Open field condition (C_2) recorded significantly higher available phosphorus in soil (69.99 kg ha^{-1}). Lower available phosphorus of soil (64.20 kg ha^{-1}) was recorded under polyhouse condition (C_2).

Available phosphorus of soil was also affected significantly by different nitrogen fertigation levels (Table 12a). Application of 120 kg N ha^{-1} (N_1) recorded significantly higher available phosphorus of soil (70.20 kg ha^{-1}) followed by N_2 (65.65 kg ha^{-1}) and lower available phosphorus of soil was recorded with N_1 (65.42 kg ha^{-1}).

Available phosphorus content of soil did not differ significantly due to different phosphorus fertigation levels, interaction effects growing conditions and nitrogen (CxP), growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and interaction effects of growing conditions, nitrogen and phosphorus (CxNxP).

4.7.3 Available potassium (kg ha^{-1})

A keen observation of data (Table 12a) indicated that, available potassium of soil was significantly influenced by different growing conditions. Polyhouse condition (C_1) recorded significantly higher available potassium of soil (339.76 kg ha^{-1}). Lower available potassium of soil (310.32 kg ha^{-1}) was observed under open field condition (C_2).

Available potassium of soil was also affected significantly by the interaction between different growing conditions, nitrogen and phosphorus fertigation levels (Table 12c). Treatment combination of $C_1N_2P_2$ (polyhouse with 180:120 kg N: P_2O_5 ha^{-1}) recorded significantly higher available potassium of soil (363.20 kg ha^{-1}) and it was *on par* with $C_1N_1P_1$, $C_1N_1P_2$, $C_1N_2P_1$, $C_2N_2P_1$, $C_1N_3P_1$ and $C_2N_3P_2$ (359.28, 343.28, 341.96, 339.16, 329.16 and 324.00 kg ha^{-1}, respectively). Lower available potassium of soil (284.00 kg ha^{-1}) was recorded with $C_2N_2P_2$ (open field with 150: 120 kg N: P_2O_5 ha^{-1}).

Table 12a: Available nutrient status of soil (N, P and K) as influenced by different growing conditions, nitrogen and phosphorus fertigation levels

Treatments		Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})
Growing conditions (C)				
C_1	Polyhouse	310.20	64.20	339.76
C_2	Open field	294.58	69.99	310.32
F-test (p=0.05)		*	*	*
S.Em.±		5.15	0.94	6.61
C.D. (p=0.05)		15.12	2.76	19.39
Nitrogen levels (N)				
N_1	120 kg ha^{-1}	296.77	70.20	326.58
N_2	150 kg ha^{-1}	302.16	65.65	332.08
N_3	180 kg ha^{-1}	309.39	65.42	316.48
F-test (p=0.05)		NS	*	NS
S.Em.±		6.31	1.15	8.10
C.D. (p=0.05)		-	3.38	-
Phosphorus levels (P)				
P_1	100 kg ha^{-1}	303.26	66.01	328.79
P_2	120 kg ha^{-1}	302.28	68.17	321.30
F-test (p=0.05)		NS	NS	NS
S.Em.±		5.15	0.94	6.61
C.D. (p=0.05)		-	-	-

*= Significant. NS = Non-significant.

Table 12b: Available nutrient status of (N, P and K) as influenced by the interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P)

Treatments		Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Growing condition x Nitrogen levels (C×N)				
C_1N_1	Polyhouse + 120 kg N ha^{-1}	296.68	67.61	351.28
C_1N_2	Polyhouse + 150 kg N ha^{-1}	320.69	63.70	352.58
C_1N_3	Polyhouse + 180 kg N ha^{-1}	315.53	61.28	315.44
C_2N_1	Open field + 120 kg N ha^{-1}	296.87	72.80	301.88
C_2N_2	Open field + 150 kg N ha^{-1}	283.63	67.61	311.58
C_2N_3	Open field + 180 kg N ha^{-1}	303.24	69.56	317.52
F-test (p=0.05)		NS	NS	NS
S.Em.±		8.93	1.63	11.45
C.D. (p=0.05)		-	-	-
Growing conditions x Phosphorus levels (C×P)				
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	311.23	63.92	343.46
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	310.70	64.47	336.06
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	295.30	68.10	314.12
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	293.86	71.88	306.53
F-test (p=0.05)		NS	NS	NS
S.Em.±		7.29	1.33	9.35
C.D. (p=0.05)		-	-	-
Nitrogen x Phosphorus levels (N×P)				
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	298.27	70.28	325.72
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	295.28	70.13	327.44
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	309.54	64.42	340.56
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	294.78	66.89	323.60
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	301.98	63.34	320.10
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	316.79	67.51	312.86
F-test (p=0.05)		NS	NS	NS
S.Em.±		8.93	1.63	11.45
C.D. (p=0.05)		-	-	-

NS = Non-significant.

Table 12c: Available nutrient status of (N, P and K) as influenced by interaction effect of growing conditions, nitrogen and phosphorus (CxNxP)

Treatments		Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)				
$C_1N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	292.31	69.00	359.28
$C_1N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	301.05	66.22	343.28
$C_1N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	327.78	62.52	341.96
$C_1N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	313.60	64.89	363.20
$C_1N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	313.60	60.25	329.16
$C_1N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	317.46	62.31	301.72
$C_2N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	304.23	71.57	292.16
$C_2N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	289.51	74.04	311.60
$C_2N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	291.30	66.32	339.16
$C_2N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	275.97	68.90	284.00
$C_2N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	290.37	66.43	311.04
$C_2N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	316.12	72.70	324.00
F-test (p=0.05)		NS	NS	*
S.Em.±		21.88	4.00	28.06
C.D. (p=0.05)		-	-	47.51

C_1 = Polyhouse condition NS= Non -significant

C_2 = Open field condition *= Significant

Available potassium of soil did not differ significantly due to nitrogen and phosphorus fertigation levels, interaction effects of growing conditions and nitrogen (CxN), growing conditions and phosphorus (CxP) and nitrogen and phosphorus levels (NxP).

4.7.4 Soil reaction (pH and EC)

An examination of data (Table 13a) indicated that soil pH and EC was significantly influenced by different growing conditions. Higher pH (7.29) of soil was observed under open field condition (C_2) and lower pH (6.46) of soil was noticed under polyhouse condition (C_1). Higher EC (0.37 dS m^{-1}) of soil was noticed under polyhouse condition (C_1) and lower soil EC (0.22 dS m^{-1}) was observed under open field condition (C_2).

Soil pH was also affected significantly by the interaction between growing conditions and nitrogen fertigation levels (Table 13b). Higher pH (7.48) of soil was recorded under open filed condition when supplied with 180 kg N ha^{-1} (C_2N_3) and it was *on par* with C_2N_2 (pH 7.33). Lower pH (6.29) of was observed under polyhouse condition when supplied with 180 kg N ha^{-1} (C_1N_3).

Soil pH was significantly influenced by the interaction between growing conditions and phosphorus levels (Table 13b). Higher pH (7.49) of soil was recorded under open field condition when supplied with 120 kg P_2O_5 ha^{-1} (C_2P_2) followed by C_2P_1 (pH 7.10). Lower pH (6.32) of soil was observed under polyhouse condition when supplied with 120 kg P_2O_5 ha^{-1} (C_1P_2).

Soil pH was significantly influenced by the interaction between nitrogen and phosphorus fertigation levels (Table 13b). Higher pH (7.07) of soil was recorded in interaction combination of N_3P_2 (180:120 kg N: P_2O_5 ha^{-1}) and it was *at par* with N_2P_1 and N_1P_2 (pH 7.06 and 6.91, respectively). Lower pH (6.70) was recorded with N_3P_1 (180:100 kg N: P_2O_5 ha^{-1}).

Table 13a: Soil reaction (pH and EC) as influenced by the different growing conditions, nitrogen and phosphor fertigation levels

Treatments		pH	EC (dS m^{-1})
Growing conditions (c)			
C_1	Polyhouse	6.46	0.37
C_2	Open field	7.29	0.22
F-test (p=0.05)		*	*
S.Em.±		0.04	0.02
C.D. (p=0.05)		0.13	0.06
Nitrogen levels (N)			
N_1	120 kg ha^{-1}	6.85	0.30
N_2	150 kg ha^{-1}	6.89	0.27
N_3	180 kg ha^{-1}	6.89	0.32
F-test (p=0.05)		NS	NS
S.Em.±		0.05	0.02
C.D. (p=0.05)		-	-
Phosphorus levels (P)			
P_1	100 kg ha^{-1}	6.85	0.30
P_2	120 kg ha^{-1}	6.90	0.29
F-test (p=0.05)		NS	NS
S.Em.±		0.04	0.02
C.D. (p=0.05)		-	-

*= Significant. NS = Non-significant.

Table 13b: Soil reaction (pH and EC) as influenced by the interaction effect of growing conditions and nitrogen (C×N), growing conditions and phosphorus (C×P) and nitrogen and phosphorus levels (N×P)

Treatments		pH	EC (dS m^{-1})
Growing conditions x Nitrogen levels (C×N)			
C_1N_1	Polyhouse + 120 kg N ha^{-1}	6.63	0.36
C_1N_2	Polyhouse + 150 kg N ha^{-1}	6.46	0.33
C_1N_3	Polyhouse + 180 kg N ha^{-1}	6.29	0.41
C_2N_1	Open field + 120 kg N ha^{-1}	7.06	0.23
C_2N_2	Open field + 150 kg N ha^{-1}	7.33	0.21
C_2N_3	Open field + 180 kg N ha^{-1}	7.48	0.23
F-test (p=0.05)		*	NS
S.Em.±		0.08	0.03
C.D. (p=0.05)		0.23	-
Condition x phosphorus levels (C×P)			
C_1P_1	Polyhouse + 100 kg P_2O_5 ha^{-1}	6.60	0.35
C_1P_2	Polyhouse + 120 kg P_2O_5 ha^{-1}	6.32	0.38
C_2P_1	Open field + 100 kg P_2O_5 ha^{-1}	7.10	0.25
C_2P_2	Open field + 120 kg P_2O_5 ha^{-1}	7.49	0.20
F-test (p=0.05)		*	NS
S.Em.±		0.06	0.3
C.D. (p=0.05)		0.19	-
Nitrogen x Phosphorus levels (N×P)			
N_1P_1	120:100 kg N:P_2O_5 ha^{-1}	6.78	0.30
N_1P_2	120:120 kg N:P_2O_5 ha^{-1}	6.91	0.30
N_2P_1	150:100 kg N:P_2O_5 ha^{-1}	7.06	0.28
N_2P_2	150:120 kg N:P_2O_5 ha^{-1}	6.72	0.26
N_3P_1	180:100 kg N:P_2O_5 ha^{-1}	6.70	0.33
N_3P_2	180:120 kg N:P_2O_5 ha^{-1}	7.07	0.31
F-test (p=0.05)		*	NS
S.Em.±		0.08	0.03
C.D. (p=0.05)		0.23	-

*= Significant. NS = Non-significant.

Table 13c: Soil reaction (pH and EC) as influenced interaction by the interaction effect of growing conditions, nitrogen and phosphorus levels (CxNxP)

Treatment combinations		pH	EC (dS m^{-1})
Growing conditions x Nitrogen x Phosphorus levels (CxNxP)			
$C_1N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	6.85	0.33
$C_1N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	6.41	0.40
$C_1N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	6.74	0.33
$C_1N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	6.18	0.33
$C_1N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	6.22	0.40
$C_1N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	6.37	0.43
$C_2N_1P_1$	120:100 kg N:P_2O_5 ha^{-1}	6.72	0.26
$C_2N_1P_2$	120:120 kg N:P_2O_5 ha^{-1}	7.41	0.20
$C_2N_2P_1$	150:100 kg N:P_2O_5 ha^{-1}	7.39	0.23
$C_2N_2P_2$	150:120 kg N:P_2O_5 ha^{-1}	7.27	0.20
$C_2N_3P_1$	180:100 kg N:P_2O_5 ha^{-1}	7.19	0.26
$C_2N_3P_2$	180:120 kg N:P_2O_5 ha^{-1}	7.78	0.20
F-test (p=0.05)		NS	NS
S.Em.±		0.20	0.09
C.D. (p=0.05)		-	-

C_1 = Polyhouse condition NS= Non -significant

C_2 = Open field condition

Soil pH did not differ significantly due to nitrogen and phosphorus fertigation levels, interaction effects of growing conditions, nitrogen and phosphorus (CxNxP).

Soil EC did not differ significantly due to nitrogen and phosphorus fertigation levels, interaction effects of growing conditions and nitrogen (CxN), growing conditions and phosphorus (CxP), nitrogen and phosphorus (NxP) and growing conditions, nitrogen and phosphorus levels (CxNxP).

4.8 Cost economics

The data on cost economics of cherry tomato cultivation with varied levels of nitrogen and phosphorus fertigation under open field and polyhouse conditions is presented in Table 14 and Fig.15.

Among 12 treatment combinations under open and polyhouse growing conditions, T_{10}-$C_2N_2P_2$ (open field with 150:120 kg N: P_2O_5 ha^{-1}) turned out to be the most profitable as revealed by the net income (Rs. 1,294,081 ha^{-1}). The total income from this treatment was Rs. 1,563,200 and associated total cost was Rs. 269,119 per hectare with a B: C ratio of 4.81. The next best treatment combination was T_{11}- $C_2N_3P_1$ (open field with 180: 100 kg N: P_2O_5 ha^{-1}) resulted in a profit of Rs. 1,053,939 per hectare. The income from this treatment was Rs. 1,330,800 and associated total cost was Rs. 276,861 per hectare with a B: C ratio of 3.81.

The least profitable treatment combination was T_2-$C_1N_1P_2$ (polyhouse with 120: 120 kg N: P_2O_5 ha^{-1}) which recorded lowest net income of Rs. 178,979 per hectare. The total income from this treatment was Rs. 651,400 per hectare and associated total cost was Rs. 472,421 per hectare with a B: C ratio of 0.38.

Table 14: Cost economics of different treatment combinations of nitrogen, phosphorus fertigation and growing conditions on cherry tomato production

Treatments		Yield (kg/ha)	Rate (Rs./kg)	Gross returns (Rs./ha)	Total cost of cultivation (Rs./ha)	Interest rate	Total cost of cultivation (Rs./ha)	Net returns (Rs./ha)	Cost: benefit Ratio
Polyhouse condition (C_1)	T_1	42730	20	854600	481338	9627	471711	382889	0.81
	T_2	32570	20	651400	482062	9641	472421	178979	0.38
	T_3	34590	20	691800	489962	9799	480162	211638	0.44
	T_4	37110	20	742200	490652	9813	480839	261361	0.54
	T_5	35550	20	711000	498552	9971	488581	222419	0.46
	T_6	37910	20	758200	499242	9985	489257	268943	0.55
Open field condition (C_2)	T_7	61160	20	1223200	265297	5306	259991	963209	3.71
	T_8	58360	20	1167200	266021	5320	260700	906500	3.48
	T_9	62840	20	1256800	273921	5478	268442	988358	3.68
	T_{10}	78160	20	1563200	274611	5492	269119	1294081	4.81
	T_{11}	66540	20	1330800	282511	5650	276861	1053939	3.81
	T_{12}	55870	20	1117400	283201	5664	277537	839863	3.03

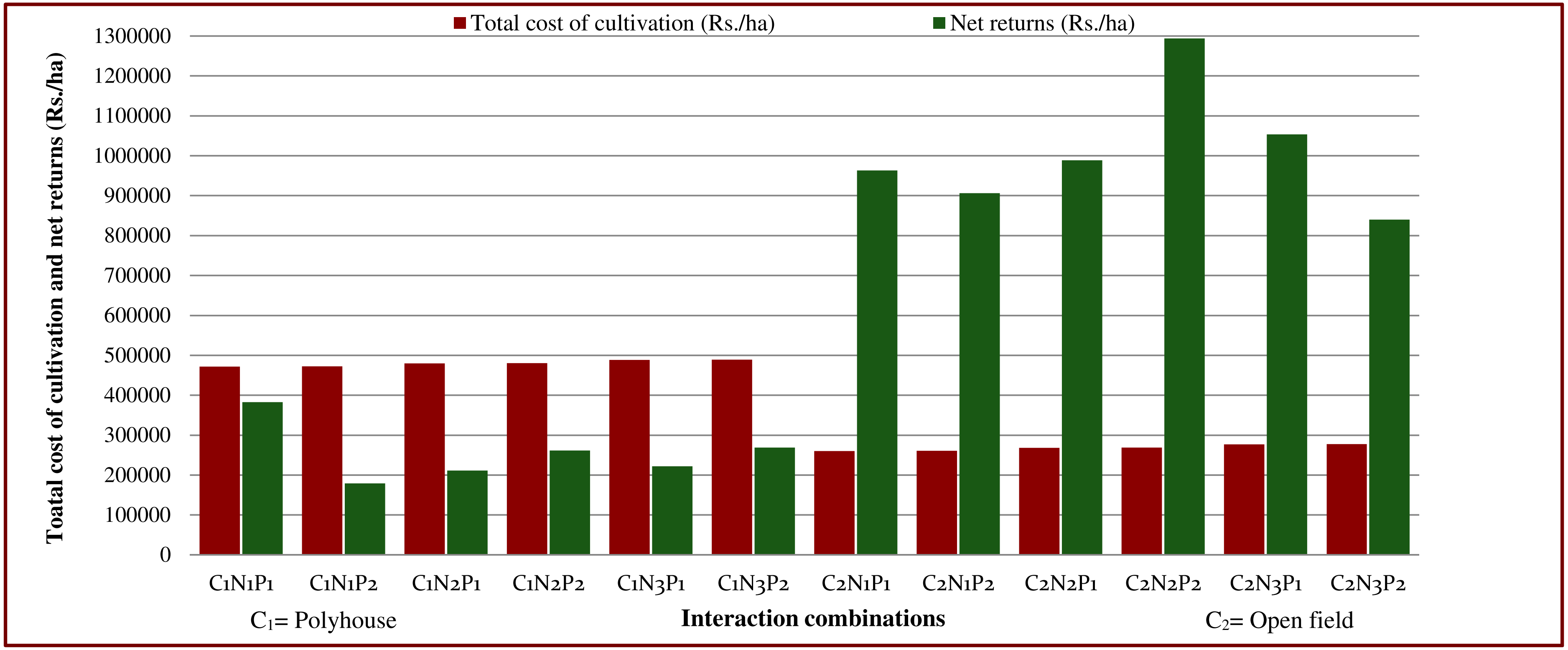

Fig. 15: Cost economics of cherry tomato as influenced by varied levels of nitrogen and phosphorus fertigation and their interaction under open and polyhouse conditions

$C_1N_1P_1$ = 120:100 kg N:P_2O_5 ha^{-1}
$C_1N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_1N_2P_1$= 150:100 kg N:P_2O_5 ha^{-1}
$C_1N_2P_2$ = 150:120 kg N:P_2O_5 ha^{-1}
$C_1N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_1N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}
$C_2N_1P_1$= 120:100 kg N:P_2O_5 ha^{-1}
$C_2N_1P_2$= 120:120 kg N:P_2O_5 ha^{-1}
$C_2N_2P_1$= 150:100 kg N:P_2O_5 ha-^{1}
$C_2N_2P_2$= 150:120 kg N:P_2O_5 ha^{-1}
$C_2N_3P_1$= 180:100 kg N:P_2O_5 ha^{-1}
$C_2N_3P_2$= 180:120 kg N:P_2O_5 ha^{-1}

V. DISCUSSION

The results of the investigation entitled "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A.Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" carried out at the Department of Horticulture, University of Agricultural Sciences, Bangalore, Gandhi Krishi Vignana Kendra during summer season of 2017 are discussed in this chapter.

Cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A.Gray] is a botanicl variety of tomato. The botanical variety is generally considered to be similar but not identical to the wild relatives of the domestic tomato. Cherry tomatoes are becoming popular in the retail chains and marketed at a premium price compared to regular tomatoes. Since cherry tomato is a newly introduced crop to Eastern Dry Zone of Karnataka (Zone-5), it does not have a separate fertilizer recommendation through fertigation for both open field and polyhouse conditions. Hence, in order to elucidate precise information on fertigation of cherry tomato under both open and polyhouse conditions, the present investigation was initiated.

This experiment was conducted to find out the best nitrogen and phosphorus fertigation levels and their combination under two growing conditions (open field and polyhouse) for better growth, yield and quality of cherry tomato. There were significant differences among different parameters of cherry tomato grown under polyhouse and open field conditions, thereby confirming the role of open field and polyhouse conditions in the cultivation of cherry tomato. It is a well-established fact that macro nutrients such as nitrogen, phosphorus and potassium have profound effect on crop productivity and quality. Among the essential nutrients, nitrogen is an integral part of chlorophyll (the only energy synthesizing apparatus of plants), protoplasm, proteins and nucleic acids. Consequently its deficiency checks the growth and reduces the yield significantly. Phosphorus on the other hand, participates in energy transfer, early and prolific flowering, stimulates root growth, seed and fruit development, whereas, potassium is essential for number of biological reactions such as transport of sugars, stomata control, cofactor of many enzymes, reduces susceptibility to plant diseases.

5.1 Weather and crop growth

Cherry tomato is warm season crop, requires plenty of sunshine but low humidity. Apart from fertigation management, the environmental conditions encountered during plant development strongly influence both vegetative and reproductive growth of the crop.

During the experimentation, dry and warm weather with bright sunshine hours was prevailed. The actual rainfall during cropping season was lower than normal during January to April, while excessive rainfall was noticed during the month of May. Excessive rains during May month coincided with fruit development and favoured higher crop yield under open field conditions. The mean sunshine hours were lower than the normal in all the months of crop growth period except February. Overall, fair weather conditions prevailed during the period of experimentation for growth and development of cherry tomato. This has reflected in terms of better growth and yield of the crop.

5.2 Effect of growing conditions, nitrogen and phosphorus fertigation levels on vigour and growth parameters of cherry tomato

In the present study, it was observed that growth parameters such as plant height, number of leaves per plant, total leaf area, fresh and dry weight, total chlorophyll content, flavanols and nitrogen balance index (NBI) were significantly affected by different growing conditions, nitrogen and phosphorus fertigation levels.

Plant vigour and growth characteristics such as plant height, number of leaves per plant and nitrogen balance index (NBI) were significantly higher under polyhouse conditions at all stages. Increased growth parameters under poly house conditions may be ascribed to the fact that plant growth occurred in suitable temperature range and other microclimatic conditions created inside the polyhouse which might have attributed to the enhanced plant metabolic activities like photosynthesis inside the polyhouse. These results are in conformity with the findings of Parvej *et al*. (2010) and Ughade *et al*. (2016) in tomato.

Total chlorophyll content (27.80 µg/cm^2) and flavanol content (0.797 µg/cm^2) were significantly higher under open field condition compared polyhouse condition. This might be due to sufficient light and optimum temperature during summer months as these all are influencing aspects of plant physiological processes. These results are also in line with Dinar and Rudich (1985) who reported that higher temperatures in the greenhouse affect several physiological and biochemical processes of tomato crop.

Plant height and number of leaves per plant at 30, 60, 90 and 120 DAT and total leaf area per plant (5871 cm^2) at 90 DAT were significantly higher with higher levels of nitrogen fertigation *i.e.,* 180 kg N ha^{-1}. This increase in nitrogen might have resulted in increased cell division and cell differentiation. Thus, increased vegetative growth of the plant. The increased growth parameters under higher levels of nitrogen are in conformity with the findings of Singh *et al*. (2005) in tomato.

Higher phosphorus fertigation levels (120 kg P_2O_5 ha^{-1}) resulted in significantly higher plant height (311.78 and 319.39 cm, respectively) at 90 and 120 DAT and higher fresh weight per plant (2.28 kg) at 90 DAT. Higher plant height and fresh weight per plant at higher levels of phosphorus fertigation might be due to more photosynthetically active leaf area per plant and number leaves per plant observed in the present study under higher levels of phosphorus fertigation. These results are in conformity with those of Ughade *et al*. (2016), Shedeed *et al*. (2009) and Emongor and Mabe (2012).

Vegetative parameters *viz.,* plant height (332.63 and 338.37 cm, respectively) at 90 and 120 DAT, fresh weight per plant (2.66 kg) and total leaf area per plant (5835 cm^2) at 90 DAT were significantly higher in the interaction of nitrogen and phosphorus at 180:120 kg N:P_2O_5 ha^{-1}(N_3P_2). This increase in growth in the said nutrient combination could be due to various metabolic processes that have led the enhanced plant growth. Since nitrogen and phosphorus are said to be closely related with cell division and development, these might have resulted in better growth parameters in the present study. The results are in conformity with those of Manoj *et al* (2013), Ughade *et al*. (2016) and Singh *et al*. (2005).

A perusal of data (Table 1c, 2c and 4c) revealed that plant height and number of leaves per plant at last stages, fresh weight per plant (3.00 kg), dry weight per plant (446.52 g), total leaf area per plant (6293 cm^2) and nitrogen balance index (48.56) were significantly higher under polyhouse condition when supplied with 180: 120 kg N: P_2O_5 ha^{-1} ($C_1N_3P_2$) compared to open field with varied levels of nitrogen and phosphorus fertigation. Increased growth parameters under treatment combination of $C_1N_3P_2$ could be due to favorable climatic conditions under protected structure with higher nitrogen and phosphorus supply which has increased the rate of metabolic activity leading to an increase in various plant metabolites responsible for cell division. The results are in conformity with the findings of Singh *et al*. (2005), Tiwari *et al.* (2012) and Ughade *et al*. (2016).

5.3 Effect of growing conditions, nitrogen and phosphorus fertigation levels on reproductive parameters of cherry tomato

Number of days taken for first flowering was significantly influenced by different growing conditions. Significantly lower number of days to first flowering (21.61) was recorded under polyhouse conditions. This might be due to the fact that, temperature plays a key role for flower initiation and development and favourable microclimatic conditions at early stages of the growth maintained inside polyhouse helps to change the phase of plant from juvenile to reproductive phase. These results are in accordance with Parvej *et al*. (2010).

Number of flower clusters and number of flowers per plant were significantly higher under polyhouse condition at 50 and 70 DAT. Favorable microclimatic conditions and increased growth attributes under polyhouse might have increased the number of flower clusters and flowers per plant in two ways: i) increasing the number of primary branches and ii) increasing shoot growth and number of secondary branches and hence, the ultimate size of the plant thereby, increasing the number of potential sites where flower clusters and flowers could develop.

Maximum numbers of days taken to first flowering and first harvest were found under the treatment receiving higher doses of nitrogen and phosphorus *i.e.,* 180 kg N ha^{-1}

(N_3) and 120 kg P_2O_5 ha^{-1} (P_2) which might be due to higher nutrition, particularly N fertigation which would have extended the vegetative phase. The results are in agreement with Sing *et al*. (2005).

It is evident from the data that number of flower clusters per plant (12.27 and 12.02 respectively) and number of flowers per plant (196.80 and 189.77 respectively) at 50 and 70 DAT were significantly higher under the treatment receiving 150 kg N ha^{-1} (N_2). Increased number of flower clusters and flowers per plant under optimum levels of nitrogen fertigation might be due to increased production of photosynthetic area and efficient photosynthates transport mechanism during the crop growth period.

Significantly maximum number of days to first flowering (23.00) was recorded under open field condition with 180:120 kg N: P_2O_5 ha^{-1} ($C_2N_3P_2$) and minimum (21.00 days) under polyhouse condition when supplied with 150:120 kg N: P_2O_5 ha^{-1} ($C_1N_2P_2$). Delayed days to first flowering under open field with higher levels of nitrogen and phosphorus fertigation might be due to the influence of lower temperature at the early stages of the growth and higher nutrition, particularly, nitrogen at higher doses leads to excessive vegetative growth and extend the vegetative phase. These results are in line with the findings of Tiwari *et al.* (2012) who stated that temperature affects flower initiation. Sing *et al.* (2005) revealed that higher levels of NPK lead excessive vegetative growth and delay in maturity.

Significantly higher number of flower clusters per plant (13.72 and 13.38 respectively) at 50 and 70 DAT and higher number of flowers per plant (215.94) at 90 DAT were recorded under polyhouse condition when supplied with 150 kg N ha^{-1} (C_1N_2). Optimum nitrogen and increased photosynthetic area and growth parameters *viz.,* plant height and number of leaves per plant have contributed for more number of flower clusters per plant and flowers initiation under polyhouse.

5.4 Effect of growing conditions, nitrogen and phosphorus fertigation levels on yield and yield attributes of cherry tomato

It can be construed from the results that, mean fruit weight (15.86 and15.68 g, respectively) at 4^{th} and 7^{th} harvests under the treatment receiving 180 kg N ha^{-1}, (15.98 g) at 4th harvest in N_3P_2 (180:120 kg N: P_2O_5 ha^{-1}) and 15.98 g in treatment combination of $C_2N_3P_1$ (open field with 180:100 kg N:P_2O_5 ha^{-1}) was significantly higher compared to other treatments. The increase in fruit weight with the increase in fertigation level might be due to more availability of nutrients to plants and effective utilization of nutrients during critical stages of crop growth which ultimately resulted in maximum fruit weight.

Yield parameters such as number of fruits per plant (258.07), yield per plant (3.60 kg) and yield per hectare (63.79 t) were significantly higher under open field condition compared to polyhouse. Reduced yield parameters under low cost polyhouse condition might be due to the adverse effect of extreme high temperature during reproductive stage in summer months that causes dryness of stigma and flower abortion. These results are in close conformity with those of Harmanto and Rabel (2005) and Dinar and Rudich (1985) who observed that, higher temperatures in the greenhouse, affect several physiological and biochemical processes of tomato crop associated with yield reduction.

Yield parameters such as number of fruits per plant (241.95), yield per plant (3.25 kg) and yield per hectare (57.63 t) were significantly highest in the interaction combination of N_2P_2 (150:120 kg N:P_2O_5 ha^{-1}). Similarly, significantly highest number of fruits per plant (316.63), yield per plant (4.46 kg) and yield per hectare (78.16 t) were recorded under open field condition when supplied with 150:120 kg N: P_2O_5 ha^{-1} ($C_2N_2P_2$). Increased yield parameters under open field with optimum levels of nitrogen and phosphorus fertigation might be due to optimum combination of nitrogen and phosphorus resulting in a favourable source to sink ratio to produce higher yield. Further, increase in nitrogen dose (180 kg N ha^{-1}) may shift the balance between vegetative growth and reproductive growth toward excessive vegetative development, thus delaying crop maturity and reducing crop yield.

5.5 Effect of growing conditions, nitrogen and phosphorus fertigation levels on quality parameters of cherry tomato

It is observed in the present study that there is a significant difference among quality parameters (TSS content and shelf life) in cherry tomato due to different growing conditions, nitrogen and phosphorus fertigation levels. TSS content (6.30 ºB at middle stage) and shelf life (15.66 days) were significantly higher for the crop grown under polyhouse condition when supplied with 180: 120 kg N: P_2O_5 ha^{-1} ($C_1N_3P_2$). This might be due to the fact that, higher fertility levels increase uptake and utilize more nutrients which increases total soluble solid content of fruits. Thus, increase in quality parameters under polyhouse condition with higher nitrogen and phosphorus fertigation levels can be attributed to increased uptake of nitrogen, phosphorus and potassium which in turn enhanced the photosynthetic activities in plant system for better accumulation of CHO in plant. The results are in close conformity with the findings of Mahajan and Sing (2006).

5.6 Effect of growing conditions, nitrogen and phosphorus fertigation levels on nutrient (N, P and K) concentration in cherry tomato plants

Combined effect of growing conditions and nitrogen fertigation levels (CxN) and nitrogen and phosphorus fertigation levels (NxP) showed significant impact on nitrogen concentration in cherry tomato plant. Nitrogen content in the plant (3.10 %) under open field with 180 N ha^{-1} (C_2N_3) and (2.89 %) in the interaction combination of N_3P_1 (180:100 kg N: P_2O_5 ha^{-1}) was significantly higher compared to other treatment combinations. Furthermore, significantly higher phosphorus content in plant (0.394 %) was observed in treatment combination of $C_2N_2P_2$ (open field with 150:120 kg N: P_2O_5 ha^{-1}. In case of potassium, significantly higher potassium content in plant (2.10 and 2.06 %) was recorded under open field (C_2) and under higher levels of nitrogen (180 kg N ha^{-1}), respectively.

Increased concentration of N, P and K in cherry tomato plants under open field condition with higher levels of nitrogen and phosphorus fertigation might be due to increased availability of nutrients in root zone, better absorption and translocation of these nutrients to different plant parts. These results are in line with the findings of Hebbar *et al.*, (2003).

5.7 Effect of growing conditions, nitrogen and phosphorus fertigation levels on N, P and K uptake by cherry tomato

Nitrogen, phosphorus and potassium uptake by cherry tomato was significantly influenced by different growing conditions, nitrogen and phosphorus fertigation levels.

Significantly higher uptake of nitrogen (181.41 kg ha^{-1}), phosphorus (30.72 kg ha^{-1}) and potassium (159.88 kg ha^{-1}) was observed under polyhouse condition with 180: 120 kg N: P_2O_5 ha^{-1}). Increased uptake of N, P and K by cherry tomato under polyhouse with higher levels of nitrogen and phosphorus fertigation may be due to the additive effect of nutrients that lead to more dry matter production and more nutrient accumulation. Thus, significantly higher dry weight per plant at 90 days after transplanting under polyhouse with higher levels of nitrogen and phosphorus fertigation seems to be responsible for higher uptake of nitrogen, phosphorus and potassium.

5.8 Effect of growing conditions, nitrogen and phosphorus fertigation levels on available nutrient status of the soil after harvest

Available nutrient status of soil after harvest did not differ significantly due to varied levels of nitrogen and phosphorus fertigation and their interaction under open and polyhouse conditions except the available potassium which was significantly higher (363.20 kg ha^{-1}) in the treatment combination of $C_1N_2P_2$ (polyhouse with 150:120 kg N:P_2O_5 ha^{-1}). In general, there was a slight increase in available nutrients of soil after harvest compared to applied and initial soil available nutrients, indicating that the crop utilized N, P and K to a greater extent to meet its requirement.

5.9 Cost economics

The cost for cultivation of cherry tomato treatment wise was calculated for an area of one hectare in open field and greenhouse conditions.

A cursory look of data embodied in Table 14 revealed that, the higher net returns (1294081 Rs. ha^{-1}) and B: C ratio (4.81) was recorded in T_{10}- $C_2N_2P_2$ (open field with 150: 120 kg N: P_2O_5 ha^{-1}). The higher net returns and benefit: cost ratio registered by the cherry tomato under open field with optimum levels of nitrogen and phosphorus fertigation are attributed to higher fruit yield recorded by this crop in the present study.

5.10 Practical utility of the experimental results

Cherry tomato cultivation is gaining popularity due to increased demand in urban area of Karnataka and India and the work on fertigation aspects of this crop is very meagre. In the absence of information on fertigation of cherry tomato, the experimental results of the present study will be helpful for the farmers for applying precise levels of N and P fertigation for better growth and yield of cherry tomato under both poly house and open field conditions. This study has shown that application of 150:120 kg N: P_2O_5 ha^{-1} through fertigation under open field condition (T_{10}) produced the higher yield of cherry tomato besides higher net returns and cost benefit ratio.

5.11 Future line of work

- The present study has to be repeated across seasons, locations and under different types of polyhouses.
- For standardization of fertigation schedule for the crop, further studies have to be conducted, including different fertigation intervals and frequency.
- Role of different organic manures in combination with primary, secondary and micronutrients to be tested for improving the growth and yield of the crop.

VI. SUMMARY

An investigation entitled "Performance of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] under open field and polyhouse conditions with varied levels of nitrogen and phosphorus fertigation" was conducted at the Department of Horticulture, University of Agricultural Sciences, Bangalore, GKVK, during summer season of 2017. The experiment had twelve treatment combinations including two growing conditions (open field and polyhouse), three levels of nitrogen (120, 150 and 180 Kg N ha^{-1}) and two levels of phosphorus fertigation (100 and 120 Kg P_2O_5 ha^{-1}) and 150 Kg ha^{-1} potassium was common with all combinations. Each treatment was replicated three times in a factorial Randomized Complete Block Design (Factorial RCBD). The salient findings of experiment are summarized below.

Growth parameters *viz.,* plant height (99.76, 239.69, 342.93 and 352.59 cm, respectively) at 30, 60, 90 and 120 DAT and number of leaves per plant (28.67, 66.71 and 57.50 respectively) at 30, 60 and 90 DAT were significantly higher under polyhouse condition (C_1) compared to open filed (C_2). The same growing condition recorded significantly higher nitrogen balance index (44.73), number of flower clusters per plant (12.62 and 11.77) and number of flowers per plant (202.60 and 185.94 respectively) at 50 and 70 DAT.

Significantly higher total chlorophyll content (27.80 µg/cm^2), flavanols (0.797 µg/cm^2), number of fruits per plant (258.07), yield per plant (3.60 Kg) and yield per hectare (63.79 t) were recorded under open filed condition (C_1).

Significantly higher nitrogen (2.50 %) and potassium (2.10%) contents in the plant were also recorded under open field condition. However, available nitrogen (310.20 Kg ha^{-1}), available potassium (339.76 Kg ha^{-1}) in soil after harvest were significantly higher under polyhouse condition, while open field condition (C_1) recorded only higher available phosphorus in soil after harvest (69.99 Kg ha^{-1}).

Application of 180 Kg N ha^{-1} (N_3) recorded significantly higher plant height (89.45, 323.58 and 328.76 cm at 30, 90 and 120 DAT, respectively), number of leaves per plant (62.95) and total leaf area per plant (5871 cm^2) at 90 DAT, mean fruit weight (15.86 and 15.68 g at 4^{th} and 7^{th} harvests, respectively), TSS content (4.75 and 5.37 ºB at initial and middle stages, respectively), shelf life (15.41 days), nitrogen and potassium content in plant (2.73 and 2.06 %, respectively), nitrogen, phosphorus and potassium uptake (171.36, 23.71 and 132.55 Kg ha^{-1}, respectively) compared to rest of the nitrogen fertigation levels.

However, plant height (211.09 cm at 60 DAT), number of leaves per plant (65.28 at 60 DAT), number of flower clusters per plant (12.27 and 12.02 at 50 and 70 DAT), number of flower per plant (196.80 and 189.77 at 50 and 70 DAT, respectively), number of fruits per plant (219.28), yield per plant (3.00 Kg) and yield per hectare (53.18 t) were significantly higher with 150 Kg N ha^{-1} (N_2) compared to rest of the nitrogen fertigation levels.

Application of 120 Kg P_2O_5 ha^{-1} (P_2) recorded significantly higher plant height (311.78 and 319.39 cm, respectively) at 90 and 120 DAT, fresh weight per plant (2.28 Kg), phosphorus content in plant (0.378%) and phosphorus uptake (23.85 Kg ha^{-1}) compared to phosphorus fertigation level at 100 Kg P_2O_5 ha^{-1} (P_1).

Growth parameters *viz.,* plant height (101.03, 365.50 and 372.86 cm, respectively) at 30, 90 and 120 DAT, number of leaves per plant (66.70) at 90 DAT, fresh weight per plant (2.57 Kg) and dry weight per plant (401.49 g) were significantly higher under under polyhouse condition when supplied with 180 Kg N ha^{-1} (C_1N_3) compared to open filed (C_2). The same interaction combination recorded significantly higher number of flowers per plant (44.73), TSS content (5.70 ºB) at middle stage, and nitrogen and potassium uptake (174.33 and 142.33 Kg ha^{-1}, respectively). However, yield per plant (4.01 Kg) and yield per hectare (70.50 t) were significantly higher under open field condition when supplied with 150 Kg N ha^{-1} (C_2N_2).

Interaction combination of C_2P_1 (polyhouse with 100 Kg P_2O_5 ha^{-1}) recorded significantly higher fruit set (52.56 %), nitrogen content in plant (2.59 %) and significantly minimum number of days to first flowering (21.55 days).

Interaction effect of N_3P_2 (180: 120 Kg N: P_2O_5 ha^{-1}) recorded significantly higher plant height (332.63 and 338.37 cm, respectively) at 90 and 120 DAT, fresh weight per plant (2.66 Kg), mean fruit weight at 4^{th} harvest (15.98 g), TSS content at middle stage (5.71 ºB), shelf life (15.50 days), potassium content in plant (2.07 %) and potassium uptake (144.17 Kg ha^{-1}). However, total leaf per plant (5906 cm^2), number of flower clusters per plant (10.83), nitrogen content in plant (2.89 %) under interaction combination of N_3P_1 ((180: 100 Kg N:P_2O_5 ha^{-1}) were significantly higher compared to rest of the interactions between nitrogen and phosphorus.

Reproductive and yield parameters viz., number of flowers per plant at 50 DAT (199.66), number of fruits per plant (241.95), yield per plant (3.25 Kg) and yield per hectare (57.63 t) were significantly higher in interaction combination of N_2P_2 (150:120 Kg N:P_2O_5 ha^{-1}) compared to rest of the interactions between nitrogen and phosphorus.

It was observed that treatment combination of $C_1N_3P_2$ (polyhouse with 180:120 Kg N:P_2O_5 ha^{-1}) recorded significantly higher plant height (101.33, 376.86 and 384.39 cm, respectively) at 30, 90 and 120 DAT, number of leaves per plant (49.33) at 120 DAT, nitrogen balance index (48.56), fresh weight per plant (3.00 Kg), dry weight per plant (446.51 g), total leaf area per plant (6293 cm^2), mean fruit weight (15.84 g at 7^{th} harvest), TSS content at middle stage (6.30 ºB), nitrogen uptake (181.41 Kg ha^{-1}), phosphorus uptake (30.72 Kg ha^{-1}) and potassium uptake (159.88 Kg ha^{-1}). However, yield and yield parameters *viz.,* number of fruits per plant (316.63), yield per plant (4.46 Kg) and yield per hectare (78.16 t) were significantly higher under open field condition when supplied with 150:120 Kg N: P_2O_5 ha^{-1} ($C_2N_2P_2$) compared to other treatments.

Significantly minimum number of days to first flowering (21.33) was record under both open and polyhouse conditions when supplied with 12:100 Kg N:P_2O_5 ha^{-1} ($C_1N_1P_1$ and $C_2N_1P_1$) compared to other combinations.

Net returns and cost benefit ratio were higher (Rs. 1294081 ha^{-1} and 4.81 respectively) under open filed condition when supplied with 150:120 Kg N: P_2O_5 ha^{-1} ($C_2N_2P_2$) compared to rest of the treatment combinations, since same treatment combination has recorded significantly higher yield per hectare. However, higher cost of cultivation (Rs.489257 ha^{-1}) was recorded under polyhouse condition when supplied with 180:120 Kg N: P_2O_5 ha^{-1} ($C_2N_3P_2$) over other combinations.

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APPENDIX-I

Normal (1972-2013) and actual monthly weather data for the period of study during 2017 at UAS, GKVK, Bangalore

Month	Rainfall (mm)			Relative Humidity (%)			Mean air temperature (°C) Maximum			Mean air temperature (°C) Minimum			Sunshine (hrs)		
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D
January	1.4	0.0	-1.4	85.7	88.9	3.2	27.4	27.3	-0.1	13.9	14.5	0.6	8.9	8.2	-0.7
February	9.4	0.0	-9.4	80.2	84.0	3.8	29.8	30.6	0.8	15.3	14.9	-0.4	9.5	10.1	0.6
March	16.4	9.8	-6.6	75.0	82.0	7	32.6	33.0	0.4	17.9	19.5	1.6	9.4	8.9	-0.5
April	56.4	1.6	-54.8	79.2	83.0	3.8	33.7	35.1	1.4	20.4	21.9	1.5	8.9	8.4	-0.5
May	99.9	246.6	146.7	81.1	85.0	3.9	33.1	32.7	-0.4	20.5	20.7	0.2	8.3	7.6	-0.7
June	78.1	65.4	-12.7	85.8	89.0	3.2	29.5	28.6	-0.9	19.4	20.1	0.7	5.7	5.2	-0.5
July	102.4	33.4	-69	87.9	89.0	1.1	28.1	28.8	0.7	19.1	19.8	0.7	4.4	5.0	0.6
August	132.5	199.8	67.3	88.8	91	2.2	27.6	28.2	0.6	18.9	20.0	1.1	4.6	3.9	-0.7

N: Normal meteorological data (mean of 1972-2013) **A:** Actual meteorological data (2017) **D**: Deviation from the normal (A-N)

APPENDIX-II

Details of cost for cultivation of hybrid cherry tomato under open field and polyhouse conditions in Bangalore

Particulars	Quantity required (ha^{-1})	Rate/unit (Rs.)	Amount (Rs.)
1. Seedlings			
a. Moscatel RZ F1	17000	1.0/Seedling	17000
2. Plant protection chemicals			
a. Dicopal	5 litres	520/litre	2600
b. Confidar	1.25 litres	2900/litre	3625
c. D.M-45	2 Kg	702/Kg	702
3. FYM	30 tonnes	500/t	15000
4. Tractor hire charge	6 hrs.	500/hr.	3000
5. Labour required			
a. Land preparation	30	200/men	6000
b. Transplanting	15	200/men	3000
c. Training and pruning	100	200/men	20000
d. Spraying	30	200/men	6000
e. Fertigation and irrigation	40	200/men	8000
f. Harvesting (11 Harvests)	150	200/men	30000
6. Plastic mulch	250 Kg	200/Kg	50000
7. water charges	2200	…….	2200
8. Drip system	90,000/ha/8years	5625/6months	5625
9. Training materials (Open field)			
a. Stakes	225	15/stake	3375
b. GI wire	100 Kg	100/Kg	10000
c. Gunny thread	150 Kg	75/Kg	11250
10. Training materials (Polyhouse)			
g. Plastic thread	150 Kg	200/Kg	30000
11. Rental value (open field)	15000/year	7500/ 6months	7500
12. Miscellaneous charges	1500	…….	1500
13. Additional cost of polyhouse			
a. Cost of establishment	433333/year	216666 /6 months	216666

14. Cost of fertilizers

Particulars	Quantity required (ha^{-1})	Rate/unit (Rs.)	Amount (Rs.)
1. T_1 and T_7			
A. Normal fertilizers			
I. Urea	52.17 Kg	5.7/Kg	297.36
II. Single superphosphate	125 Kg	7.4/Kg	925.00
III. Muriate of potash	50 Kg	16/Kg	800.00
A. Water soluble fertilizers			
I. NPK mixture (19:19:19)	421.05 Kg	108/Kg	45,473.40
II. Calcium nitrate	103.22 Kg	55/Kg	5,644.41
III. Potassium sulphate	80 Kg	91/Kg	7,280.00
2. T_2 and T_8			
A. Normal fertilizers			
I. Urea	52.17 Kg	5.7/Kg	297.36
II. Single superphosphate	150 Kg	7.4/Kg	1,110.00
III. Muriate of potash	50 Kg	16/Kg	800.00
B. Water soluble fertilizers			
I. NPK mixture (19:19:19)	505.26 Kg	108/Kg	54,568.40
II. Calcium nitrate	0.00 Kg	55/Kg	0.00
III. Potassium sulphate	48 Kg	91/Kg	4,368.00
3. T_3 and T_9			
C. Normal fertilizers			
I. Urea	65.21 Kg	5.7/Kg	371.73
II. Single superphosphate	125 Kg	7.4/Kg	925.00
III. Muriate of potash	50 Kg	16/Kg	800.00
D. Water soluble fertilizers			
I. NPK mixture (19:19:19)	421.05 Kg	108/Kg	45,473.40
II. Calcium nitrate	258.06 Kg	55/Kg	14,193.50
III. Potassium sulphate	80 Kg	91/Kg	7,280.00

…Cost of fertilizers

Particulars	Quantity required (ha^{-1})	Rate/unit (Rs.)	Amount (Rs.)
4. T_4 and T_{10}			
A. Normal fertilizers			
I. Urea	65.21 Kg	5.7/Kg	371.73
II. Single superphosphate	150 Kg	7.4/Kg	1,110.00
III. Muriate of potash	50 Kg	16/Kg	800.00
B. Water soluble fertilizers			
I. NPK mixture (19:19:19)	505.25 Kg	108/Kg	54,568.40
II. Calcium nitrate	154.83 Kg	55/Kg	8,516.12
III. Potassium sulphate	48 Kg	91/Kg	4,368.00
5. T_5 and T_{11}			
A. Normal fertilizers			
I. Urea	78.26 Kg	5.7/Kg	446.08
II. Single superphosphate	125 Kg	7.4/Kg	925.00
III. Muriate of potash	50 Kg	16/Kg	800.00
B. Water soluble fertilizers			
I. NPK mixture (19:19:19)	421.05 Kg	108/Kg	45,473.40
II. Calcium nitrate	412.90 Kg	55/Kg	22,709.60
III. Potassium sulphate	80 Kg	91/Kg	7,280.00
6. T_6 and T_{12}			
A. Normal fertilizers			
I. Urea	78.26 Kg	5.7/Kg	446.08
II. Single superphosphate	150 Kg	7.4/Kg	1,110.00
III. Muriate of potash	50 Kg	16/Kg	800.00
B. Water soluble fertilizers			
I. NPK mixture (19:19:19)	505.26 Kg	108/Kg	54,568.00
II. Calcium nitrate	309.6 Kg	55/Kg	17,032.20
III. Potassium sulphate	48 Kg	91/Kg	4,368.00

APPENDIX- III

Schedule of cultural operations followed for the experiment during 2017

Dates	Cultural operations
04-1-2017	Preparation and sowing of nursery
13-1-2017	Land preparation and FYM application
16-1-2017	Layout of experiment and preparation of planting beds
2-2-2017	Application of basal fertilizers and laying of drip laterals
3-4-2017	Covering of beds with polyethylene mulch film
4-2-2017	Transplanting of seedlings and irrigation
14-2-2017	First spray of plant protection chemicals
22-2-2017	Manual weeding between planting beds
25-2-2017	Starting of fertigation
28-2-2017	First pruning of plants and staking with nylon threads
3-3-2017	Second spray of plant protection chemicals
10-3-2017	Tying operation and removal of side suckers
15-3-2017	Manual weeding between planting beds
25-3-2017	Third spray of plant protection chemicals
30-3-2017	Tying operation and removal of side suckers
6-4-2017	First picking of fruits (polyhouse)
7-4-2017	First picking of fruits (open field)
15-4-2017	Tying operation
17-4-2017	Fourth spray of plant protection chemicals
8-5-2017	Fifth spray of plant protection chemicals
28-5-2017	Sixth spray of plant protection chemicals
15-6-2017	Last fertigation
21-6-2017	Last (8^{th}) picking of fruits under polyhouse condition
21-6-2017	Last (11^{th}) picking of fruits under open field condition

Note: Irrigation was given daily for 45 minutes to 1 hour depending on weather condition and growth stage of the crop. Fertigation was given once in three days as per treatment fertigation schedule and fruits were harvested when they attained ripe red stage.