NUTRIENT REQUIREMENT AND POST HARVEST STUDIES ON BUSH JASMINE (*Jasminum sambac* Ait)

By

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2001

Dedicated

to my

Husband & Daughter

DECLARATION

I hereby declare that this thesis entitled **"Nutrient requirement and post harvest studies on bush jasmine (*Jasminum sambac* Ait)"** is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"Nutrient requirement and post harvest studies on bush jasmine (*Jasminum sambac* Ait)"** is a record of research work done independently by **Mrs. J. D. Nirmalatha** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CONTENTS

Page No.

1. INTRODUCTION 1

2. REVIEW OF LITERATURE 3

3. MATERIALS AND METHODS 24

4. RESULTS 34

5. DISCUSSION 112

6. SUMMARY 133

REFERENCES i

APPENDICES 1

ABSTRACT

LIST OF TABLES

Table Number	Title	Page Number
1	Main effect of N. P, K on length of main shoot (cm)	35
2	Interaction effect of NP, NK and PK on length of main shoot (cm)	36
3	Main effect of N. P, K on number of primary branches	38
4	Interaction effect of NP, NK and PK on number of primary branches	39
5	Main effect of N, P, K on number of secondary branches	41
6	Interaction effect of NP, NK and PK on number of secondary branches	42
7	Main effect of N, P, K on length of primary branches (cm)	44
8	Interaction effect of NP, NK and PK on length of primary branches (cm)	45
9	Main effect of N, P, K on length of secondary laterals (cm)	47
10	Interaction effect of NP, NK and PK on length of secondary branches (cm)	48
11	Main effect of N, P, K on spread of plant in North-South direction (cm)	50
12	Interaction effect of NP, PK and NK on spread of plant in North-South direction (cm)	51
13	Main effect of N, P, K on spread of plant in East-West direction (cm)	53

Table Number	Title	Page Number
14	Interaction effect of NP, NK and PK on spread of plant in East-West direction (cm)	54
15	Main effect of N, P, K on yield of flowers (kg ha^{-1})	55
16	Interaction effect of NP. NK and PK on yield of flowers (kg ha^{-1})	56
17	Main effect of N, P. K on monthly yield pattern (kg ha^{-1})	58
18	Interaction effect of NP, NK and PK on monthly yield pattern of flowers (kg ha^{-1})	59
19	Main effect of N, P, K on 100 bud weight (g)	61
20	Interaction effect of NP, NK, PK on 100 bud weight	62
21	Main effect of N, P, K on time taken for opening of flowers (hours)	64
22	Interaction effect of NP, NK and PK on time taken for flower opening (hours)	65
23	Main effect of N, P, K on leaf nutrient content (per cent)	67
24	Interaction effect of NP, NK and PK on leaf nutrient content (per cent of nutrients)	68
25	Main effect of N, P, K on carbohydrate content of flowering shoot (per cent)	73
26	Interaction effect of NP, NK, PK on carbohydrate content of flowering shoot (per cent)	74
27	Main effect of N, P, K on uptake of plant nutrients (kg ha^{-1})	76
28	Interaction effect of NP, NK and PK on uptake of plant nutrients (kg ha^{-1})	77
29	Main effect of N, P, K on essential oil content (per cent)	81

Table Number	Title	Page Number
30	Interaction effect of NP, NK and PK on essential oil content (per cent)	82
31	Main effect of N, P, K on available soil (kg ha^{-1}) nutrients	83
32	Interaction effect of NP, NK and PK on available soil nutrients (kg ha^{-1})	84
33	Main effect of N, P, K on shelf life of flowers ($V_0E_0S_0$) hours	88
34	Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_0S_0$) hours	90
35	Main effect of N, P, K on shelf life of flowers ($V_0E_0S_1$) hours	91
36	Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_0S_1$) hours	93
37	Main effect of N, P, K on shelf life of flowers ($V_0E_1S_0$) hours	94
38	Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_1S_0$) hours	96
39	Main effect of N, P, K on shelf life of flowers ($V_0E_1S_1$) hours	97
40	Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_1S_1$) hours	99
41	Main effect of N, P, K on shelf life of flowers ($V_1E_0S_0$) hours	100
42	Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_0S_0$) hours	101
43	Main effect of N, P, K on shelf life of flowers ($V_1E_1S_1$) hours	102
44	Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_1S_1$) hours	103
45	Main effect of N,P,K on shelf life of flowers ($V_1E_0S_1$) hours	105

Table Number	Title	Page Number
46	Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_0S_1$) hours	106
47	Main effect of NPK on shelf life of flowers ($V_1E_1S_0$) hours	107
48	Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_1S_0$) hours	109
T 49	Shelf life studies on bush jasmine (hours)	110

LIST OF FIGURES

Figure Number	Title	Between Pages
1	Effect of N, P, K on flower yield	118-119
2	Effect of N, P, K on 100 weight of buds	120-121
3	Shelf life studies of bush jasmine	132-133

LIST OF PLATES

Plate Number	Title	Between Pages
1	T_2 $(n_1p_1k_2)$	55-56
2	T_5 $(n_1p_2k_2)$	55 - 56
3	T_4 $(n_1p_2k_1)$	55 - 56
4	T_1 $(n_1p_1k_1)$	55 - 56
5	Buds kept at 0°C	110-111
6	Buds treated with ethylene absorbants	110 - 111
7	Buds treated without ethylene absorbants	110 - 111

LIST OF APPENDICES

Appendix Number	Title	Page Number
1	Weather data during the experimental period	1
2	Initial soil nutrient status	2
3	Interaction effect of NPK in length of main shoot (cm)	3
4	Interaction effect of NPK on number of primary branches	4
5	Interaction effect of NPK on number of secondary branches	5
6	Interaction effect of NPK on length of primary branches (cm)	6
7	Interaction effect of NPK on length of secondary branches (cm)	7
8	Interaction effect of NPK on North-South spread of plant (cm)	8
9	Interaction effect of NPK on spread of plant in East-West direction (cm)	9
10	Interaction effect of NPK on yield of flowers (kg ha^{-1})	10
11	Interaction effect of NPK on monthly yield pattern (kg ha^{-1})	11
12	Interaction effect of NPK on 100 bud weight (g)	12
13	Interaction effect of NPK on time taken for flower opening (hours)	13
14	Interaction effect of N, P, K, Mg, Zn on leaf nutrient content (per cent)	14
15	Interaction effect of NPK on carbohydrate content of flowering shoot (per cent)	15

Appendix Number	Title	Page Number
16	Interaction effect of NPK on uptake of nutrients (kg ha^{-1})	16
17	Interaction effect of NPK on essential oil content (per cent)	17
18	Interaction effect of NPK on available soil nutrients (kg ha^{-1})	18
19	Interaction effectof NPK on shelf life of flowers ($V_0E_0S_0$) hours	19
20	Interaction effect of NPK on shelf life of flowers ($V_0E_0S_1$) hours	20
21	Interaction effect of NPK on shelf life flowers ($V_0E_1S_0$) hours	21
22	Interaction effect of NPK on shelf life of flowers ($V_0E_1S_1$) hours	22
23	Interaction effect of NPK on shelf life of flowers ($V_1E_0S_0$) hours	23
24	Interaction effect of NPK on shelf life of flower ($V_1E_0S_1$) hours	24
25	Interaction effect of NPK on shelf life of flowers ($V_1E_1S_0$) hours	25
26	Interaction effect of NPK on shelf life of flowers ($V_1E_1S_1$) hours	26

INTRODUCTION

1. INTRODUCTION

Jasmine is one of the most important ornamental flowering plant widely cultivated and esteemed for its attractive fragrant flowers. It is also one of the leading traditional flowers of India, which occupies 6,385 ha of land. Jasmine is cultivated in the states of Tamil Nadu, Karnataka, Gujarat, Maharashtra, Andhra Pradesh and Kashmir. Jasmine flowers are being sold in large quantity in the important flower markets of cities such as Mumbai, Calcutta, Chennai, Delhi and Bangalore. About 15,000 kg of loose flowers are sold every day (Dohare *et al.*, 1978). The jasmine concrete itself is a marketable product which is of high value in perfume industry.

There are more than 300 species of jasmine belonging to the family Oleaceae. Among them *Jasminum sambac* is valued very much for its fresh flowers. Bush jasmine belonging to *Jasminum sambac* can be cultivated in limited areas owing to its compact nature. It is being grown in homesteads by housewives and as a small scale enterprise by small and marginal farmers.

In Kerala the climatic conditions are conducive to cultivate jasmine without the use of expensive environment control devices. As a result the cultivation of bush jasmine in the state has increased. However, lack of sufficient information regarding the agrotechnique of the crops like training and pruning, use of growth regulators, manuring etc. hampers the cultivation of bush jasmine and prevents the extension of area under cultivation. Moreover, the flowers are highly perishable and the post harvest loss is met by farmers. Facilities have not yet been standardised for prolonging the shelf life of jasmine flowers.

In this context the present study was undertaken with the objective of assessing the growth and yield of bush jasmine (*Jasminum sambac* Ait.) in response to nutrient treatments and identifying the best nutrient dosage. The second objective was to find techniques to prolong shelf life of jasmine flowers.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1. Effect of nutrients on morphological characters

2.1.1. Nitrogen (N)

Much work has been done on the effect of nitrogen, on morphological aspects of ornamental plants, especially in jasmine.

According to Bhattacharjee (1985 a) the height and number of branches in *Jasminum sambac* improved due to increased application of nitrogen. Pal *et al.* (1985) were also of the same view that increased application of nitrogen in *Jasminum sambac* brought a beneficial effect on number of branches produced.

Srinivasan *et al.* (1989) obtained good vegetative growth with 90 g N per bush in *Jasminum sambac.* As a result, it was found that maximum length of primary and secondary laterals was 75.35 cm and 67.04 cm respectively.

Vegetative characters like the length of main shoot, number of primary and secondary branches, length of primary and secondary branches, North-South and East-West spread of the bush, were significantly higher at the highest level of N at 150 kg ha^{-1} (Asha Raj, 1999).

In *Jasminum grandiflorum,* Natarajan (1977), reported that the number of secondary laterals was found higher when N was applied at 60 g per plant.

In *Jasminum grandiflorum* Natarajan and Rao (1980) found that application of N at 900 g m^{-2} increased primary shoot length. Nitrogen applied at 600 g m^{-2} produced more number of secondary laterals.

According to Bhattacharjee (1983 b) treating *Jasminum grandiflorum* plants with urea upto 100 g per plant improved all vegetative characters. This was confirmed in a later study in *Jasminum grandiflorum* by him in 1988. He also found that N at 33.3 g per plant during December, April and August promoted shoot length by 8.51 per cent and also stimulated the production of more number of shoots.

With respect to growth attributes in *Jasminum auriculatum* Bhattacharjee (1980) found that increased N application upto 900 kg ha^{-1} improved length and diameter of primary shoot, increased number of secondary laterals and productive shoots. Pal *et al.* (1984) found that plants treated with 35 g N m^{-2} produced 173 branches per plant in *Jasminum auriculatum..*

In *Polianthus tuberosa* high dose of N (200 kg ha^{-1}) improved vegetative growth. (Mukhopadyay and Sadhu, 1987).

In a work with Rose var. 'Super Star' Uma and Gowda (1987) noticed maximum shoot length when 16 g of N was applied per bush. In Rose there is another report by Bhattacharjee (1995) that application of 25 g N per 1.44 m^2 increased secondary shoots.

2.1.2. Effect of phosphorus on growth

Srinivasan *et al.* (1989) reported that phosphorus application in *Jasminum sambac* Ait.Cv Gundumalli increased the length of primary and secondary lateral shoots. He also found that application of P at 120 g increased the shoot length. The length of primary shoot was 68.72 cm and that of secondary laterals, was 58.99 cm.

Phosphorus application upto 150 kg ha^{-1} in *Jasminum sambac* significantly increased vegetative characters like length of main shoot, number of primary and secondary branches and spread of plant (Asha Raj, 1999).

According to Bhattacharjee (1983b) increased rate of P application increased the number of branches per plant in *Jasminum grandiflorum*.

In an experiment with 'Montezuma' cultivar of rose, Yadav, *et al.* (1985) found that phosphorus application at the rate of 200 kg ha^{-1} proved very effective for improving vegetative character.

2.1.3. Effect of potassium on growth

In *Jasminum sambac* Ait, length of main shoot, length of primary and secondary branches, North-South and East-West spread of the bush were positively influenced when P was applied at the rate of upto 150 kg ha^{-1} (Asha Raj, 1999).

In gladiolus, significant increase in plant height was found with K application (Deswal *et al.*, 1982).

Uma and Gowda (1987) noticed maximum shoot length in rose var. 'Super star' when 16 g K_2O per plant was applied.

2.1.4. Role of nitrogen, phosphorus and potassium in the growth of plants

In *Jasminum sambac* Ait, vegetative characters like the length of main shoot, number of primary and secondary branches, length of primary and secondary branches, North-South and East-West spread of bush were significantly higher at the fertilizer dose of 150 kg N, 150 kg P_2O_5 and 150 kg K_2O ha^{-1} (Asha Raj, 1999).

From a field trial experiment on *Dahlia variablis* Cv. 'Black out', Bhattacharjee and Mukherjee (1981) concluded that 40 kg N, 50 kg P_2O5 and 40 kg K_2O per acre were optimum for increased vegetative growth.

In rose Bhattacharjee and Damke (1994) concluded that application of 175 g N, 125 g P_2O_5 and 100 g K_2O $1.44m^{-2}$ resulted in maximum vegetative growth.

John *et al.* (1997) in an experiment with gladiolus Cv. 'Oscar' found NPK dose of 100, 100 and 50 kg ha^{-1} produced tallest plants with longest spikes.

2.2. Effect of nutrients on yield

2.2.1. Nitrogen

Natarajan *et al.* (1981) recorded highest flower yield (2.19 t ha^{-1}) with 40 g N per plant in *Jasminum sambac* Ait Cv. Gundumalli. Also in *Jasminum sambac,* Ramesh Kumar and Gill (1983) observed that application of 30 g N per plant gave the highest yield of flower buds. The highest yield of flower buds was 635.8 g per plant whereas the control yielded only 353.7 g per plant.

In *Jasminum sambac* Pal *et al.* (1985) observed that application of N at 350 kg ha^{-1} produced higher yield of flowers. In *Jasminum sambac* Ait, highest yield of flowers 10959.57 kg ha^{-1} was obtained when 150 kg N ha^{-1} was applied (Asha Raj, 1999).

Foliar spray of N at 30 g per plant in *Jasminum sambac* was more economical than the conventional method of applying N at 120 g per plant through the soil (Anon, 1975).

Natarajan and Madhava Rao (1980 .) studied the effect of nitrogen on *Jasminum grandiflorum*. They found that maximum flower yield of 3.642 kg per plant was obtained when N was applied at the rate of 60 g per plant.

From a field trial experiment on *Jasminum grandiflorum* (Bhattacharjee, 1985b) observed significant improvement in yield of flowers with each increment of N dose upto 100 g per plant per year.

Bhattacharjee (1988) found that application of N at 100 g in *Jasminum grandiflorum* influenced yield. Application of N at 33.3 g per plant each during December, April and August increased flower yield by 28.67 per cent. He further found that the requirement of N can be reduced to half the recommended dose by foliar spray of 50 g N (Bhattacharjee, 1989).

According to Srinivasan *et al.* (1989) application of N had a significant influence on bud diameter, weight of 100 buds and flower bud length in *Jasminum sambac*. Nitrogen at 30 g provided maximum flower bud length, whereas increase in dose of N from 30 to 90 g reduced the weight of flower buds.

In *Jasminum auriculatum* Muthuswamy and Pappiah (1976) reported that plants receiving N at 120 g recorded more flower yield compared to N at 240 g. Highest flower yield was obtained when N was applied as foliar spray at 60 g N per plant in *Jasminum auriculatum* (Muthuswamy and Pappiah, 1980). Another study was done in the same species by Pal *et al.* (1984). He found that maximum flower yield of (1985.5 kg ha^{-1}) was obtained by applying N at 350 kg ha^{-1}.

When four levels of nitrogen (ie., 0, 300, 600 and 900 kg ha^{-1}) was applied to *Jasminum auriculatum*, Bhattacharjee (1980) obtained the maximum flower yield with N at 600 kg ha^{-1}.

According to Venkatakrishna (1982) in *Jasminum multiflorum* maximum flower yield was obtained when nitrogen was applied at 120 g per plant.

Nambisen *et al.* (1979) conducted a trial on Edward rose. They found that plants applied with 40 g N per bush in soil gave the highest yield of flowers.

In *Polianthus tuberosa* Mukhopadyay and Sadhu (1987) reported that high yield of flowers was obtained when N was applied at 200 kg ha^{-1}. According to Bhattacharjee (1995) in rose variety 'Super star' application of 25 g N per 1.44 m^2 increased the number of flowers per plant per year. Another work was done in Rose by Tajuddin *et al.* (1995). They obtained an increase in number of flowers per plant with increasing rate of N application (0, 75 or 150 kg ha^{-1}).

2.2.2. Effect of phosphorus on yield

Pal *et al.* (1985) studied the effect of phosphorus on flower yield in *Jasminum sambac* sol var 'Khoya'. He found that an appreciable increase in yield was recorded at 30 g P_2O_5 per square meter. Asha Raj (1999) got the highest yield of flower buds (10959.57 kg ha^{-1}) in *Jasminum sambac* when P_2O_5 was applied at the rate of 150 kg ha^{-1}.

Bhattacharjee (1985b) reported that phosphorus application at the rate of 150 g P_2O_5 per annum increased flower yield in *Jasminum grandiflorum*.

In *Jasminum auriculatum* Muthuswamy and Pappiah (1976) reported that application of P at 0, 120 and 240 g per plant per year did not increase yield. Similar effect was found by Pal *et al.* (1984) in *Jasminum auriculatum*. He said that there was no beneficial effect on yield with increasing P rates.

In Rose, 200 kg ha^{-1} P_2O_5 proved effective for improving yield of flowers (Yadav *et al.*, 1985). Higher spike yield was obtained at 80 g P_2O_5 in *Polianthus tuberosa* (Banker and Mukhopadyay, 1985).

Mukhopadyay and Sadhu (1987) inferred that application of phosphorus at the rate of 75 kg ha^{-1} in tuberose Cv. 'Double' increased flower yield and quality of flowers.

2.2.3. Effect of potassium on flower yield

Higher flower yield of 12.19 t ha^{-1} was obtained in *Jasminum sambac* at 40 g K_2O per plant along with equal dose of N and P (Natarajan *et al.*, 1981). In *Jasminum sambac* when potassium was applied at the rate of 150 kg ha^{-1}, highest yield of 10959.57 kg ha^{-1} was obtained (Asha Raj, 1999).

In *Jasminum grandiflorum* flower yield of 3.6 kg per plant was recorded when 120 g K_2O per plant was applied (Natarajan and Madhava Rao, 1980).

Bhattacharjee (1983b) observed that K application at 100 g per plant improved flower yield in *Jasminum grandiflorum*. He further confirmed that 100 g K_2O per plant per year was best for maximising flower yield (Bhattacharjee, 1985b).

In *Jasminum auriculatum* Vahl., no significant increase in yield of flowers was observed when K was applied independently at 0, 120 and 240 g per plant per year (Muthuswamy and Pappiah, 1976).

Potassium application showed significant effect in *Polianthus tuberosa*. Application of K_2O 125 kg ha^{-1} resulted in higher spike yield (Mukhopadhyay, 1978).

In *Gladiolus grandiflora* Cv. H.B. Pitt, more florets per spike was obtained with K application (Deswal *et al.*, 1982).

2.3. Effect of split application of nitrogen, phosphorus and potassium on yield

Natarajan *et al.* (1981) found that bimonthly applications of 40 g each of N, P and K per plant in *Jasminum sambac* Ait. Cv. Gundumalli gave the highest flower yield (12.19 t ha^{-1}). Ramesh Kumar and Gill (1983) observed that application of 50 g N per plant in two split doses with half at pruning and half at the end of first flowering flush gave the highest flower yield. During the same year they also found that *Jasminum sambac* plants receiving N at 30g per plant in split doses gave the highest yield of flower buds (635.8 g per plant). The control yielded only 353.7 g per plant.

Pal *et al.* (1985) observed that flower yield of *Jasminum sambac* was highest in a plot with 40,000 plants per hectare receiving N at 350 kg ha^{-1}, P_2O_5 300 kg ha^{-1}.

According to Srinivasan *et al.* (1989) application of N and P in four bimonthly intervals in *Jasminum sambac* resulted in the earliest flowering but other floral characters were not affected by split fertilizer application. They have obtained good floral characteristics with 90 g N. 120 g P_2O_5, 240 g K_2O and 25 kg FYM per bush.

In a nutrient trial on *Jasminum sambac* it was found that bimonthly application of N 150 kg, P_2O_5 150 kg and K_2O 150 kg ha^{-1} was more effective (Asha Raj, 1999).

In *Jasminum grandiflorum* increased flower yield was obtained with foliar application of P and K at 120 g per plant (Kumaraguruparan, 1974). Muthuswamy and Pappiah (1977) also reported that application of N : P : K at 120:240:240 g and FYM 30 kg in six split doses per plant per year in *Jasminum grandiflorum* increased flower yield by 17.4 to 20 per cent.

The effect of frequency of fertilizer application in *Jasminum grandiflorum* was studied by Natarajan and Madhava Rao (1980 a). The maximum flower yield (3.642 kg per plant) was recorded when 15 kg FYM, 60 g N, 120 g P_2O_5 and 120 g K_2O were applied per plant in 12 monthly applications. Natarajan and Madhava Rao (1980) again reported that application of N at 60 g and P_2O_5 120 g enhanced flower yield in *Jasminum grandiflorum*. The best result was obtained when N and P application at 60 g and 120 g per plant combined with 240 g K_2O and 30 kg FYM per plant.

According to Nofal and Marwan (1982) highest flower yield was reported in *Jasminum grandiflorum* at 578 kg N $acre^{-1}$ followed by 300 kg N $acre^{-1}$.

In a nutritional trial in *Jasminum grandiflorum* four levels of N, three levels of P_2O_5 and two levels of K_2O accompanied by FYM revealed the best dose per plant to be N 100 g, P_2O_5 150 g, K_2O 100 g and FYM 10 kg. This when applied in three splits, resulted in highest flower yield (Bhattacharjee and Divakar, 1983).

Muthuswamy and Abdul Khader (1986) studied the effect of split application of fertilizer in *Jasminum grandiflorum*. They found that a fertilizer dose of N 60 g, P_2O_5 120 g and K_2O 120 g per plant along with 10 kg FYM applied in two splits was found to be optimum.

A four year trial with *Jasminum auriculatum* was done by Muthuswamy and Pappiah (1976). They found that plants receiving N, P and K each at 0, 120 and 240 g per plant annually in all possible combinations showed that flower yield was highest with N at 120 or 240 g per plant. The effects of P and K alone were not very pronounced, but with N at 120 g per plant , there was response to K at 120 g per plant. Moreover, the level of N could be reduced to half the recommended dose of 120 g per plant if applied as foliar spray at monthly intervals.

In a nutrient trial with *Jasminum auriculatum* Vahl. it was found that maximum number of flowers per plant and flower yield was obtained when 60 g N, 120 g P and 120 g K was applied (Hugar and Nalawadi, 1994).

Mukhopadhyay *et al.* (1978) concluded that application of 200 kg N, 75 kg P_2O_5, 125 kg K_2O ha^{-1} resulted in higher yield and quality flowers in tuberose cv. Double. Mukhopadyay and Sadhu (1987) further found that high dose of N and P resulted in improvement in flowering and bulb formation. In *Polianthus tuberosa* L. var. 'Single' Gopalakrishnan *et al.* (1995) found that average number of flowers per spike was highest with 120 kg N + 60 kg P_2O_5 + 30 kg K_2O ha^{-1}.

Amarjeet *et al.* (1996) conducted a fertilizer trial with (N - 0, 100, 200, 300 and 400 kg ha^{-1}) P and K each at (0, 100 and 200 kg ha^{-1}) in *Polianthus tuberosa* cv. 'Single' and found that high rate of N, P and K delayed spike emergence and prolonged shelf life.

In rose variety 'Super Star' application of 25 g N per 1.44 m^2 each in October, December and February resulted in higher number of flowers per plant per year over single application of 75 g N in October (Bhattacharjee, 1995). He also said that a fertilizer dose of 75 g N, 125 g P and 100 g K per plot produced more number of good quality flowers.

John *et al.* (1997) obtained longest spike and more florets per spike in gladiolus cv. 'Oscar' with N at 100 kg ha^{-1} P_2O_5 and K_2O each at 50 kg ha^{-1}.

2.4. Interaction effect of nutrients

In *Jasminum sambac* sol.var 'Khoya' Pal *et al.* (1985) observed that interactions of higher level of nitrogen (350 kg ha^{-1}) and phosphorus (300 kg ha^{-1}) caused appreciable increase in flower production.

Srinivasan *et al.* (1989) found in *Jasminum sambac* a significant influence of N x P interaction on length of primary and secondary lateral shoots. N x P interaction also influenced floral characters like number of days taken for flower bud initiation, first flower bud picking and weight of hundred buds.

In *Jasminum sambac* N x P interaction was significant with 150 kg N and 150 kg P_2O_5 ha^{-1} producing taller plants. Among the P x K interactions, 150 kg P_2O_5 with 150 kg K_2O ha^{-1} resulted in maximum height of plants. Maximum number of primary and secondary branches was obtained at N x P and N x K interaction each at 150 kg ha^{-1} (Asha Raj, 1999).

Regarding the spread of the plant in *Jasminum sambac* P x K interaction was found significant with 150 kg P_2O_5 + 150 kg K_2O ha^{-1} showing maximum North-South spread of bush while 150 kg P_2O_5 + 150 kg K_2O ha^{-1} produced maximum East-West spread of bush. Similar effect was found in N x P interaction (Asha Raj, 1999).

N x P, N x K and P x K interaction were significant with 150 kg N + 150 kg P_2O_5 ha^{-1}, 150 kg N + 150 kg K_2O ha^{-1} and 150 kg P_2O_5 + 100 kg K_2O ha^{-1} produced maximum content of essential oil (Asha Raj, 1999).

In *Jasminum auriculatum* vahl, significant effects of N x P interaction on yield of flowers was seen. N x K interaction also recorded significant effects. With no nitrogen supply there was little response to K. With a moderate N supply (120 g), K at 240 g recorded a better yield than K at 120 g. In the case of P x K interaction, higher levels of application of both P and K (240 g) or a high level of one (240 g) and a moderate supply of other (120 g) was inferior to moderate supply of both (120 g each) (Muthuswamy and Pappiah, 1976).

In *Polianthus tuberosa* N x P interaction has much influenced yield (Mukhopadhyay and Sadhu, 1987). Deswal *et al.* (1982) found that the interactions of N x P was significant in *Gladiolus grandiflora* cv. H.B. 'Pitt'. There was significant interaction in plant height and yield of florets. It was also found that the effect of N was enhanced in presence of P and individual response of N, P and K were increased in presence of all these nutrients.

In rose Yadav *et al.* (1985) reported that there was significant influence of N and P interaction on yield. It was found that 600 kg N and 200 kg P ha^{-1} was found effective. In rose variety 'Super Star' Uma and Gowda (1987) noticed maximum shoot length with application of 16 g each of N and K_2O per plant per year.

2.5. Effect of nutrients on essential oil content

Ramesh Kumar and Gill (1988) studied the effect of concrete production in *Jasminum sambac*. They found that application of nitrogen does not affect concrete recovery. According to Asha Raj (1999) in *Jasminum sambac* highest essential oil content of flowers was obtained with 100 kg N and P_2O_5 ha^{-1}.

In *Jasminum grandiflorum* it was observed that essential oil content of 9.69g per plant was obtained when 15 kg FYM + 60 g N + 120 g P_2O_5 + 120 g K_2O were applied per plant in twelve monthly application (Natarajan and Madhava Rao, 1980). Natarajan and Rao (1983) again reported that flower earliness was promoted by low N levels and high P levels in *Jasminum grandiflorum*. High oil content was obtained with high N and P levels. A fertilizer dose of 30 kg FYM per plant, 120 g N + 240g P_2O_5 + 240 g K_2O per plant were found best for high flower yield and oil recovery.

In *Jasminum grandiflorum* Nofal and Marwan (1982) studied different levels of N on concrete content. The different levels were 300, 600 and 900 kg per feddan (1 feddan = 1.038 acres). It was said that the concrete content was unaffected by N levels. but a slight increase in absolute content was noted in plants receiving highest N level.

In *Jasminum grandiflorum* Bhattacharjee and Divakar (1983a) recorded that the treatment with increased doses of N (0 to 100 g) and P_2O_5 (0 to 150 g) significantly increased concrete percentage, while addition of K_2O did not improve the concrete content.

Pal *et al.* (1984) found that in *Jasminum auriculatum*, that the essential oil content increased with rising N levels, but P had no beneficial effect.

In 'Red Crimea' roses K application reduced oil yield whereas application of N each at 90 kg ha^{-1} increased essential oil content in flowers (Subina and Masanova, 1970). According to Singh *et al.* (1976) a fertilizer dose of 80 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} increased essential oil content in *Polianthus tuberosa.*

Nitrogen application upto 150 kg ha^{-1} was found to increase the yield of essential oil content of *Mentha piperita* (Singh *et al.*, 1977).

Dellacecca (1977) reported that in *Mentha piperita* application of N at 200 kg ha^{-1} increased essential oil content. Regarding

P_2O_5, application at the rate of 150 kg ha^{-1} was found optimum to obtain maximum essential oil.

In *Majorona hortensis* application of 320 kg ha^{-1} nitrogen gave an oil yield of 52.79 kg ha^{-1}. Phosphorus application gave the highest oil yield of 48.87 kg ha^{-1} (Farooq *et al.*, 1991).

2.6. Effect of foliar spray of nutrients

2.6.1. Effect of zinc

In an experiment with *Jasminum grandiflorum* Bhattacharjee (1983 a) revealed that foliar spray of $ZnSO_4$ 0.25 per cent before bloom increased the yield of flowers.

Bhattacharjee (1989 b) studied the effect of Zn on *Jasminum grandiflorum*. It was found that maximum beneficial effect on growth and flower production was obtained with 10 kg $ZnSO_4$ ha^{-1}.

Foliar spray of Zn in different phases was tried in *Jasminum grandiflorum*. It was found that foliar spray of $ZnSO_4$ (0.25 %) during February, April and June increased flower yield to 32.44 per cent, 35.35 per cent, 35.34 per cent (Bhattacharjee, 1990).

Foliar application of Zn in combination with NPK is essential for vigorous growth and profuse flowering in 'Belcanto' rose variety (Sinha and Motial, 1969). In a field trial was conducted by Bhattacharjee (1993) in rose it was found that there was significant promotion of plant height when one per cent $ZnSO_4$ was applied along with other micronutrients.

Chaturvedi *et al.* (1986) reported that in gladiolus var. 'Sylvia', Zn application, two per cent foliar spray produced largest spike with largest duration of flowering.

2.6.2. Effect of magnesium

Application of $MgSO_4$ (0.5 %) in *Jasminum grandiflorum* before bloom increased the yield of flowers (Bhattacharjee, 1983 a).

According to the studies conducted by Bhattacharjee (1989 b) in *Jasminum grandiflorum* it was found that better growth and high flower yield was obtained with magnesium at the rate of 40 kg ha^{-1}. He again reported (1990) that foliar spray of Mg as $MgSO_4$ (0.5 %) in *Jasminum grandiflorum* was found to increase flower yield. It was found that foliar spray of $MgSO_4$ 0.5 per cent during February, April and June increased yield of flowers by 32.44 per cent, 35.35 per cent and 35.34 per cent.

In rose variety 'Belcanto' foliar spray of Zn along with N, P, K produced vigorous growth of plant and profuse flowering (Sinha and Motial, 1969).

Chaturvedi *et al.* (1986) found that in gladiolus var. Sylvia application of Mg two per cent enhanced duration of flowering with largest spike.

Bhattacharjee (1993) found in the study with rose variety 'Belcanto' that, $MgSO_4$ one per cent improved plant height.

2.7. Post harvest studies

2.7.1. Effect of chemicals for prolonging shelf life

An experiment was conducted on fully developed flower buds of *Jasminum sambac* var 'Khoya'. Flower buds were soaked in different concentrations of sugar, sodium chloride, boric acid, citric acid, copper sulphate, aluminium sulphate, maleic hydrazide, sodium benzoate, potassium metabisulphite, cycoceland silver nitrate. Distilled water served as control. The flower buds treated with sucrose, boric acid, copper sulphate, aluminium sulphate and silver nitrate remained fresh upto 75 hours without affecting the fragrance (Mukhopadyay *et al.*, 1988).

In another trial, fully matured *Jasminum sambac* flower buds were treated with solutions of 0.5 per cent sucrose, 10 ppm benzyl adenine purine, 15 per cent $KMnO_4$ and five per cent kaoline. It was found that 0.5 per cent sucrose solution extended shelf life to the maximum of 29.33 hours, 10 ppm benzyl adenine purine 27 hours, 15 per cent $KMnO_4$ 67 hours and five per cent kaoline 38 hours. The combination of 0.5 per cent sucrose + 10 ppm benzyl adenine purine + 15 per cent $KMnO_4$ + five per cent kaolin extended shelf life to 42 hours (Sudha, 1998).

In another study on *Jasminum sambac* by Salvi *et al.* (1990), post harvest treatment was given to loose flowers and unopened buds with silver nitrate, benzyl adenine, cycocel and triadimefon each at five to 25 ppm. Water served as control. Keeping quality was same for open flowers (2 days) including control. In case of unopened buds chemicals at higher concentration gave a keeping quality of four days.

In another study Nichols and Kofranek (1982) reported that ethylene prevented opening of carnation buds. Goszczynska and Reid (1985) found that opening of tight rose buds was found to be inhibited by low concentration of ethylene.

Chrysanthenum flowers treated with a detergent as post harvest treatment increased water uptake, delayed wilting and yellowing of leaves, improved flower opening during the first days of vase life (Leopard and Nooden, 1988).

2.7.2. Effect of temperature on shelf life

Mukhopadhyay *et al.* (1988) found that cold treatment of *Jasminum sambac* buds, enhanced longevity of flowers.

Skene (1924) stated that opening of crocus, flax and many other flowers was inhibited by a decrease in temperature.

Carnation buds were preconditioned in a solution containing silverthiosulphate 550 milligram per litre and sucrose 100 gram per litre.

The buds were stored at 0 to 1°C. After 20 and 24 weeks storage, flowers had a vase life of about twelve and six days (Kofranaek *et al.*, 1972). Also according to Kofranek and Reid (1983), chrysanthenum and carnation buds held at 10°C took longer time to open than those held at 20°C.

2.7.3. Prolonging shelf life by modified atmospheric package

According to Sudha (1998) *Jasminum sambac* buds were placed in polythene bag of size 22 x 18 cm and 200 gauge thickness. Under active modified atmospheric packaging the flower buds could be stored upto 84 hours at 25°C. Under passive modified atmospheric package flower buds could be stored upto 42 hours at 25°C.

MATERIALS AND METHODS

MATERIALS AND METHODS

The field trial for the experiment was laid out in the garden attached to the Department of Horticulture, College of Agriculture, Vellayani. The trial was to standardise the requirement of major nutrients (N, P, K) for optimum growth and flowering of bush jasmine and post harvest studies with different treatment combinations.

Location

The experimental site was selected in the college garden under the Department of Horticulture. The site was located 29 meters above Mean Sea Level with latitude 8.5°N and longitude 76.9°E.

Climate

Parameters like minimum and maximum temperature, relative humidity and rainfall were recorded during the period of study.

Materials for study

One year old plants of *Jasminum sambac* already existing in the field served as the material for study.

Field preparation

The field was prepared and made free of weeds. Spacing adopted was 1 x 1.25 m. There were seven plants in a row. 10 kg FYM was applied in each pit, as basal dose.

Experimental design and layout

Experiment I

The experiment was $3^3 + 2$ factorial and design adopted was Randomised Block Design. The details are :

Total number of treatments - 27

Number of controls - 2

Number of replications - 3

Number of plants per plot - 7

Spacing - 1 x 1.25 m

Number of observational plants - 3

Treatments

All combinations of three levels of nitrogen, phosphorus and potassium in addition to zinc and magnesium as foliar spray uniformly in all treatments + two controls.

i) Levels of nitrogen

1. n_1 - 300 kg ha^{-1}
2. n_2 - 450 kg ha^{-1}
3. n_3 - 600 kg ha^{-1}

ii) Levels of phosphorus

1. p_1 - 300 kg ha^{-1}
2. p_2 - 450 kg ha^{-1}
3. p_3 - 600 kg ha^{-1}

iii) Levels of potassium

1. k_1 - 300 kg ha^{-1}
2. k_2 - 450 kg ha^{-1}
3. k_3 - 600 kg ha^{-1}

iv) Zn (0.25 %) + Mg (0.5 %) as foliar spray uniformly in all treatments

v) Controls

1. C_1 - Control with nitrogen - 150 kg ha^{-1}
   potassium - 150 kg ha^{-1}
   phosphorus - 150 kg ha^{-1}

   C_2 - Control with Farm yard manure - 10 kg $plant^{-1}$

Experiment II - Post harvest studies

Design - Completely Randomised Design

Total number of treatments - 8

Number of replications - 3

Buds (5 g each) were packed in polythene covers (15 x 10 cms. 150 gauge) with six punch holes.

Treatment 1

i) V_0 Without newspaper lining

ii) V_1 With newspaper lining

Treatment 2

i) E_0 - Without ethylene absorbant

ii) E_1 - With ethylene absorbant (potassium permanganate)

Treatment 3

i) S_0 - Placing buds at room temperature

ii) S_1 - refrigerated storage of buds at 0°C

Soil nutrient status

The soil was red laterite, acidic and high in available nitrogen, potassium and phosphorus.

Fertilizer application

The fertilizers like urea, rock phosphate, muriate of potash and foliar spray of zinc sulphate and magnesium sulphate were given in six equal split doses at bimonthly intervals.

Observations

Observations were recorded after fertilizer application.

3.1. Vegetative characters

3.1.1 Length of main shoot

The longest central shoot from the base of the shoot upto the terminal pair of leaves was measured and expressed in centimeters.

3.1.2 Number of primary branches

The total number of lateral branches arising from the base and also from the main shoot was counted and also the lateral shoots that developed from main shoot was numbered as primary branches.

3.1.3. Number of secondary branches

The number of lateral shoots that were seen to develop from primary branches were numbered as secondary branches.

3.1.4. Length of primary branches

This was measured from the base of the shoot upto the base of terminal pair of leaves and expressed in centimeters.

3.1.5. Length of secondary branches

Length of secondary shoot was measured from the base of the secondary shoot upto the base of terminal pair of leaves and expressed in centimeters.

3.1.6. North-South spread of the plant

North-South spread of plant was measured by taking dimensions, in centimeters, across the bush in North-South direction.

3.1.7. East-West spread of the plant

This was measured by taking dimensions in centimeters, across the bush in East-West direction.

3.2. Flowering and floral characters

3.2.1. Flower yield in kg ha^{-1} (daily)

Flower buds were harvested daily, treatment-wise and flower buds were weighed accordingly and yield expressed in kg ha^{-1} $year^{-1}$.

3.2.2. Monthly yield pattern

The yield was recorded treatment-wise daily and from this daily yield, monthly yield was calculated and expressed in kg ha^{-1} per month.

3.2.3. Weight of 100 buds in grams

Flower buds which were about to bloom next day were harvested between one and two p.m. Weight of hundred flower buds were recorded for a period of twelve months. The average weight of buds in each treatment was taken and expressed in percentage.

3.2.4. Time taken for opening of flowers after harvest

Flowers were harvested between 1-2 pm and the time taken for opening after harvest was recorded.

3.3. Content of nutrients in leaves

Leaf samples were analysed after application of fertilizers.

The technique of sampling suggested for shrubs by Davidson (1966), Cannon *et al.* (1960) and Smith (1972) was followed. The leaves were dried in an oven and used for analysis.

Leaf analysis

Nutrient	Method	Reference
Nitrogen	Microkjeldal	Jackson (1970)
Phosphorus	Vanodomolybdate yellow colour method	Jackson (1970)
Potassium	Flame photometer	Jackson (1970)
Zinc	3110 Perkin Elemer Atomic Absorption spectrophotometer	Jackson (1973)
Magnesium	3110 Perkin Elemer Atomic Absorption spectrophotometer	Jackson (1973)

3.4. Content of nutrients in soil

The soil samples were anlysed before and after the application of fertilizers.

Soil analysis

Available nutrients	Method	Reference
Nitrogen	Alkaline permanganate	Subbiah and Asija (1956)
Phosphorus	Ascorbic acid method	Watnable and Olsen (1965)
Potassium	Flame photometer method	Jackson (1970)

3.5. Uptake of N, P, K, Zn and Mg by plants

The nitrogen content in the plants was determined by microkjeldal method (Jackson, 1970), phosphorus content vanodomolybdate yellow colour method (Jackson, 1970) and potassium content was recorded in flame photometer (Jackson, 1970). Zinc and magnesium content was recorded in 3110 Perkin Elmer atomic absorption spectrophotometer (Jackson, 1973). The uptake of nutrients was calculated and the average was worked out.

3.6. Essential oil content of flowers

Essential oil content of flowers was analysed (petroleum ether in soxhlet apparatus) and expressed as percentage weight basis.

Experiment II

3.7. Shelf life studies

3.7.1. Time taken for opening of buds

The flower buds were harvested treatment-wise and time taken for opening of buds was noted for different treatment combinations.

3.7.2. Time taken for colour fading

Time taken for the change of colour from pure white to dull brown colour was noted.

3.7.3. Time taken for loss of turgidity

Time was noted when the flowers became loose and placid and compared with different treatment combinations.

3.8. Other observations

3.8.1. Incidence of pest and diseases

The attack of pests like bud worm, aphids and diseases like leaf spot and sooty mould were studied and periodic spray was given.

3.8.2. Statistical analysis

The data collected on different treatments were analysed by applying the technique of analysis of variance for randomised block design and Completely Randomised Design (Panse and Sukhatme (1967).

RESULTS

RESULTS

The observations recorded from the experiment on nutrient requirement and post harvest studies on bush jasmine (*Jasminum sambac*) were statistically analysed and the important findings are presented below.

Experiment I

4.1. Vegetative characters

These were measured in terms of main shoot length, number of primary and lateral branches and spread of plant in North-South and East-West direction of the bush.

4.1.1. Effect of nutrients on length of main shoot

The effect of nutrients on length of main shoot is presented in Tables 1 and 2.

Main effect of major nutrients on length of main shoot.

The application of major nutrients *viz.*, N, P, K were found to be highly significant in influencing the length of main shoot throughout the growth period. It was found that the level n_3 recorded the highest length

Table 1. Main effect of N, P, K on length of main shoot (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1	37.27	42.82	48.34	53.16	57.94	62.85
n_2	41.19	48.41	54.39	60.32	66.27	73.10
n_3	58.72	65.35	71.84	79.43	87.57	95.42
F	64.91**	71.61**	86.97**	124.41**	202.31**	255.90**
CD	4.00	3.98	3.76	3.50	3.08	3.09
p_1	42.37	47.77	53.79	58.58	64.55	71.07
p_2	46.55	52.68	58.38	65.00	70.96	77.47
p_3	49.25	56.12	62.39	69.34	76.27	83.83
F	6.18**	9.18**	10.83**	19.85**	29.88**	35.23**
CD	4.00	3.98	3.76	3.50	3.08	3.09
k_1	43.29	49.59	55.61	62.17	68.44	74.75
k_2	45.24	51.25	57.60	63.60	70.01	77.28
k_3	49.64	55.74	61.36	67.14	73.33	80.34
F	5.44**	5.27**	4.99**	4.40*	5.42**	6.76**
CD	4.00	3.98	3.76	3.50	3.08	3.09

* Significant at 5 per cent level   ** Significant at 1 per cent level

Table 2. Interaction effect of NP, NK and PK on length of main shoot (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	33.85	39.77	45.61	49.47	54.83	60.32
n_1p_2	37.08	41.77	46.86	52.40	56.84	61.30
n_1p_3	40.88	46.92	52.56	57.61	62.15	66.92
n_2p_1	41.61	47.32	53.45	58.98	63.65	70.48
n_2p_2	43.90	49.15	54.99	60.44	68.15	72.32
n_2p_3	41.06	48.75	54.71	61.54	69.01	76.51
n_3p_1	51.65	56.22	62.31	67.24	75.16	82.39
n_3p_2	58.68	67.12	69.00	71.17	89.89	98.79
n_3p_3	65.82	72.70	79.91	88.88	97.66	108.08
F	NS	2.77**	3.68**	5.97**	7.03**	9.95**
CD	—	6.89	6.56	3.50	5.34	5.35
n_1k_1	36.46	42.20	47.08	52.37	57.89	62.16
n_1k_2	36.63	41.08	47.35	51.65	56.82	64.46
n_1k_3	38.71	45.18	50.60	55.45	59.11	63.92
n_2k_1	40.22	46.22	52.70	58.98	65.42	71.62
n_2k_2	40.91	48.03	54.06	59.35	65.98	73.05
n_2k_3	45.44	50.97	56.40	62.63	67.42	74.65
n_3k_1	53.21	60.34	67.04	75.18	82.00	90.48
n_3k_2	58.17	64.63	71.38	79.80	87.24	96.33
n_3k_3	64.77	71.06	77.08	83.32	93.46	102.45
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	41.83	47.80	53.33	59.02	64.95	70.48
p_1k_2	40.61	46.12	53.48	51.55	62.90	69.73
p_1k_3	44.67	49.40	54.57	59.11	65.79	73.00
p_2k_1	42.09	48.54	54.37	61.51	68.10	73.80
p_2k_2	47.62	53.19	59.24	64.79	71.26	78.88
p_2k_3	49.94	56.31	61.53	68.72	73.52	79.73
p_3k_1	45.96	52.42	59.12	65.99	72.25	79.98
p_3k_2	47.48	54.44	60.08	68.46	75.88	83.23
p_3k_3	54.31	61.51	67.88	73.58	80.69	88.30
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

of main shoot (Table 1). Similarly the levels p_3 and k_3 influenced the length of main shoot, than other levels and were superior throughout the period of study.

Interaction effect of NP, NK and PK on length of main shoot

N x P interaction was found significant in increasing length of main shoot. NP interaction influenced the length of main shoot significantly from the fourth month onwards and continued upto the end of study. During the fourth month, the combination n_3p_3 recorded the highest main-shoot length (72.70 cm) followed by n_3p_2 (67.12 cm). In the sixth, eighth, tenth and twelveth month also the interaction n_3p_3 was found superior. The interactions N x K and P x K were found non significant

4.1.2. Effect of nutrients on number of primary branches

The effect of nutrients on the number of primary branches recorded are presented in Table 3 and 4.

Main effect of major nutrients on number of primary branches

The effect of N was more pronounced and this was seen throughout the period of study. The level n_3 was found highly significant than levels n_1 and n_2. The number of primary branches at n_3 level during the second month was 9.45 and during the twelveth month (22.83) respectively.

Table 3. Main effect of N, P, K on number of primary branches

Treatments	Months					
	2	4	6	8	10	12
n_1	7.35	9.39	11.07	13.46	15.66	17.56
n_2	8.56	10.08	12.03	14.48	17.25	19.23
n_3	9.45	12.26	14.95	17.62	20.32	22.83
F	43.97**	114.02**	145.65**	292.15**	146.78**	138.77**
CD	0.14	0.13	0.23	0.36	0.18	0.21
p_1	8.24	9.70	11.54	14.10	16.37	18.43
p_2	8.75	10.80	12.87	15.66	17.94	19.95
p_3	8.36	11.24	13.64	15.81	18.91	21.24
F	28.07**	281.58**	177.95**	55.67**	42.43**	179.49**
CD	0.14	0.13	0.23	0.36	0.18	0.21
k_1	8.41	10.26	12.57	15.11	17.70	19.52
k_2	8.40	10.91	13.04	15.46	17.71	20.14
k_3	8.54	10.57	12.44	15.00	17.81	19.96
F	NS	47.42**	15.93**	3.51*	NS	19.33**
CD	—	0.13	0.23	0.36	NS	0.21

* Significant at 5 per cent level ** Significant at 1 per cent level NS - Non significant

Table 4. Interaction effect of NP, NK and PK on number of primary branches

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	6.92	8.50	10.06	12.73	14.74	16.78
n_1p_2	7.77	9.76	11.97	14.39	16.71	18.40
n_1p_3	7.35	9.91	11.18	13.27	15.52	17.50
n_2p_1	8.64	9.64	12.13	14.62	16.89	18.59
n_2p_2	8.91	10.86	12.13	15.16	17.50	19.64
n_2p_3	8.13	9.75	11.83	13.66	17.36	19.46
n_3p_1	9.17	10.97	12.43	14.95	17.49	19.91
n_3p_2	9.57	11.77	14.52	17.43	19.60	21.81
n_3p_3	9.59	14.05	17.90	20.49	23.86	26.77
F	12.10**	129.97**	136.46**	65.41**	289.37**	240.22**
CD	0.25	0.13	0.39	0.62	0.30	0.30
n_1k_1	7.18	9.16	10.93	13.26	15.34	17.25
n_1k_2	7.19	9.38	10.63	12.87	15.13	17.13
n_1k_3	7.68	9.63	11.64	14.26	16.50	18.31
n_2k_1	8.64	10.14	12.23	15.06	18.25	19.80
n_2k_2	8.56	10.63	12.92	15.60	17.57	19.91
n_2k_3	8.46	9.48	10.94	12.78	15.92	17.98
n_3k_1	9.40	11.48	14.56	17.02	19.50	21.51
n_3k_2	9.45	12.71	15.57	17.90	20.44	23.38
n_3k_3	9.49	12.60	14.72	17.96	21.02	23.60
F	4.73**	40.02**	33.51**	29.71**	110.90**	82.76**
CD	0.25	0.23	0.39	0.62	0.30	0.36
p_1k_1	8.18	9.76	11.57	14.42	16.22	17.98
p_1k_2	8.31	10.05	12.19	14.81	16.95	19.29
p_1k_3	8.24	9.29	10.86	13.06	15.95	18.00
p_2k_1	8.89	10.36	13.37	16.17	18.19	20.26
p_2k_2	8.59	11.26	12.77	15.48	17.56	19.57
p_2k_3	8.77	10.77	12.47	15.34	18.06	20.02
p_3k_1	8.15	10.65	12.78	14.75	18.68	20.32
p_3k_2	8.29	11.41	14.16	16.08	18.63	21.55
p_3k_3	8.63	11.65	13.97	16.60	19.44	21.85
F	4.54**	22.86**	23.99**	18.44**	24.95**	32.97**
CD	0.25	0.23	0.39	0.62	0.30	0.36

** Significant at 1 per cent level

Similarly the effect of P was highly significant from the second month onwards. The level p_3 produced more number of primary branches proving its superiority. The level k_3 was found highly significant upto twelveth month (19.96) except tenth month.

Interaction effect of NP, PK and NK on number of primary branches

Interactions between N x P, N x K and P x K had significant effect in influencing the number of primary branches. N x P interaction was highly significant all throughout the period of study.

The highest number of primary branches was obtained in the combination n_3p_3 (9.59). During the rest of the observational period also the combination n_3p_3 ranked first. In N x K interaction the treatment n_3k_3 was found as the best treatment. Similar effect was also found in P x K interaction. P x K interaction was more effective from the second month onwards, thereafter significantly influencing the number of primary branches. During the second, fourth, sixth, tenth and twelveth month the number of primary branches recorded were 8.63, 11.65, 13.97, 16.60, 19.44, 21.85 respectively.

4.1.3. Effect of nutrients on number of secondary branches

The effect of nutrients on number of secondary branches is presented in Tables 5 and 6.

Table 5. Main effect of N, P, K on number of secondary branches

Treatments	Months					
	2	4	6	8	10	12
n_1	8.89	9.80	10.86	11.85	12.72	13.67
n_2	14.49	15.86	17.01	18.33	19.97	21.38
n_3	16.84	18.46	19.15	20.73	21.77	23.14
F	36.20**	32.04**	24.65**	29.82**	28.72**	34.16**
CD	1.95	2.21	2.49	2.42	2.57	2.47
p_1	11.19	12.52	13.09	14.50	15.57	16.49
p_2	15.00	16.26	17.54	18.64	19.74	21.12
p_3	14.04	15.29	16.46	17.76	19.15	20.59
F	8.52**	6.38**	7.12**	6.74**	6.38**	8.63**
CD	1.95	2.21	2.49	2.42	2.57	2.47
k_1	11.70	12.97	13.77	14.95	15.98	17.20
k_2	14.82	16.13	17.16	18.88	20.11	21.58
k_3	13.70	14.96	16.09	17.07	18.37	19.43
F	5.40**	4.32**	3.99**	5.48**	5.36**	6.46**
CD	1.95	2.21	2.49	2.42	2.57	2.47

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 6. Interaction effect of NP, NK and PK on number of secondary branches

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	8.08	8.66	9.58	10.36	11.04	11.63
n_1p_2	9.36	10.28	11.30	12.33	13.43	14.53
n_1p_3	9.24	10.47	11.70	12.86	13.68	14.86
n_2p_1	11.30	12.80	14.00	15.25	16.62	17.71
n_2p_2	17.71	19.05	20.24	21.59	22.69	24.00
n_2p_3	14.45	15.73	16.79	18.13	20.59	28.43
n_3p_1	14.19	16.69	16.90	17.88	19.03	20.14
n_3p_2	17.92	19.45	21.07	22.01	23.09	24.81
n_3p_3	18.43	19.66	20.70	22.30	23.19	24.49
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	7.51	8.36	9.29	10.15	10.98	11.76
n_1k_2	9.96	10.89	12.02	12.95	13.90	15.05
n_1k_3	9.21	10.15	11.27	12.44	13.28	14.22
n_2k_1	13.96	15.16	16.62	17.99	19.54	20.94
n_2k_2	14.45	15.92	16.87	18.69	20.02	21.67
n_2k_3	15.05	16.51	17.55	18.30	20.34	21.53
n_3k_1	13.64	15.39	15.41	16.70	17.43	18.89
n_3k_2	20.04	21.57	22.60	25.01	26.40	28.02
n_3k_3	16.85	18.23	19.44	20.47	21.48	22.53
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	9.61	11.24	11.39	12.21	13.23	14.31
p_1k_2	12.36	13.46	14.08	16.41	17.25	18.25
p_1k_3	11.60	12.85	13.80	14.87	16.21	16.93
p_2k_1	13.66	14.85	16.01	17.15	18.15	19.31
p_2k_2	17.34	18.69	20.02	21.33	22.63	24.35
p_2k_3	14.00	15.23	16.58	17.44	18.43	19.69
p_3k_1	11.84	12.82	13.92	15.49	16.56	17.98
p_3k_2	14.76	16.24	17.38	18.91	20.43	22.14
p_3k_3	15.51	16.81	17.89	18.96	20.46	21.66
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Main effect of major nutrients on number of secondary branches

Application of nitrogen profoundly influenced the number of secondary branches throughout the period of study and the maximum number was recorded at n_3 level. In case of P application p_2 level recorded the maximum number of secondary branches as compared to p_1 and p_3. An increasing trend in the number of secondary branches was noticed with application of potassium at k_2 level.

Interaction effect of NP, NK and PK on number of secondary branches

The interactive effects of N x P, N x K and P x K were non significant on number of secondary branches.

4.1.4. Effect of nutrients on length of primary branches

The effect of nutrients on length of primary branches are presented in Tables 7 and 8.

Main effect of major nutrients on length of primary branches

From the data presented in Table 7, it is clear that length of primary branches was significantly influenced by nitrogen application throughout the period of study. The impact of nitrogen was more pronounced at n_3 level recording a length of 85.35 cm during the twelveth month. The influence of phosphorus on length of primary branches was

Table 7. Main effect of N, P, K on length of primary branches (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1	34.09	38.28	43.35	47.79	52.36	51.93
n_2	39.38	45.93	51.46	56.76	63.04	68.84
n_3	52.15	58.77	65.56	72.11	78.70	85.35
F	82.62**	104.53**	121.97**	169.52**	194.97**	299.21**
CD	2.93	2.91	2.92	2.71	2.73	2.29
p_1	37.51	43.09	49.10	54.92	60.33	66.52
p_2	43.65	43.76	54.88	59.45	65.70	71.36
p_3	44.47	50.11	56.39	63.30	67.98	74.24
F	13.86**	15.26**	14.28**	15.53**	17.01**	23.93**
CD	2.73	2.91	2.92	2.71	2.73	2.29
k_1	40.35	46.57	52.01	57.52	62.76	68.80
k_2	42.38	47.90	53.78	59.20	64.97	70.79
k_3	42.88	48.49	54.57	59.95	66.28	72.53
F	NS	NS	NS	NS	3.48*	5.48**
CD	—	—	—	—	2.73	2.29

* Significant at 5 per cent level ** Significant at 1 per cent level NS - Non significant

Table 8. Interaction effect of NP, NK and PK on length of primary branches (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	30.68	34.57	39.43	44.12	48.86	54.51
n_1p_2	36.07	39.83	44.33	48.31	52.88	58.71
n_1p_3	35.52	40.43	46.29	50.95	55.04	60.58
n_2p_1	35.90	41.43	47.39	52.49	57.74	63.78
n_2p_2	39.73	48.00	52.39	55.97	63.46	68.49
n_2p_3	42.52	48.35	54.60	61.81	67.93	74.24
n_3p_1	45.95	53.28	60.49	68.14	74.38	81.27
n_3p_2	55.14	61.46	67.92	74.07	80.77	86.88
n_3p_3	55.35	61.56	68.27	74.13	80.97	87.91
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	34.37	38.84	43.52	48.19	51.77	57.13
n_1k_2	33.58	38.01	43.30	47.19	52.24	58.18
n_1k_3	34.32	37.98	43.22	48.00	52.77	58.49
n_2k_1	37.63	44.11	49.04	54.26	66.65	68.47
n_2k_2	40.69	46.80	52.64	58.31	63.94	69.40
n_2k_3	40.44	46.87	52.70	57.69	64.54	70.63
n_3k_1	49.66	56.77	63.47	70.10	75.86	82.80
n_3k_2	52.88	58.89	65.41	72.09	78.73	84.77
n_3k_3	53.89	60.64	67.81	74.14	81.52	88.48
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	34.37	39.43	45.97	51.78	56.73	63.83
p_1k_2	39.09	45.53	50.46	56.39	61.66	66.90
p_1k_3	39.07	44.32	50.87	58.58	62.59	68.32
p_2k_1	43.79	50.68	54.17	58.29	64.87	69.63
p_2k_2	42.30	47.06	53.29	58.06	64.06	70.68
p_2k_3	44.85	51.56	57.18	62.01	68.19	73.77
p_3k_1	42.90	49.62	55.90	62.48	66.68	72.94
p_3k_2	45.76	51.11	57.60	63.15	69.19	74.78
p_3k_3	44.73	49.60	55.67	61.25	68.06	75.01
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS - Not significant

significant and p_3 level was found to be superior. The main effect of K did not exert much variation in the length of primary branches. The level k_3 was found significant only during tenth and twelveth month.

Interaction effect of NP, NK and PK on length of primary branches

Interaction effect of N x P, N x K and P x K was found non significant in influencing the length of primary branches.

4.1.5. Effect of nutrients on length of secondary branches

The effect of nutrients on length of secondary branches is seen in Table 9 and 10.

Main effect of major nutrients on length of secondary branches

The length of secondary branches, proved to be more effective during the second month of study and thereafter influencing the length towards the end of twelveth month of observation. The level n_3 was dominant throughout the period of study, compared to n_1 and n_2.

In phosphorus application, p_3 was dominant and in K the level k_3 was superior during the study period.

Interaction effect of NP, NK and PK on length of secondary branches

There was no significant interactive effects in length of secondary branches between the treatments.

Table 9. Main effect of N, P, K on length of secondary laterals (cm)

Treatment	Months					
	2	4	6	8	10	12
n_1	21.91	26.79	32.64	37.68	43.32	48.44
n_2	29.91	35.34	40.80	46.93	52.89	58.47
n_3	39.05	46.10	52.49	58.41	64.73	70.74
F	76.64**	98.40**	97.18**	126.27**	149.94**	189.74**
CD	2.81	2.80	2.91	2.65	2.51	2.33
p_1	27.81	33.32	39.78	44.50	49.89	55.83
p_2	30.74	36.23	41.71	47.46	53.75	59.10
p_3	32.32	38.68	44.44	51.06	57.29	62.71
F	5.46**	7.55**	5.37**	12.66**	17.85**	18.02**
CD	2.81	2.80	2.91	2.65	2.51	2.33
k_1	27.36	33.17	39.11	45.23	51.45	57.03
k_2	30.71	36.72	42.66	47.71	53.63	59.25
k_3	32.81	38.34	44.17	50.08	55.85	61.37
F	7.85**	7.35**	6.59**	3.88**	6.29**	7.17**
CD	2.81	2.80	2.91	2.65	2.51	2.33

** Significant at 1 per cent level

Table 10. Interaction effect of NP, NK and PK on length of secondary branches (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	21.42	26.05	31.66	34.87	40.27	46.29
n_1p_2	21.75	26.50	32.01	37.42	43.30	47.80
n_1p_3	22.57	27.83	34.24	40.75	46.37	51.23
n_2p_1	27.53	32.55	38.52	44.35	49.28	54.70
n_2p_2	29.49	34.47	39.79	45.13	51.09	56.71
n_2p_3	32.10	38.99	44.09	51.32	58.31	64.01
n_3p_1	34.48	41.36	49.14	54.27	60.13	66.51
n_3p_2	40.98	47.73	53.32	59.83	66.86	72.80
n_3p_3	41.70	49.22	55.01	61.12	67.19	72.90
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	20.45	24.85	29.87	35.48	41.84	46.92
n_1k_2	22.77	27.86	34.32	38.18	43.26	48.74
n_1k_3	22.52	27.66	33.72	39.39	44.85	49.66
n_2k_1	27.84	33.71	39.20	45.96	51.84	56.81
n_2k_2	29.89	35.84	41.08	46.49	52.61	57.90
n_2k_3	31.99	36.46	42.13	48.35	54.22	60.70
n_3k_1	33.79	40.95	48.25	54.25	60.68	67.35
n_3k_2	39.46	46.47	52.57	58.48	65.63	71.11
n_3k_3	43.91	50.89	56.66	62.49	68.47	73.75
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	23.85	29.24	35.97	41.49	46.69	53.40
p_1k_2	30.91	37.19	43.78	45.83	51.33	56.93
p_1k_3	28.67	33.53	39.60	46.18	51.66	57.16
p_2k_1	28.86	33.75	39.24	45.32	52.08	56.92
p_2k_2	29.23	35.02	40.69	46.79	53.01	58.97
p_2k_3	34.13	39.93	45.20	50.28	56.16	61.43
p_3k_1	29.38	36.52	42.11	48.88	55.59	60.76
p_3k_2	31.98	37.96	43.52	50.53	56.57	61.85
p_3k_3	35.61	41.56	47.70	53.77	59.72	65.52
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS - Not significant

4.1.6. Effect of nutrients on spread of plants in North-South direction

The effect of nutrients on spread of plants in North-South direction is presented in Tables 11 and 12.

Main effect of major nutrients on spread of plant in North-South direction

The effect of N in spread of plant in North-South direction was significant throughout the period of observation. It was felt that n_3 fared over other levels *viz.*, n_1 and n_2 proving its high significance in an increasing trend recording a final plant spread of North-South direction of 82.32 cm. Similar increasing effect of significance was also followed by P application at p_3 level recording finally a maximum plant spread of 74.23cm. The effect of K was found non significant.

Interaction effect of NP, NK and PK on spread of plant in North-South direction

The interactive effects were found non significant in spread of plant in North-South direction.

4.1.7. Effect of nutrients on spread of plant in East-West direction

The effect of nutrients on the spread of plant in East-West direction is presented in Tables 13 and 14.

Table 11. Main effect of N, P, K on spread of plant in North-South direction (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1	35.17	39.65	43.67	47.33	51.71	55.63
n_2	48.46	53.38	58.80	64.41	69.48	74.85
n_3	52.73	57.97	63.67	68.49	75.89	82.32
F	61.97**	68.27**	66.64**	46.31**	77.56**	85.04**
CD	3.30	3.39	3.62	4.68	4.03	4.23
p_1	42.40	46.47	51.66	56.44	64.47	66.12
p_2	46.19	51.67	56.64	61.75	67.13	72.47
p_3	47.77	52.82	57.84	62.05	68.48	74.23
F	5.64*	7.63**	6.60**	3.66**	6.84**	8.17**
CD	3.30	3.39	3.62	4.68	4.03	4.23
k_1	44.20	48.54	53.55	58.31	63.43	68.17
k_2	45.52	50.44	55.73	61.45	66.17	71.28
k_3	46.64	51.43	56.76	60.48	67.47	73.36
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level NS Not significant

Table 12. Interaction effect of NP, PK and NK on spread of plant in North-South direction (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	30.53	33.70	38.63	41.53	46.59	50.96
n_1p_2	36.74	40.93	45.67	49.62	53.48	57.16
n_1p_3	38.25	42.52	46.72	50.84	55.05	58.78
n_2p_1	44.34	49.08	53.65	59.52	64.92	69.58
n_2p_2	48.11	52.99	59.73	65.35	70.34	76.24
n_2p_3	52.92	58.07	63.03	68.36	73.17	78.74
n_3p_1	52.31	56.63	62.69	68.27	72.89	77.30
n_3p_2	53.73	59.31	64.53	70.27	77.58	84.01
n_3p_3	52.15	57.99	63.78	66.94	77.21	85.16
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	34.01	37.63	43.13	45.27	49.72	53.62
n_1k_2	35.13	39.31	43.32	47.69	52.18	55.44
n_1k_3	36.35	40.20	44.57	49.03	53.22	57.84
n_2k_1	46.71	50.84	55.16	60.93	66.46	71.40
n_2k_2	47.84	53.32	59.03	64.67	69.47	75.48
n_2k_3	50.83	55.98	62.22	67.63	72.50	77.69
n_3k_1	51.88	57.14	62.36	68.74	74.12	79.49
n_3k_2	53.57	58.68	64.86	71.98	76.87	82.93
n_3k_3	52.74	58.11	63.79	64.76	76.69	84.55
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	40.34	44.34	49.82	53.67	58.82	63.35
p_1k_2	42.19	46.11	51.10	56.87	62.18	66.21
p_1k_3	44.66	48.95	54.05	58.77	63.40	68.78
p_2k_1	45.24	50.11	55.25	59.98	64.83	69.46
p_2k_2	46.39	51.77	57.64	62.90	67.89	73.15
p_2k_3	46.95	51.34	57.04	62.36	68.68	74.78
p_3k_1	47.03	51.15	55.58	61.29	66.64	71.69
p_3k_2	47.98	53.43	58.46	64.57	68.45	74.46
p_3k_3	48.31	54.00	59.49	60.29	70.34	76.53
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Main effect of major nutrients on spread of plant in East-West direction

As levels of N increased the spread of plant in East-West direction also showed an increasing trend. The highest level of N recorded the highest East-West spread of plant throughout the period of study (Table 13). In case of phosphorus increased level of P increased positively the East-West spread of the bush. The effect of K was non-significant.

Interaction effects of NP, NK and PK on East-West spread of plant

The interaction effect on East-West spread of plant was found non significant.

4.2. Effects of nutrients on flower yield

The effect of nutrients on flower yield is presented in Tables 15 and 16.

Main effect of major nutrients on flower yield

Yield of flowers was significantly influenced by the application of Nitrogen. The level n_1 (300 kg ha^{-1}) was found superior (5595.92 kg ha^{-1}) over other treatments *viz.*, n_2 and n_3.

There was significant difference between all three levels of P. level p_1 was superior followed by p_2 and p_3. The level p_1 (300 kg ha^{-1} recorded a maximum yield (4828.19 kg ha^{-1}).

Table 13. Main effect of N, P, K on spread of plant in East-West direction (cm)

Treatment	Months					
	2	4	6	8	10	12
n_1	33.49	37.51	41.57	45.69	50.52	54.54
n_2	45.29	50.26	55.47	61.09	66.92	72.87
n_3	49.81	56.07	61.58	69.37	76.50	84.24
F	73.66**	113.11**	75.66**	141.71**	141.36**	160.82**
CD	2.78	2.53	3.34	2.86	3.13	3.35
p_1	38.78	43.44	48.57	53.52	58.88	64.50
p_2	46.06	48.02	53.37	59.01	65.07	71.09
p_3	46.75	52.38	56.68	63.62	69.99	76.05
F	16.56**	5.12**	11.98**	25.07**	25.37**	24.05**
CD	2.78	2.53	3.34	2.86	3.13	3.35
k_1	42.07	46.77	51.74	56.77	62.07	68.31
k_2	43.26	48.72	54.35	60.17	68.06	71.02
k_3	43.26	48.34	52.33	59.21	65.81	72.32
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level NS Not significant

Table 14. Interaction effect of NP, NK and PK on spread of plant in East-West direction (cm)

Treatments	Months					
	2	4	6	8	10	12
n_1p_1	29.06	31.94	35.40	38.87	42.60	45.41
n_1p_2	34.42	38.83	43.33	47.56	52.79	56.84
n_1p_3	37.00	41.76	46.00	50.64	56.16	61.36
n_2p_1	47.82	49.00	52.02	57.15	62.72	69.08
n_2p_2	45.40	50.54	55.25	60.68	66.69	72.61
n_2p_3	47.65	53.24	59.12	65.43	71.36	76.91
n_3p_1	44.47	51.37	58.29	64.54	71.32	79.00
n_3p_2	49.37	54.69	61.53	68.79	75.73	83.83
n_3p_3	55.59	62.15	64.91	74.78	82.44	89.89
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	31.92	35.60	40.27	43.99	48.13	51.37
n_1k_2	32.80	37.08	41.80	45.66	50.65	54.36
n_1k_3	35.76	39.84	43.37	47.42	52.77	57.88
n_2k_1	45.14	49.36	53.82	58.78	63.84	71.44
n_2k_2	45.62	51.52	57.21	62.43	68.81	73.79
n_2k_3	45.11	49.90	55.36	61.05	68.12	73.37
n_3k_1	49.16	55.36	61.11	67.54	74.23	82.11
n_3k_2	51.35	57.57	64.75	71.41	78.73	84.90
n_3k_3	48.92	55.28	58.87	69.17	76.53	85.71
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
p_1k_1	39.30	43.63	48.04	52.48	57.03	62.65
p_1k_2	39.96	45.67	51.43	57.20	62.65	65.87
p_1k_3	37.08	41.02	46.23	50.89	56.96	64.98
p_2k_1	40.78	45.77	51.25	56.42	61.60	67.73
p_2k_2	43.30	48.48	53.80	59.65	66.00	72.01
p_2k_3	45.11	49.81	55.05	60.97	67.60	73.53
p_3k_1	46.14	50.93	55.91	61.42	67.56	74.54
p_3k_2	46.51	52.02	57.81	63.65	69.54	75.17
p_3k_3	47.60	54.20	56.31	65.78	72.87	78.45
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Table 15. Main effect of N, P, K on yield of flowers (kg ha^{-1})

Treatment	Yield
n_1	5595.92
n_2	4597.57
n_3	3135.17
F	52.539**
CD	483.67
p_1	4828.19
p_2	4757.34
p_3	3743.14
F	12.639**
CD	483.67
k_1	4644.76
k_2	4825.17
k_3	3858.74
F	9.057**
CD	483.67

** Significant at 1 per cent level

Plate 1. T_2 $(n_1p_1k_2)$

Plate 2. T_5 $(n_1p_2k_2)$

Plate 3. T_4 $(n_1p_2k_1)$

Plate 4. T_1 $(n_1p_1k_1)$

Table 16. Interaction effect of NP, NK and PK on yield of flowers (kg ha^{-1})

Treatments	Yield
n_1p_1	5849.86
n_1p_2	5955.62
n_1p_3	4982.29
n_2p_1	5688.91
n_2p_2	4977.11
n_2p_3	3726.70
n_3p_1	3545.79
n_3p_2	3339.27
n_3p_3	2520.44
F	NS
CD	—
n_1k_1	5792.21
n_1k_2	6597.40
n_1k_3	4398.17
n_2k_1	5066.46
n_2k_2	4713.36
n_2k_3	4612.90
n_3k_1	3075.60
n_3k_2	3164.76
n_3k_3	3165.15
F	4.208**
CD	837.74
p_1k_1	5047.44
p_1k_2	5249.65
p_1k_3	4187.47
p_2k_1	5302.41
p_2k_2	5013.10
p_2k_3	3956.49
p_3k_1	3584.42
p_3k_2	4212.76
p_3k_3	3432.26
F	NS
CD	—

** Significant at 1 per cent level NS Not significant

Potassium application also significantly influenced the yield of flowers. The highest yield (4825.17 kg ha^{-1}) was recorded at k_2 (450 kg ha^{-1}) and was superior over other treatments, following a decreasing trend from k_2, k_1 and k_3.

Interaction effects of NP, NK and PK on flower yield

In comparing the yield of flowers, interaction effect of N x P and P x K was not significant. But N x K interaction highly influenced the yield of flowers. The treatment n_1k_2 was superior to all other interactions recording a maximum flower yield of 6597.40 kg ha^{-1}.

4.2.1. Effect of nutrients on monthly yield pattern

The effect of nutrients on monthly yield pattern is presented in Tables 17 and 18.

Main effect of major nutrients on monthly yield pattern

Application of nitrogen significantly influenced the monthly yield pattern. The yield decreased with increasing levels of N. The highest yield obtained was at lowest level of N application throughout the period of study.

The yield showed an increasing trend from second to fourth month, a decreasing trend during sixth and eighth and again increased during tenth and twelveth month.

Table 17. Main effect of N, P, K on monthly yield pattern (kg ha^{-1})

Treatment	Months					
	2	4	6	8	10	12
n_1	474.15	483.96	385.11	442.60	531.32	658.85
n_2	341.99	359.28	323.25	356.31	472.40	514.80
n_3	249.59	220.49	221.11	236.20	316.17	375.16
F	29.83**	29.73**	21.84**	34.41**	31.70**	31.55**
CD	58.60	68.54	50.25	50.10	55.98	73.79
p_1	370.63	397.64	339.68	387.50	473.29	517.69
p_2	368.19	388.65	328.97	369.53	475.18	572.01
p_3	317.91	277.44	260.81	278.29	371.34	459.11
F	NS	7.67**	5.83**	10.96**	9.06**	6.60**
CD	—	68.54	50.25	50.10	55.98	73.79
k_1	377.21	405.91	326.20	364.25	452.53	546.61
k_2	368.15	376.71	336.61	369.34	461.90	589.17
k_3	320.37	281.11	266.66	301.52	405.38	473.03
F	NS	7.29**	4.54*	4.57*	NS	5.10**
CD	—	68.54	50.25	50.10	—	73.79

* Significant at 5 per cent level ** Significant at 1 per cent level NS Not significant

Table 18. Interaction effect of NP, NK and PK on monthly yield pattern of flowers ($kg\ ha^{-1}$)

Treatments	Months 2	4	6	8	10	12
n_1p_1	470.61	551.30	413.01	500.51	568.15	661.36
n_1p_2	507.60	501.72	407.70	457.86	568.40	689.14
n_1p_3	444.25	398.87	334.60	369.50	457.15	626.65
n_2p_1	397.21	396.31	358.97	404.37	494.27	635.78
n_2p_2	335.71	425.54	335.85	397.15	509.21	667.18
n_2p_3	293.05	255.99	274.93	267.40	413.71	481.43
n_3p_1	271.08	245.33	247.06	257.61	351.44	435.93
n_3p_2	261.25	238.68	243.37	253.64	347.92	419.71
n_3p_3	216.44	177.46	172.90	197.96	243.16	269.85
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
n_1k_1	496.78	563.75	398.21	459.54	534.69	675.15
n_1k_2	516.57	581.44	455.77	518.77	619.65	764.98
n_1k_3	409.10	306.69	301.33	349.50	439.36	536.42
n_2k_1	387.07	435.88	360.41	398.37	515.06	607.49
n_2k_2	340.38	333.75	331.88	363.65	466.15	619.23
n_2k_3	298.52	308.20	277.46	306.89	435.98	497.68
n_3k_1	247.78	218.09	219.96	234.83	307.83	357.18
n_3k_2	247.50	214.95	222.18	225.61	299.89	383.31
n_3k_3	253.48	228.43	221.18	248.16	340.80	385.00
F	NS	4.41**	NS	2.86**	3.18*	NS
CD	—	118.71	—	86.78	96.96	—
p_1k_1	420.46	467.01	362.49	408.78	483.37	587.92
p_1k_2	392.20	419.80	370.96	422.59	504.03	626.31
p_1k_3	326.24	306.13	285.59	330.51	432.46	518.85
p_2k_1	389.03	455.64	366.96	414.61	518.76	629.49
p_2k_2	377.33	398.50	356.96	377.07	487.23	610.65
p_2k_3	338.20	311.79	263.03	316.90	419.54	475.89
p_3k_1	322.15	295.08	249.14	269.35	355.45	422.42
p_3k_2	334.92	311.84	281.95	308.37	394.44	530.55
p_3k_3	296.07	225.40	3251.35	257.13	364.14	424.36
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level NS Not significant

Phosphorus also significantly influenced the monthly yield pattern right from fourth month onwards, continuing thereafter. The level p_1 was more effective than other treatments however during tenth and twelveth months p_2 was on par with p_1.

K application also influenced significantly the monthly yield pattern. The yield was significantly influenced from fourth month and continued thereafter except during tenth month. The level k_1 was found superior during fourth month. But during sixth, eighth, tenth and twelveth months k_2 was superior.

Interaction effect of NP, NK and PK on monthly yield pattern

N x K interaction showed maximum effect during fourth, eighth and tenth month. The combination n_1k_2 proved to be the best, and during the twelveth month, recorded a maximum monthly yield (764.98 kg ha^{-1}). N x P and P x K interactions were non significant.

4.2.2. Effect of nutrients on weight of 100 buds

The effect of nutrients on weight of 100 buds is presented in Table 19 and 20.

Main effect of major nutrients on 100 bud weight

The 100 bud weight varied significantly by application of nitrogen and phosphorus. Nitrogen at the level n_1 recorded a bud weight of 24.58g and phosphorus nutrient at p_2 was best recording a maximum bud weight of 23.19g. There was no significant influence of potassium on 100 bud weight.

Table 19. Main effect of N, P, K on 100 bud weight (g)

Treatment	100 bud weight
n_1	24.58
n_2	22.39
n_3	21.54
F	58.75**
CD	0.58
p_1	22.86
p_2	23.19
p_3	22.46
F	3.208**
CD	0.58
k_1	22.83
k_2	22.88
k_3	22.81
F	NS
CD	—

** Significant at 1 per cent level NS Not significant

Table 20. Interaction effect of NP, NK, PK on 100 bud weight

Treatments	100 bud weight
n_1p_1	24.82
n_1p_2	25.47
n_1p_3	23.46
n_2p_1	22.29
n_2p_2	22.60
n_2p_3	22.28
n_3p_1	21.47
n_3p_2	21.51
n_3p_3	21.65
F	2.772**
CD	1.005
n_1k_1	25.13
n_1k_2	24.52
n_1k_3	24.10
n_2k_1	22.21
n_2k_2	22.45
n_2k_3	22.52
n_3k_1	21.17
n_3k_2	21.66
n_3k_3	21.80
F	NS
CD	—
p_1k_1	22.63
p_1k_2	23.23
p_1k_3	22.73
p_2k_1	23.41
p_2k_2	22.90
p_2k_3	23.27
p_3k_1	22.47
p_3k_2	22.50
p_3k_3	22.42
F	NS
CD	—

** Significant at 1 per cent level NS Not significant

Interaction effect of NP, NK and PK on 100 bud weight

The effect was found to be influenced by N x P interaction, n_1p_2 produced the highest 100 bud weight (25.47 g), followed by n_1p_1 (24.82 g). Regarding P x K and N x K interaction there was no significant variation among the treatments.

4.2.3. Effect of nutrients on time taken for opening of flowers after harvest

The effect of nutrients on time taken for flower opening after harvest was analysed (Table 21 and 22)

Main effect of major nutrients on time taken for flower opening

Among the major nutrients applied phosphorus application was found to influence significantly the time taken for flower opening. The level p_3 was found superior (4.52 hrs.) followed by p_2 and p_1 whereas nitrogen and potassium application did not influence significantly the time taken for flower opening.

Interaction effect of NP, NK and PK on time taken for flower opening

The interaction effects on time taken for flower opening was found to be influenced significantly. The treatment n_3p_3 was best compared to other treatments (4.56 hours). In N x K interaction n_1k_3 and n_3k_2 were found statistically on par with each other and were best among

Table 21. Main effect of N, P, K on time taken for opening of flowers (hours)

Treatment	Time taken for opening of flowers
n_1	4.69
n_2	4.35
n_3	4.40
F	NS
CD	—
p_1	4.20
p_2	4.41
p_3	4.52
F	83.334**
CD	0.05
k_1	4.36
k_2	4.38
k_3	4.40
F	NS
CD	—

** Significant at 1 per cent level NS - Not significant

Table 22. Interaction effect of NP, NK and PK on time taken for flower opening (hours)

Treatments	Time taken for flower opening
n_1p_1	4.18
n_1p_2	4.48
n_1p_3	4.52
n_2p_1	4.23
n_2p_2	4.33
n_2p_3	4.48
n_3p_1	4.20
n_3p_2	4.43
n_3p_3	4.56
F	4.15*
CD	0.087
n_1k_1	4.44
n_1k_2	4.33
n_1k_3	4.46
n_2k_1	4.33
n_2k_2	4.33
n_2k_3	4.38
n_3k_1	4.31
n_3k_2	4.46
n_3k_3	4.43
F	4.95**
CD	0.087
p_1k_1	4.16
p_1k_2	4.19
p_1k_3	4.25
p_2k_1	4.38
p_2k_2	4.41
p_2k_3	4.46
p_3k_1	4.54
p_3k_2	4.53
p_3k_3	4.49
F	4.71*
CD	0.087

** Significant at 1 per cent level * Significant at 5 per cent level other treatments (4.46 hrs.). In P x K interaction p_3k_1 was superior recording a time of 4.54 hours followed by p_3k_2.

4.3. Effect of nutrients on content of N, P, K, Zn and Mg in leaves

The effect of major nutrients on N, P, K, Zn and Mg content in leaves is presented in Table 23 and 24.

4.3.1. Effect of nutrients on leaf nitrogen content

Main effect of major nutrients on leaf nitrogen content.

The level n_3 was found to increase the leaf nitrogen content (3.21 per cent) followed by n_2 and n_1, while in phosphorus the levels p_3 and p_1 was found superior over other treatments recording a value (2.82 per cent). K application was found to influence the leaf nitrogen content. The level k_3 was found more competent than other levels in increasing the leaf nitrogen content (2.93 per cent).

Interaction effect of NP, NK and PK on leaf nitrogen content

Interaction between N and P was found more effective with combinations n_3p_3 and n_3p_1. The treatments were statistically on par and superior over other treatments, giving a maximum leaf N content (3.25 per cent). N x K interaction was found to be superior at n_3k_3 recording a maximum nitrogen content (3.34 per cent). The combination p_3k_3 was

Table 23. Main effect of N, P, K on leaf nutrient content (per cent)

Treatment	N	P	K	Mg	Zn
n_1	2.31	0.72	5.43	0.050	0.026
n_2	2.83	0.74	5.58	0.057	0.030
n_3	3.21	0.74	5.32	0.06	0.029
F	82.38**	31.37**	23.97**	30.14**	9.81**
CD	0.033	0.005	0.073	0.025	0.019
p_1	2.82	0.70	5.46	0.060	0.027
p_2	2.70	0.74	5.48	0.057	0.029
p_3	2.82	0.77	5.39	0.050	0.029
F	35.64**	299.18**	3.93*	31.90**	3.76*
CD	0.033	0.005	0.073	0.025	0.019
k_1	2.72	0.74	4.67	0.057	0.026
k_2	2.70	0.72	5.56	0.056	0.031
k_3	2.93	0.75	6.16	0.056	0.028
F	116.46**	34.24**	20.86**	NS	14.19**
CD	0.033	0.005	0.073	—	0.019

** Significant at 1 per cent level NS - Not significant

Table 24. Interaction effect of NP, NK and PK on leaf nutrient content (per cent of nutrients)

Treatments	N	P	K	Mg	Zn
n_1p_1	2.29	0.67	5.24	0.057	0.020
n_1p_2	2.41	0.73	5.60	0.054	0.029
n_1p_3	2.23	0.77	5.45	0.04	0.029
n_2p_1	2.94	0.71	5.77	0.063	0.032
n_2p_2	2.58	0.74	5.52	0.056	0.029
n_2p_3	2.97	0.77	5.44	0.052	0.029
n_3p_1	3.25	0.72	5.38	0.06	0.028
n_3p_2	3.11	0.75	5.33	0.061	0.029
n_3p_3	3.25	0.76	5.26	0.058	0.029
F	59.19**	20.49**	14.60**	7.04**	10.19**
CD	0.057	0.009	0.128	0.043	0.033
n_1k_1	2.20	0.74	4.66	0.052	0.018
n_1k_2	2.23	0.71	5.61	0.051	0.033
n_1k_3	2.50	0.72	6.02	0.047	0.025
n_2k_1	2.84	0.74	4.75	0.057	0.029
n_2k_2	2.70	0.73	5.55	0.064	0.033
n_2k_3	2.94	0.75	6.43	0.054	0.027
n_3k_1	3.12	0.74	4.60	0.062	0.030
n_3k_2	3.16	0.73	5.33	0.055	0.026
n_3k_3	3.34	0.76	6.04	0.062	0.030
F	10.08**	9.49**	8.04**	6.05**	19.55**
CD	0.05	0.009	0.12	0.043	0.033
p_1k_1	2.82	0.71	4.60	0.057	0.020
p_1k_2	2.76	0.68	5.54	0.060	0.03
p_1k_3	2.29	0.71	6.25	0.062	0.03
p_2k_1	2.59	0.73	4.80	0.061	0.029
p_2k_2	2.63	0.72	5.63	0.059	0.031
p_2k_3	2.89	0.76	6.63	0.051	0.026
p_3k_1	2.75	0.77	4.62	0.052	0.028
p_3k_2	2.71	0.77	5.33	0.049	0.031
p_3k_3	3.00	0.77	6.21	0.050	0.027
F	10.64**	9.85**	10.19**	7.45**	8.59**
CD	0.057	0.009	0.128	0.043	0.033

** Significant at 1 per cent level

higher than other treatments recording a maximum (3.00 per cent) of nitrogen.

4.3.2. Effect of nutrients on leaf phosphorus content

Main effect of major nutrients on leaf phosphorus content

Applied N highly influenced the leaf P content. The levels n_2 and n_3 were statistically on par and proved to be significant producing a maximum P content (0.74 per cent). The highest content of P (0.77 per cent) was recorded at p_3 level. Potassium also influenced significantly the leaf P content. The level k_3 was found best resulting in 0.75 per cent content of P followed by k_1 and k_2.

Interaction effects of NP, NK and PK on leaf phosphorus content

N x P interaction was significant with leaf phosphorus content. The treatments n_2p_3 and n_1p_3 were on par and produced the maximum P content (0.77 per cent). In N x K interaction n_3k_3 was found best (0.76 per cent) compared to other treatments. In interaction between P and K the combinations p_3k_1, p_3k_2, p_3k_3 was found statistically on par with each other and confirmed their superiority of leaf P content (0.77 per cent).

4.3.3. Effect of nutrients on leaf potassium content

Main effect of major nutrients on leaf potassium content

Nitrogen application highly influenced the leaf potassium content. The highest value (5.58 per cent) was recorded at n_2 followed by n_1 and

n_3 successively. Phosphorus application influenced the leaf potassium content. the level p_2 confirmed its superiority recording a maximum P content (5.48 per cent) followed by p_1 and p_2. Among K levels tried the level k_3 was the best (6.16 per cent) followed by k_2 and k_1.

Interaction effects of NP, NK and PK on leaf K content

N x P interaction significantly influenced potassium content in leaves. It was found that the combination n_2p_1 proved to be the best recording the highest leaf K content (5.77 per cent). The treatment n_2k_3 was found to be the best one than other treatments in N x K interaction. P x K interaction influenced significantly the leaf potassium content with p_2k_3 recording a maximum K content (6.63 per cent).

4.3.4. Effect of nutrients on leaf magnesium content

Main effect of major nutrients on leaf magnesium content

Nitrogen application influenced significantly the leaf Mg content. Here the level n_3 was superior (0.06 per cent) followed by other levels such as n_2 and n_1 (Table 23). In case of phosphorus application the level p_1 proved was superior over other levels. Effect of K was found non significant

Interaction effect of NP, NK and PK on leaf Mg content

Interaction between N and P highly influenced the leaf Mg content. It was found that the level n_2p_1 was the best treatment and superior over others and recorded a maximum Mg content (0.063 per cent). N x K interaction was highly significant, the effect was more pronounced at n_2k_2 and in P x K interaction p_1k_3 recorded the maximum Mg content (0.062 per cent).

4.3.5. Effect of nutrients on leaf zinc content

Main effect of major nutrients on leaf zinc content

Nitrogen application influenced the leaf Zn content and the level n_2 proved best (0.030 per cent). Regarding phosphorus application the levels p_2 and p_3 were statistically on par and were found to be the superior treatments in influencing the leaf zinc content, recording (0.029 per cent) of zinc. Application of K too influenced the leaf Zn content and it was found that the level k_2 was superior (0.031 per cent) compared to k_1 and k_3.

Interaction effects of NP, NK, PK on leaf zinc content

N x P interaction influenced the leaf Zn content and n_2p_1 was found to be the best treatment recording (0.03 per cent). The treatment n_1k_2 and n_2k_2 were found to be superior in N x K interaction and in P x K interaction p_2k_2 and p_3k_2 were statistically on par with each other and found to be the best treatments and superior over other interactions recording a maximum Zn content (0.03 per cent)

4.4. Effect of nutrients on carbohydrate content of flowering shoot

The effect of nutrients on carbohydrate content of flowering shoot are presented in Tables 25 and 26.

Main effect of major nutrients on carbohydrate content of flowering shoot

Increased levels of nitrogen decreased the level of carbohydrate content. The level n_1 recorded the highest carbohydrate content (19.84 per cent). P and K application had no effect on the carbohydrate content of flowering shoot.

Interaction effect of NP, NK and PK on carbohydrate content of flowering shoot

The carbohydrate content was significantly influenced by N x P interaction with n_1p_1 recording a maximum carbohydrate content (21.89 per cent). N x K interaction also highly influenced the carbohydrate content, where the combination n_1k_1 was found superior (21.45 per cent), p_2k_2 treatment proved to be superior (19.82 per cent) than other treatments in P x K interaction.

4.5. Effect of nutrients on uptake of N, P, K, Zn and Mg by plants

The effect of nutrients on uptake of N, P, K, Mg and Zn is presented in Tables 27 and 28.

Table 25. Main effect of N, P, K on carbohydrate content of flowering shoot (per cent)

Treatment	Carbohydrate content of flowering shoot
n_1	19.84
n_2	17.98
n_3	17.66
F	13.37**
CD	0.912
p_1	18.96
p_2	18.63
p_3	17.90
F	NS
CD	—
k_1	18.69
k_2	18.70
k_3	18.10
F	NS
CD	—

*** Significant at 1 per cent level* NS *Not significant*

Table 26. Interaction effect of NP, NK, PK on carbohydrate content of flowering shoot (per cent)

Treatments	Carbohydrate content of flowering shoot
n_1p_1	21.89
n_1p_2	19.02
n_1p_3	18.62
n_2p_1	17.74
n_2p_2	18.62
n_2p_3	17.59
n_3p_1	17.26
n_3p_2	18.25
n_3p_3	17.48
F	4.667**
CD	1.58
n_1k_1	21.45
n_1k_2	19.66
n_1k_3	18.41
n_2k_1	17.50
n_2k_2	18.37
n_2k_3	18.08
n_3k_1	17.12
n_3k_2	18.07
n_3k_3	17.80
F	3.864**
CD	1.58
p_1k_1	19.21
p_1k_2	19.19
p_1k_3	18.48
p_2k_1	17.96
p_2k_2	19.82
p_2k_3	18.10
p_3k_1	18.90
p_3k_2	17.08
p_3k_3	17.71
F	2.805**
CD	1.58

** Significant at 1 per cent level

4.5.1. Effect of nutrients on uptake of nitrogen

Main effect of major nutrients on uptake of nitrogen

Application of nitrogen was found to have a significant influence on uptake of nitrogen the highest uptake being at n_3 level followed by n_2 and n_1. Influence of applied P was also found significant in the uptake of N with the level p_3 recording the maximum uptake of nutrient nitrogen (6.90 kg ha^{-1}) followed by p_2. The uptake of nitrogen was found effective with level k_3 (6.45 kg ha^{-1}) recording the highest uptake.

Interaction effect of NP, NK and PK on uptake of nitrogen

Uptake of nitrogen was found to be significantly influenced by N x P interaction at n_3p_3 (10.36 kg ha^{-1}). N x K interaction was found to be effective at n_3k_3 (9.19 kg ha^{-1}). P x K interaction was also significant with p_3k_2 recording 7.04 kg ha^{-1} of uptake of nitrogen.

4.5.2. Effect of nutrients on uptake of phosphorus

Main effect of major nutrients on uptake of phosphorus

Applied N was found significant in increasing the uptake of phosphorus. The level n_3 recorded the highest uptake (5.10 kg ha^{-1}) followed by n_1 and n_2. Applied P proved to have significant effect on uptake of phosphorus. The level p_3 proved to be superior over other levels *viz.*, p_2 and p_1 respectively. Influence of K at k_3 level was best (4.57 kg ha^{-1}).

Table 27. Main effect of N, P, K on uptake of plant nutrients (kg ha^{-1})

Treatment	N	P	K	Mg	Zn
n_1	3.96	4.07	6.94	0.067	0.039
n_2	5.95	4.00	7.27	0.07	0.043
n_3	8.67	5.10	8.02	0.074	0.043
F	33.99**	49.22**	271.81**	60.75**	16.67**
CD	0.266	0.111	0.095	0.013	0.018
p_1	5.36	3.67	7.36	0.072	0.039
p_2	6.38	4.36	7.44	0.071	0.041
p_3	6.90	5.14	7.43	0.068	0.045
F	76.13**	53.72	NS	23.711**	26.86*
CD	0.265	0.110	–	0.013	0.0183
k_1	5.93	4.17	6.95	0.072	0.042
k_2	6.20	4.43	7.88	0.068	0.042
k_3	6.45	4.57	7.40	0.072	0.041
F	7.93**	27.74**	194.720**	34.91**	NS
CD	0.266	0.111	0.095	0.013	—

** Significant at 1 per cent level * Significant at 5 per cent level NS - Not significant

Table 28. Interaction effect of NP, NK and PK on uptake of plant nutrients (kg ha^{-1})

Treatments	N	P	K	Mg	Zn
n_1p_1	3.90	2.84	6.78	0.063	0.034
n_1p_2	4.14	4.02	6.88	0.068	0.040
n_1p_3	3.84	5.34	7.15	0.069	0.043
n_2p_1	4.83	3.75	8.53	0.077	0.043
n_2p_2	6.52	3.96	6.07	0.069	0.039
n_2p_3	6.51	4.30	7.20	0.065	0.047
n_3p_1	7.16	4.42	6.77	0.076	0.040
n_3p_2	8.48	5.11	9.35	0.075	0.043
n_3p_3	10.36	5.77	7.94	0.070	0.046
F	29.14**	52.46**	72.95**	39.42**	5.98**
CD	0.460	0.191	0.165	0.022	0.031
n_1k_1	3.93	3.69	6.01	0.061	0.035
n_1k_2	4.07	4.14	8.15	0.67	0.041
n_1k_3	3.88	4.38	6.65	0.069	0.040
n_2k_1	5.72	3.99	7.42	0.073	0.044
n_2k_2	5.83	4.12	7.76	0.068	0.042
n_2k_3	6.30	3.89	6.64	0.07	0.043
n_3k_1	8.13	4.83	7.42	0.082	0.046
n_3k_2	8.69	5.03	7.75	0.064	0.043
n_3k_3	9.19	5.45	8.90	0.076	0.039
F	3.35*	1.97**	77.74**	71.81**	8.77**
CD	0.460	0.191	0.165	0.022	0.031
p_1k_1	4.69	3.70	7.11	0.072	0.040
p_1k_2	5.38	3.68	7.84	0.069	0.038
p_1k_3	5.81	3.63.	7.13	0.075	0.038
p_2k_1	6.34	3.79	7.09	0.074	0.042
p_2k_2	6.17	4.47	7.78	0.065	0.041
p_2k_3	6.63	4.83	7.44	0.073	0.039
p_3k_1	6.74	5.02	6.64	0.069	0.044
p_3k_2	7.04	5.14	8.03	0.067	0.047
p_3k_3	6.92	5.26	7.63	0.067	0.045
F	3.51*	18.00**	21.28**	10.91**	NS
CD	0.460	0.191	0.165	0.022	—

** Significant at 1 per cent level * Significant at 5 per cent level NS Not significant

Interaction effect of NP, NK and PK on uptake of P

Regarding interaction effect of N x P the combination n_3p_3 recorded the highest value (5.77 kg ha^{-1}). N x K interaction was found significant with n_3k_3 recording the highest uptake of P (5.45 kg ha^{-1}) and interaction of P x K was found significant with p_3k_3 recording the highest uptake of P (5.26 kg ha^{-1}).

4.5.3. Effect of nutrients on uptake of potassium

Main effect on uptake of K

Uptake of potassium was found to be significantly influenced by application of nitrogen. Maximum uptake was seen at n_3 level. Applied P was found non significant in influencing uptake of K. Application of K was also found to influence its uptake significantly. Level k_2 was found superior (7.88 kg ha^{-1}) compared to k_3 and k_1.

Interaction effect of NP, NK and PK on uptake of K

N x P interaction was significant with maximum uptake of K (9.35 kg ha^{-1}) at n_3p_2. Among N x K interaction n_3k_3 proved best in effecting highest uptake (8.9 kg ha^{-1}). P x K interaction was also seen highly significant with p_3k_2 recording 8.03 kg ha^{-1}.

4.5.4. Effect of nutrients on uptake of magnesium

Main effect of major nutrients on uptake of Magnesium

Application of nitrogen influenced significantly the uptake of Mg by plants. The level n_3 was best (0.074 kg ha^{-1}) among other treatments and in phosphorus application the level p_1 proved superior. Influence of applied K on uptake of Mg also significant with levels k_1 and k_3 rercording (0.072 kg ha^{-1}) which were on par with each other.

Interaction effect of NP, NK and PK on uptake of Mg

NP interaction was found significant and n_2p_1 was superior over all other treatments. NK interaction was highly significant and treatment n_3k_1 (0.082 kg ha^{-1}) gave the highest value. Interaction of P and K was also found significant at P_1K_3 recording the highest value.

4.5.5. Effect of nutrients on uptake of zinc

Main effect of major nutrients on uptake of zinc

Uptake of zinc was influenced significantly by application of nitrogen. The levels n_3 and n_2 were on par and superior to level n_1 recording a maximum uptake of 0.043 kg ha^{-1}. The applied P significantly influenced the uptake of zinc. However a reducing trend was noted from p_3 to p_1. Potassium application was found non significant in the uptake of zinc.

Interaction effect of NP, NK and PK on uptake of zinc

Interaction of N x P, N x K and P x K significantly influenced the uptake of zinc by bush jasmine. In N x P interaction, n_2p_3 was found highest

(0.047 kg ha^{-1}) and N x K interaction was influenced with n_3k_1 recording the maximum Zn uptake. Interaction of P and K was found non significant in the uptake of zinc.

5.0 Effect of nutrients on essential oil content of flowers

The effect of nutrients on essential oil content of flowers are presented in Table 29 and 30.

Main effect of major nutrients on essential oil content of flowers

Nitrogen application has increased the essential oil content of flowers. The level n_1 and n_3 were found superior (0.29 per cent) than n_2. There was no significant influence of P and K levels in essential oil content of flowers.

Interaction effect of NP, NK and PK on essential oil content of flowers

There was no significant difference with N x P and P x K interaction. But N x K interaction has significantly influenced the essential oil content of flowers. The combinations n_1k_2, n_1k_3, n_2k_1, n_3k_1, n_3k_2, n_3k_3 were found to be on par (0.29 per cent) and best treatments comparing others in influencing the essential oil content of flowers.

6.0 Effect of nutrients on available soil nitrogen

The effect of nutrients on available soil N, P, K is presented in Table 31 and 32.

Table 29. Main effect of N, P, K on essential oil content (per cent)

Treatment	Essential oil content
n_1	0.29
n_2	0.28
n_3	0.29
F	8.833**
CD	0.003
p_1	0.29
p_2	0.29
p_3	0.28
F	NS
CD	—
k_1	0.29
k_2	0.28
k_3	0.29
F	NS
CD	—

** Significant at 1 per cent level

Table 30. Interaction effect of NP, NK and PK on essential oil content (per cent)

Treatments	Essential oil content
n_1p_1	0.29
n_1p_2	0.29
n_1p_3	0.28
n_2p_1	0.28
n_2p_2	0.28
n_2p_3	0.29
n_3p_1	0.29
n_3p_2	0.28
n_3p_3	0.29
F	NS
CD	—
n_1k_1	0.28
n_1k_2	0.29
n_1k_3	0.29
n_2k_1	0.29
n_2k_2	0.28
n_2k_3	0.28
n_3k_1	0.29
n_3k_2	0.29
n_3k_3	0.29
F	3.240**
CD	0.005
p_1k_1	0.29
p_1k_2	0.29
p_1k_3	0.29
p_2k_1	0.29
p_2k_2	0.29
p_2k_3	0.28
p_3k_1	0.29
p_3k_2	0.28
p_3k_3	0.28
F	NS
CD	—

** Significant at 1 per cent level NS Not significant

Table 31. Main effect of N, P, K on available soil (kg ha^{-1}) nutrients

Treatment	N	P	K
n_1	192.51	560.62	568.66
n_2	263.96	531.23	569.83
n_3	332.56	620.44	630.28
F	679.93**	104.36**	9.87**
CD	3.83	12.60	31.76
p_1	241.95	443.84	581.46
p_2	257.43	598.74	553.90
p_3	589.64	669.71	633.42
F	323.48**	673.59**	12.96**
CD	3.83	12.60	31.76
k_1	246.41	551.57	505.52
k_2	264.69	579.38	631.16
k_3	277.92	581.34	632.10
F	136.79**	14.00**	42.15**
CD	3.83	12.60	31.76

** Significant at 1 per cent level

Table 32. Interaction effect of NP, NK and PK on available soil nutrients (kg ha^{-1})

Treatments	N	P	K
n_1p_1	151.34	428.21	560.41
n_1p_2	205.38	577.53	502.92
n_1p_3	220.81	676.11	642.66
n_2p_1	258.12	427.13	523.84
n_2p_2	239.71	572.56	632.80
n_2p_3	294.04	593.99	552.85
n_3p_1	316.40	476.17	660.12
n_3p_2	327.20	646.11	525.97
n_3p_3	354.08	739.04	704.76
F	63.29**	13.15**	55.02**
CD	6.63	4.84	5.75
n_1k_1	171.36	569.21	432.26
n_1k_2	191.96	566.34	615.37
n_1k_3	214.21	546.30	658.36
n_2k_1	245.70	518.00	464.84
n_2k_2	284.08	549.04	593.10
n_2k_3	262.09	526.63	651.55
n_3k_1	322.17	567.50	619.44
n_3k_2	318.04	622.75	685.02
n_3k_3	357.45	671.08	586.39
F	49.93**	19.07**	59.34**
CD	6.63	4.83	5.75
p_1k_1	237.08	391.51	489.09
p_1k_2	239.18	466.93	636.46
p_1k_3	249.58	473.07	618.02
p_2k_1	214.99	582.48	475.38
p_2k_2	276.45	557.04	605.19
p_2k_3	280.84	656.69	581.12
p_3k_1	287.16	680.71	552.07
p_3k_2	278.45	714.17	651.84
p_3k_3	303.32	614.26	696.36
F	73.65**	54.67**	NS
CD	6.63	4.83	—

** Significant at 1 per cent level NS Non significant

Available nitrogen was significantly influenced by nitrogen application. It was found that the level n_3 recorded the maximum available soil N of 332.56 kg ha^{-1} in soil, followed by n_2 and n_1. Applied P was also found significant. The level P_3 recorded the highest (589.64 ha^{-1}) available soil nitrogen. Similarly application of K was found significant with k_3 recording a maximum of 277.92 kg ha^{-1} of soil nitrogen.

Interaction effect of NP, NK and PK on available soil N

Interaction effect of N x P, N x K and P x K highly influenced available soil N. N x P interaction was found superior with n_3p_3 recording (354.08 kg ha^{-1}) and in N x K interaction with n_3k_3 recording a value (357.45 kg ha^{-1}) and P x K interaction with p_3k_3 recording a maximum of 303.32 kg ha^{-1}.

6.1. Effect of nutrients on available soil phosphorus

Main effect of major nutrients on available soil P

Application of nutrients significantly influenced the available P content in soil. In case of nitrogen application the level n_3 contained highest soil P (620.44 kg ha^{-1}). Highest available P being recorded with P_3 and in K, the level k_3 recorded the highest soil phosphorus content (581.34 kg ha^{-1}).

Interaction effect of NP, NK and PK on available soil P

N x P interaction was significant with n_3p_3 recording the highest value (739.04 kg ha^{-1}). Among N x K interaction the treatment n_3k_3 proved to be highly significant and in PK interaction the treatment p_3k_2 was highly significant providing the maximum available soil P of 714.17 kg ha^{-1}.

6.1.2. Effect of nutrients on available soil potassium

Main effect of major nutrients on available soil K

Application of potassium highly influenced the available soil potassium. It was found that the level n_3 was found superior (630.28 kg ha^{-1}) over other levels. Applied P was found to influence the available K content in soil. The level p_3 proved superior (633.42 kg ha^{-1}) over other treatments. Application of K was found to influence the available soil potassium. Level k_3 recorded the highest value (632.10 kg ha^{-1}).

Interaction effect of NP, NK and PK on available soil K

Available soil potassium was influenced much by N x P and N x K interaction. N x P interaction was superior with n_3p_3. N x K interaction the maximum available soil K of 685.02 kg ha^{-1} was recorded at n_3k_2. There was no significant variation with P x K interaction on available soil K.

Experiment II - Post harvest studies in bush jasmine

7.0. Effect of nutrients on shelf life of flowers under different post harvest treatments

7.1. Treatment $V_0E_0S_0$ (without newspaper lining, no ethylene absorbants and at room temperature)

Main effect of major nutrients on shelf life

The effect of nutrients on shelf life are presented in Table 33.

In this treatment nitrogen application was found to have good influence on time taken for flower opening. Flowers collected from plants receiving 300 kg N and 200 kg K_2O ha^{-1} took maximum time for opening (5.48 and 5.43 hours). Phosphorus also influenced the time taken for flower opening. Flowers from plants receiving 600 kg P_2O_5 ha^{-1} took a maximum time of 5.42 hours for flower opening.

The influence of N was highly significant for time taken for colour fading. The level n_1 was superior which took a maximum of 9.51 hours for colour to fade. In phosphorus application the colour retention was maximum at p_3 level (10.46 hours). When potassium was applied, k_1 was found to be the best recording a maximum time of 9.46 hours as far as colour retention is concerned.

Time taken for loss of turgidity was found significant. Loss of turgidity was retained maximum (28.17 hours) at n_1 and k_1 levels when nitrogen and potassium was applied. Phosphorus at p_3 level took a maximum of 28.17 hours to retain turgidity.

Table 33. Main effect of N, P, K on shelf life of flowers ($V_0E_0S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1	5.48	9.51	28.17
n_2	5.34	9.38	28.00
n_3	5.32	9.38	28.00
F	62.39**	25.90**	28.00**
CD	0.01	0.01	0.03
p_1	5.33	9.43	28.00
p_2	5.38	9.38	28.00
p_3	5.42	10.46	28.17
F	41.26**	87.24**	38.20**
CD	0.01	0.01	0.03
k_1	5.43	9.46	28.17
k_2	5.38	9.43	28.00
k_3	5.33	9.38	28.00
F	95.75**	87.24**	38.20**
CD	0.01	0.01	0.03

** Significant at 1 per cent level

Interaction effect of NP, PK and NK on shelf life

The interaction effects were found significant for delaying the time taken for flower opening (Table 34). In NxP interaction the treatment combination n_1p_3 was best (5.64 hours). In NxK interaction n_1k_1 was superior (5.59 hours) and in PxK interaction p_3k_2 was best (5.49 hours)

Time taken for colour fading was found significant by NxP interaction. The combination n_1p_1 was best (9.53 hours) favouring maximum colour retention. A maximum of 9.62 hours was taken by n_1k_1 in NxK interaction followed by n_2k_3 which recorded 9.58 hours. In PxK interaction p_1k_2 was superior (9.54 hours), compared to other treatments in retaining the colour.

Combination of n_1p_3, n_1k_1 and p_3k_1 were found to be on par with each other and significantly superior to other treatments in retaining the turgidity (28.51 hours)

7.2. Treatment $V_0E_0S_1$ (without newspaper lining, no ethylene absorbants and at 0°C)

Main effect of major nutrients on shelf life

The effect of major nutrients on the time taken for flower opening, colour fading and loss of turgidity was found non-significant in this treatment (Table 35).

Table 34. Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_0S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	5.33	9.53	28.00
n_1p_2	5.46	9.38	28.00
n_1p_3	5.64	9.38	28.51
n_2p_1	5.34	9.38	28.00
n_2p_2	5.37	9.38	28.00
n_2p_3	5.32	9.38	28.00
n_3p_1	5.32	9.38	28.00
n_3p_2	5.32	9.38	28.00
n_3p_3	5.31	9.38	28.00
F	67.18**	65.14**	91.24**
CD	0.01	0.01	0.05
n_1k_1	5.59	9.62	28.51
n_1k_2	5.51	9.54	28.00
n_1k_3	5.34	9.38	28.00
n_2k_1	5.37	9.38	28.00
n_2k_2	5.34	9.38	28.00
n_2k_3	5.32	9.58	28.00
n_3k_1	5.32	9.38	28.00
n_3k_2	5.31	9.38	28.00
n_3k_3	5.32	9.38	28.00
F	84.38**	54.10**	91.24**
CD	0.01	0.01	0.05
p_1k_1	5.33	9.37	28.00
p_1k_2	5.34	9.54	28.00
p_1k_3	5.32	9.38	28.00
p_2k_1	5.48	9.38	28.00
p_2k_2	5.33	9.38	28.00
p_2k_3	5.34	9.38	28.00
p_3k_1	5.46	9.63	28.51
p_3k_2	5.49	9.38	28.00
p_3k_3	5.32	9.38	28.00
F	61.63**	40.76**	91.24**
CD	0.01	0.01	0.05

** Significant at 1 per cent level

Table 35. Main effect of N, P, K on shelf life of flowers ($V_0E_0S_1$) hours

Treatments	Time taken for colour fading	Time taken for loss of turgidity
n_1	516.00	586.80
n_2	516.00	586.80
n_3	516.00	586.80
F	NS	NS
CD	—	—
p_1	516.00	586.80
p_2	516.00	586.80
p_3	516.00	586.80
F	NS	NS
CD	—	—
k_1	516.00	586.80
k_2	516.00	586.80
k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Interaction effect of NP, NK and PK on shelf life

The interaction effects on shelf life was found non significant (Table 36).

7.3. Treatment $V_0E_1S_0$ (without newspaper lining, with ethylene absorbants and at room temperature)

Main effect of major nutrients on shelf life

Nitrogen and phosphorus application significantly influenced the time taken for flower opening. The level n_2 took a longer time (6.96 hours). Phosphours at p_3 level recorded (6.87 hours) for flower opening. K application was found to have no significant effect on time taken for flower opening (Table 37).

Application of nitrogen and phosphorus influenced the time taken for colour fading. The level n_2 was considered as the best recording a time of 78.63 hours for retention of colour. Increased level of P applied (p_3) delayed the time taken for colour fading (78.67 hours). K application was found to have no effect on time taken for colour fading.

Time taken for loss of turgidity was much influenced by major nutrient application. Nitrogen applied was more effective at n_2 level and phosphorus applied prolonged the time at p_3 level both recording a time of 126.88 hours. K application was highly significant at levels k_1 and k_2 which were statistically on par with each other (126.87 hours).

Table 36. Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_0S_1$) hours

Treatments	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	516.00	586.80
n_1p_2	516.00	586.80
n_1p_3	516.00	586.80
n_2p_1	516.00	586.80
n_2p_2	516.00	586.80
n_2p_3	516.00	586.80
n_3p_1	516.00	586.80
n_3p_2	516.00	586.80
n_3p_3	516.00	586.80
F	NS	NS
CD	—	—
n_1k_1	516.00	586.80
n_1k_2	516.00	586.80
n_1k_3	516.00	586.80
n_2k_1	516.00	586.80
n_2k_2	516.00	586.80
n_2k_3	516.00	586.80
n_3k_1	516.00	586.80
n_3k_2	516.00	586.80
n_3k_3	516.00	586.80
F	NS	NS
CD	—	—
p_1k_1	516.00	586.80
p_1k_2	516.00	586.80
p_1k_3	516.00	586.80
p_2k_1	516.00	586.80
p_2k_2	516.00	586.80
p_2k_3	516.00	586.80
p_3k_1	516.00	586.80
p_3k_2	516.00	586.80
p_3k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Table 37. Main effect of N, P, K on shelf life of flowers ($V_0E_1S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1	6.38	78.58	126.85
n_2	6.96	78.63	126.88
n_3	6.62	78.48	126.85
F	23.12*	31.84*	59.87*
CD	0.12	0.05	0.04
p_1	6.65	78.48	126.85
p_2	6.63	78.53	126.85
p_3	6.87	78.67	126.88
F	8.95*	45.49*	89.81*
CD	0.12	0.05	0.04
k_1	6.72	78.56	126.85
k_2	6.72	78.56	126.87
k_3	6.72	78.56	126.87
F	NS	NS	44.90*
CD	—	—	0.04

NS - Not significant   * Significant at 5 % per cent level

Interaction effects of NP, NK and PK on shelf life

The interaction effects of NxP, NxK and PxK were highly significant for delaying flower opening (Table 38). The treatment combinations n_2p_1, n_2k_1 and p_3k_2 were found superior which took longer time (7.05, 7.65, 7.02 hours) for flower opening.

Interaction between N and P was found beneficial for retention of colour. The treatment combinations n_1p_3 and n_2p_3 were on par with each other and superior to other treatments recording a time period of 78.77 hours. NxK interaction prolonged the time to the maximum (78.77 hours) with n_1k_3. There was no significant variation with PxK interaction on time taken for colour fading.

The effect of NxP, NxK and PxK interactions on time taken for loss of turgidity was found to be non significant.

7.4. Treatment $V_0E_1S_1$ (without newspaper lining, with ethylene absorbants and at 0^oC)

Main effect of major nutrients on shelf life

In this treatment application of major nutrients did not influence the time taken for flower opening, time taken for loss of turgidity and time taken for colour fading (Table 39). However, in case of time taken for retention of colour all treatments except control II were on par with each other and significantly differed from control II which recorded 500.01 hours (Appendix 22).

Table 38. Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_1S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	6.38	78.48	126.85
n_1p_2	6.38	78.48	126.85
n_1p_3	6.98	78.77	126.85
n_2p_1	7.05	78.48	126.85
n_2p_2	6.95	78.63	126.85
n_2p_3	6.87	78.77	126.85
n_3p_1	6.53	78.48	126.85
n_3p_2	6.57	78.48	126.85
n_3p_3	6.75	78.48	126.85
F	7.99**	9.10**	NS
CD	0.21	0.08	—
n_1k_1	6.38	78.58	126.85
n_1k_2	6.68	78.58	126.85
n_1k_3	6.68	78.77	126.85
n_2k_1	7.65	78.63	126.85
n_2k_2	6.91	78.63	126.85
n_2k_3	6.92	78.48	126.85
n_3k_1	6.72	78.48	126.85
n_3k_2	6.57	78.48	126.85
n_3k_3	6.57	78.48	126.85
F	3.85**	18.20**	NS
CD	0.21	0.05	—
p_1k_1	6.52	78.48	126.85
p_1k_2	6.57	78.48	126.85
p_1k_3	6.57	78.48	126.85
p_2k_1	6.57	78.53	126.85
p_2k_2	6.57	78.53	126.85
p_2k_3	6.76	78.53	126.85
p_3k_1	6.75	78.67	126.85
p_3k_2	7.02	78.67	126.85
p_3k_3	6.83	78.67	126.85
F	4.44**	NS	NS
CD	0.21	—	—

** Significant at 1 per cent level

Table 39. Main effect of N, P, K on shelf life of flowers ($V_0E_1S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1	516.00	586.80
n_2	516.00	586.80
n_3	516.00	586.80
F	NS	NS
CD	—	—
p_1	516.00	586.80
p_2	516.00	586.80
p_3	516.00	586.80
F	NS	NS
CD	—	—
k_1	516.00	586.80
k_2	516.00	586.80
k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Interaction effect of NP, NK and PK on shelf life

The interaction effects of nutrients on time taken for flower opening, colour fading, loss of turgidity was found non significant (Table 40).

7.5. Treatment $V_1E_0S_0$ (with newspaper lining, no ethylene absorbants and at room temperature)

Main effect of major nutrients on shelf life

There was no significant influence between the treatments (Table 41).

Interaction effect of NP, NK and PK on shelf life

The interaction effect of nutrients on shelf life was found non significant (Table 42).

7.6. Treatment $V_1E_1S_1$ (with newspaper lining, with ethylene absorbants and at 0^oC)

Main effect of major nutrients on shelf life

No significant difference was found between the treatments (Table 43).

Interaction effect of NP, NK and PK on shelf life

Interaction effects were found non significant (Table 44).

Table 40. Interaction effect of NP, NK and PK on shelf life of flowers ($V_0E_1S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	516.00	586.80
n_1p_2	516.00	586.80
n_1p_3	516.00	586.80
n_2p_1	516.00	586.80
n_2p_2	516.00	586.80
n_2p_3	516.00	586.80
n_3p_1	516.00	586.80
n_3p_2	516.00	586.80
n_3p_3	516.00	586.80
F	NS	NS
CD	—	—
n_1k_1	516.00	586.80
n_1k_2	516.00	586.80
n_1k_3	516.00	586.80
n_2k_1	516.00	586.80
n_2k_2	516.00	586.80
n_2k_3	516.00	586.80
n_3k_1	516.00	586.80
n_3k_2	516.00	586.80
n_3k_3	516.00	586.80
F	NS	NS
CD	—	—
p_1k_1	516.00	586.80
p_1k_2	516.00	586.80
p_1k_3	516.00	586.80
p_2k_1	516.00	586.80
p_2k_2	516.00	586.80
p_2k_3	516.00	586.80
p_3k_1	516.00	586.80
p_3k_2	516.00	586.80
p_3k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Table 41. Main effect of N, P, K on shelf life of flowers ($V_1E_0S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1	5.86	31.48	67.13
n_2	5.86	31.48	67.13
n_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—
p_1	5.86	31.48	67.13
p_2	5.86	31.48	67.13
p_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—
k_1	5.86	31.48	67.13
k_2	5.86	31.48	67.13
k_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—

NS - Not significant

Table 42. Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_0S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	5.86	31.48	67.13
n_1p_2	5.86	31.48	67.13
n_1p_3	5.86	31.48	67.13
n_2p_1	5.86	31.48	67.13
n_2p_2	5.86	31.48	67.13
n_2p_3	5.86	31.48	67.13
n_3p_1	5.86	31.48	67.13
n_3p_2	5.86	31.48	67.13
n_3p_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—
n_1k_1	5.86	31.48	67.13
n_1k_2	5.86	31.48	67.13
n_1k_3	5.86	31.48	67.13
n_2k_1	5.86	31.48	67.13
n_2k_2	5.86	31.48	67.13
n_2k_3	5.86	31.48	65.50
n_3k_1	5.86	31.48	67.13
n_3k_2	5.86	31.48	67.13
n_3k_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—
p_1k_1	5.86	31.48	67.13
p_1k_2	5.86	31.48	67.13
p_1k_3	5.86	31.48	67.13
p_2k_1	5.86	31.48	67.13
p_2k_2	5.86	31.48	67.13
p_2k_3	5.86	31.48	67.13
p_3k_1	5.86	31.48	67.13
p_3k_2	5.86	31.48	67.13
p_3k_3	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—

NS - Not significant

Table 43. Main effect of N, P, K on shelf life of flowers ($V_1E_1S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1	516.00	586.80
n_2	516.00	586.80
n_3	516.00	586.80
F	NS	NS
CD	—	—
p_1	516.00	586.80
p_2	516.00	586.80
p_3	516.00	586.80
F	NS	NS
CD	—	—
k_1	516.00	586.80
k_2	516.00	586.80
k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Table 44. Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_1S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	516.00	586.80
n_1p_2	516.00	586.80
n_1p_3	516.00	586.80
n_2p_1	516.00	586.80
n_2p_2	516.00	586.80
n_2p_3	516.00	586.80
n_3p_1	516.00	586.80
n_3p_2	516.00	586.80
n_3p_3	516.00	586.00
F	NS	NS
CD	—	—
n_1k_1	516.00	586.80
n_1k_2	516.00	586.80
n_1k_3	516.00	586.80
n_2k_1	516.00	586.80
n_2k_2	516.00	586.80
n_2k_3	516.00	586.80
n_3k_1	516.00	586.80
n_3k_2	516.00	586.80
n_3k_3	516.00	586.80
F	NS	NS
CD	—	—
p_1k_1	516.00	586.80
p_1k_2	516.00	586.80
p_1k_3	516.00	586.80
p_2k_1	516.00	586.80
p_2k_2	516.00	586.80
p_2k_3	516.00	586.80
p_3k_1	516.00	586.80
p_3k_2	516.00	586.80
p_3k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not signficant

7.7. Treatment $V_1E_0S_1$ (with newspaper lining, without ethylene absorbants and at 0°C)

Main effect of major nutrients on shelf life

The main effect of major nutrients on time taken for flower opening, colour fading and loss of turgidity was found non significant (Table 45).

Interaction effect of NP, NK and PK on shelf life

This was found non significant (Table 46).

7.8. Treatment $V_1E_1S_0$ (with newspaper lining, with ethylene absorbants and at room temperature)

Main effect of major nutrients on shelf life

The time taken for flower opening was found to be influenced significantly by nitrogen application (Table 47). It was found that level n_2 was found superior and delayed the time taken for flower opening (7.27 hours). Phosphours application was found effective in time taken for flower opening. The level p_3 fared over other levels viz., p_1 and p_2, recording a maximum time of 7.26 hours. When K was applied, the level k_3 took a longer time (7.25 hours) for the flower buds to open.

Major nutrients applied proved significant in time taken for colour fading. The levels n_2 and p_3 took 78.63, 78.67 hours, to colour fade which was found to be effective levels compared to other treatments. But the effect of k was found non significant.

Table 45. Main effect of N,P,K on shelf life of flowers ($V_1E_0S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1	516.00	586.80
n_2	516.00	586.80
n_3	516.00	586.80
F	NS	NS
CD	—	—
p_1	516.00	586.80
p_2	516.00	586.80
p_3	516.00	586.80
F	NS	NS
CD	—	—
k_1	516.00	586.80
k_2	516.00	586.80
k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Table 46. Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_0S_1$) hours

Treatment	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	516.00	586.80
n_1p_2	516.00	586.80
n_1p_3	516.00	586.80
n_2p_1	516.00	586.80
n_2p_2	516.00	586.80
n_2p_3	516.00	586.80
n_3p_1	516.00	586.80
n_3p_2	516.00	586.80
n_3p_3	516.00	586.80
F	NS	NS
CD	—	—
n_1k_1	516.00	586.80
n_1k_2	516.00	586.80
n_1k_3	516.00	586.80
n_2k_1	516.00	586.80
n_2k_2	516.00	586.80
n_2k_3	516.00	586.80
n_3k_1	516.00	586.80
n_3k_2	516.00	586.80
n_3k_3	516.00	586.80
F	NS	NS
CD	—	—
p_1k_1	516.00	586.80
p_1k_2	516.00	586.80
p_1k_3	516.00	586.80
p_2k_1	516.00	586.80
p_2k_2	516.00	586.80
p_2k_3	516.00	586.80
p_3k_1	516.00	586.80
p_3k_2	516.00	586.80
p_3k_3	516.00	586.80
F	NS	NS
CD	—	—

NS - Not significant

Table 47. Main effect of NPK on shelf life of flowers ($V_1E_tS_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1	7.20	78.58	125.27
n_2	7.27	78.63	125.27
n_3	7.25	78.48	125.27
F	23.56**	31.84*	NS
CD	0.01	0.05	—
p_1	7.23	78.48	125.27
p_2	7.22	78.53	125.27
p_3	7.26	78.67	125.27
F	67.22	45.49*	NS
CD	0.01	0.05	—
k_1	7.24	78.56	125.27
k_2	7.24	78.56	125.27
k_3	7.25	78.56	125.27
F	64.44**	NS	NS
CD	0.01	—	—

* Significant at 5 per cent level
** Significant at 1 per cent level
NS - Not significant

Time taken for loss of turgidity was found non significant with the application of major nutrients.

Interaction effect of NP, NK and PK on shelf life

The interaction effects were found highly significant in influencing the time taken for flower opening (Table 48). In NxP interaction the treatments n_2p_3 was more effective in increasing the time taken for flower opening by 7.27 hours.

NxK interaction was more pronounced at n_2k_1 recording the maximum time (7.28 hours). In PxK interaction, treatment p_3k_3 recorded a longer time (7.28 hours) for flower opening.

Time taken for colour fading was influenced by NxP and NxK interaction. Interaction between N and P, was more effective at n_1p_3 and n_2p_3 which were on par with each other. The time recorded was 78.77 hours. In NxK interaction n_1k_3 was best (78.77 hours) in influencing the time taken for colour fading. PxK interaction was found non significant for colour fading.

The interactive effects on time taken for loss of turgidity was found non significant.

8.0. Effect of post harvest treatments on shelf life of flowers

The shelf life of flowers as influenced by different post harvest treatments were analysed and the data are presented in Table 49.

Table 48. Interaction effect of NP, NK and PK on shelf life of flowers ($V_1E_1S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
n_1p_1	7.18	78.48	125.27
n_1p_2	7.17	78.48	125.27
n_1p_3	7.24	78.77	125.27
n_2p_1	7.27	78.48	125.27
n_2p_2	7.25	78.67	125.27
n_2p_3	7.30	78.77	125.27
n_3p_1	7.25	78.48	125.27
n_3p_2	7.25	78.48	125.27
n_3p_3	7.25	78.48	125.27
F	18.89**	9.10**	NS
CD	0.01	0.08	—
n_1k_1	7.18	78.58	125.27
n_1k_2	7.19	78.58	125.27
n_1k_3	7.23	78.77	125.27
n_2k_1	7.28	78.63	125.27
n_2k_2	7.27	78.63	125.27
n_2k_3	7.27	78.48	125.27
n_3k_1	7.25	78.48	125.27
n_3k_2	7.25	78.48	125.27
n_3k_3	7.25	78.48	125.27
F	18.22**	18.20**	NS
CD	0.01	0.05	—
p_1k_1	7.23	78.48	125.27
p_1k_2	7.22	78.48	125.27
p_1k_3	7.25	78.48	125.27
p_2k_1	7.25	78.53	125.27
p_2k_2	7.25	78.53	125.27
p_2k_3	7.21	78.53	125.27
p_3k_1	7.21	78.67	125.27
p_3k_2	7.23	78.67	125.27
p_3k_3	7.28	78.67	125.27
F	12.44**	NS	NS
CD	0.01	—	—

** Significant at 1 per cent level

Table 49. Shelf life studies on bush Jasmine (hours)

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
$V_0E_0S_0$	5.4	8.46	28.91
$V_0E_0S_1$	Buds didn't open	508.03	586.86
$V_0E_1S_0$	6.71	77.86	125.27
$V_0E_1S_1$	Buds didn't open	508.03	586.86
$V_1E_0S_0$	5.86	31.48	67.13
$V_1E_0S_1$	Buds didn't open	508.03	586.86
$V_1E_1S_0$	7.20	77.86	125.27
$V_1E_1S_1$	Buds didn't open	508.03	586.86
F	5.33**	83.68**	163.22**
CD	1.70	1.70	1.70

** Significant at one per cent level.

Plate 5. Buds kept at 0°C

Plate 6. Buds treated with ethylene absorbants

Plate 7. Buds treated without ethylene absorbants

The results obtained in post harvest studies clearly showed that there is significant variation between the treatments in case of time taken for flowering opening, time taken for colour fading and time taken for loss of turgidity.

It was noted that the buds kept at low temperature (0°C) failed to open. This was in the case of treatments $V_0E_0S_1$, $V_0E_1S_1$, $V_1E_0S_1$ and $V_1E_1S_1$. Among other treatments the treatment combination $V_1E_1S_0$ delayed in flower opening (7.2 hours) followed by $V_0E_1S_0$ (6.71 hours). The treatments $V_0E_0S_0$ took less time for flower opening (5.4 hours).

It is evident (Table 49) that the treatments varied significantly for time taken for colour fading. Among which the treatments $V_0E_0S_1$, $V_0E_0S_1$, $V_1E_0S_1$, $V_1E_1S_1$ retained the colour to the maximum (508.03 hours). This was followed by other treatments which also showed significant difference, $V_0E_1S_0$, $V_1E_1S_0$ which were statistically on par with each other and delayed the time taken for colour fading. The treatment $V_1E_0S_0$ took 31.48 hours for the flower buds to colour fade. Finally the least time was taken up by the treatment $V_0E_0S_0$ (8.46 hours) to retain colour.

There was high significance between the treatments in case of time taken for loss of turgidity. The flower buds which were kept at 0°C recorded a longer time for loss of turgidity (586.86 hours). The treatments $V_0E_1S_0$ and $V_1E_1S_0$ followed next (125.24 hours). The least time was recorded by $V_0E_0S_0$ (28.91 hours).

DISCUSSION

5. DISCUSSION

Bush jasmine is presently being cultivated in Kerala by large number of small and marginal farmers and housewives in small scale. Not many studies have been taken up to standardise the agrotechniques for this crop under Kerala conditions. With this in view two experiments were undertaken in bush jasmine at the department of Horticulture, College of Agriculture, Vellayani. The first experiment aimed at standardising the nutrient requirement of bush jasmine and second experiment was conducted to study the post harvest life of bush jasmine flowers.

The first experiment consisted of three levels of nitrogen (300, 450, 600, N $Kgha^{-1}$) and three levels of phosphorus (300, 450, 600 P_2O_5 kg ha^{-1}) and three levels of potassium (300, 450, 600 K_2O kg ha^{-1}) in Randomized Block Design. Along with the major nutrients, uniform foliar spray of Zn (0.25% $ZnSO_4$) and Mg (0.5% $MgSO_4$) was also included in the study. The total number of treatments were 27 and two controls. Control I consisted of N, P, K dose (150:150:150 kg ha^{-1}), Control II with farm yard manure 10 kg per plant. The fertilizer was applied in six equal splits at bimonthly intervals.

The experiment II consisted of three treatments each with two levels. Treatment one V_0 (without newspaper lining), V_1 (with newspaper lining), treatment two included E_0 (without ethylene absorbants), E_1 (with ethylene absorbants), treatment three consisted of S_0 (placing buds at room temperature), S_1 (refrigerated storage of buds at 0°C). The experiment was carried out at Completely Randomized Design.

Experiment I

The effect of nitrogen on length of the main shoot was significant. An increasing trend in plant main shoot length was obtained with increasing dose of N (600 Kg N ha^{-1}). Nitrogen being the major element to enhance vegetative growth the fact of increased dose of N enhancing the growth of main shoot is observed in this study also. Several workers have reported the positive influence of N nutrition on length of main shoot like Bhattacharjee (1985 a) and Asha Raj (1999) in *Jasminum sambac*, Natarajan (1977) in *Jasminum grandiflorum* and Hugur & Nalawadi (1994) in *Jasminum auriculatum.*

There was significant difference between the main shoot length with respect to phosphorus application . Here the highest dose of 600 kg P_2O_5 ha^{-1} was found highly significant throughout the period of study. In a plant like bush jasmine high supply of P is essential to sustain high photosynthetic activity. This result supports the reports of Srinivasan *et al.,* (1989) and Asha Raj (1999) in bush jasmine, Young *et al.,* (1973) in rose, Bose and Jana (1978) in bougainvilleas.

Application of potassium produced a lengthy main shoot. The highest main shoot length was noted with 600 Kg K_2O ha^{-1}. The effect was significant throughout the period of study. Similar effects were reported by Asha Raj (1999) in *Jasminum sambac* and by Deswal *et al.*, (1982) in gladiolus.

Interactions between Nitrogen and phosphorous influenced the main shoot length with 600 kg N and 600 kg P_2O_5 ha^{-1}. The interaction effect was more pronounced from fourth month onwards. Similar interactive effects were reported by Asha Raj (1999) in bush jasmine, Uma Maheswari (1999) in Dendrobium sonia-17.

From the data presented in the table 25 and 26 it is revealed that nitrogen has persistently increased the number of primary and secondary branches. Application of N at the highest level of 600 kg N ha^{-1} produced the maximum number of primary and lateral branches. This is due to the induction of lateral buds because of nitrogen application. Similar effect of nitrogen application was reported by Asha Raj (1999) in *Jasminum sambac* by Natarajan and Madhava Rao (1980) in *Jasminum grandiflorum*.

The effect of phosphorous application was also found to influence the production of primary and the secondary branches. The highest level of P (600 kg P_2O_5 ha^{-1}) significantly increased the number of primary and the secondary branches. According to Ledlie (1923) phosphorus is an active ingredient of the cell nucleus and encourages root growth, the vigour of plant and also produce healthy foliage and sturdy plants. Ferman (1965) quoted that phosphorus is the constituent of the cell nucleus and is closely associated with meristematic activity. So the application of P_2O_5 at higher levels increased the number of branches. The findings of Asha Raj (1999) in *Jasminum sambac* agreed with the above results.

In the case of potassium nutrition an increasing trend was observed in the production of primary and secondary branches. Here the maximum number of primary branches was obtained when 600 kg K_2O ha^{-1} was applied. Maximum number of secondary branches was obtained with 450 kg K_2O ha^{-1}. Potassium plays an important role in conversion of amino acids to proteins and soluble sugars to starch. This may have resulted in the increased production of primary and secondary branches.

N x P, N x K and P x K interactions were significant and recorded the highest values at the maximum levels producing maximum number of primary and secondary branches.

From the results obtained it can be seen that a positive response to applied N was observed and progressively increased the length of primary and secondary branches during the period of study. The treatments which received 600 kg N ha^{-1} produced maximum length of primary and secondary branches (Tables 7-10). This agrees with the observations in *Jasminum sambac* by Pal *et al.* (1985), Srinivasan *et al.* (1989) and Asha Raj (1999).

Applied phosphorus also contributed to increase in the length of primary and secondary branches. Phosphorus when applied at the increased dose of 600 kg ha^{-1} was found beneficial. Phosphorus a nutrient to increase meristematic activity (Ferman, 1965) which in turn increased the length of primary and secondary branches. This was in conformity with the reports of Srinivasan (1989), Asha Raj (1999) in *Jasminum sambac*. Bose and Jana (1978) in bougainvilleas.

In the case of potassium application, a mixed trend was observed in the length of primary branches. The effect of K_2O was more pronounced only during the tenth and twelvth month of study. The length of secondary branches was significant throughout the period of study. The highest level of potassium (600 kg K_2O ha^{-1}) was effective in influencing the length of primary and secondary branches. Similar effect of K was reported by Asha Raj in (1999) in *Jasminum sambac* and also by Deswal *et al.*, (1982) in Gladiolus. The interaction effect of N x P, N x K were found non significant.

The controls recorded a lesser value than the treatments. This indicated that the supply of nutrients was inadequate (Appendix 6 and 7).

In the present investigation it was found that the application of nitrogen had significantly increased the spread of plant in North-South and East-West direction during the study period . The increased dose of N applied (600 Kg N ha^{-1}) increased the spread of the plant. The increased number of primary and the secondary branches due to the nitrogen application increased the spread of the plant.

Application of phosphorus at the highest dose (600 Kg P_2O_5 ha^{-1}) was found to produce maximum spread of plant in the North-South and East-West direction. This result was in conformity with the studies of Asha Raj (1999) in *Jasminum sambac*. Potassium applied was found non significant.

The interactive effects on the spread of the plant was not significant. But the controls registered lower spread comparing to treatments indicating the low quantity of the nutrients applied which is not sufficient for the normal growth of the plant.

Application of all the three nutrients lead to a positive increase in the vegetative characters like the length of the primary and secondary branches, number of primary and secondary branches but there was no such proportionate increase in the yield of flowers. In this study it was observed that application of N, P, K above a certain level promoted only vegetative growth and not flowering.

It was found that application of N at lowest level of 300 kg N ha^{-1} produced maximum yield. This agreed with the findings of Natarajan *et al.*, (1981) that a highest flower yield (2.19 t ha^{-1}) was recorded with 40g N per plant in *Jasminum sambac*. Ramesh Kumar and Gill (1983) reported in the same crop that application of 30g N per plant gave the highest yield of flower buds. Pal *et al.*, (1985) also observed that the application of N @ 350 Kg ha^{-1} in *Jasminum sambac* produced the highest yield of flowers. Results agree with the findings of Asha Raj (1999) in *Jasminum sambac*.

The flower yield increased with 300 kg P_2O_5 ha^{-1} application. This result agrees with Pal *et al.*, (1985) in *Jasminum sambac*. He found that an appreciable increase in the yield was recorded at 30g P_2O_5 per square meter Asha Raj (1999) got the highest yield of flowers buds in *Jasminum sambac* at 150 kg P_2O_5 ha^{-1}.

Potassium application also significantly influenced the yield of flowers. The highest yield was recorded when potassium was applied at the rate of 450 kg K_2O ha^{-1}. This was in conformity with the findings of the Natarajan *et al.* (1981) in *Jasminum sambac*. He reported that higher flower yield was obtained at 40 kg K_2O per plant. According to Asha Raj (1999) highest yield of flowers was obtained when 150 kg K_2O ha^{-1} was applied. Bhattacharjee (1983b) observed that K application at 100g per plant improved flower yield in *Jasminum grandiflorum* (Fig. 1).

Interaction effect of nutrients was found to influence the yield of flowers. N x K interaction was significant at 300 N ha^{-1} with 450 kg K_2O ha^{-1}. Significant effects of N and K interaction was reported by Asha Raj (1999) in *Jasminum sambac* and also by Muthuswamy and Pappiah (1976) in *Jasminum auriculatum*. N x P and P x K interactions were found non significant.

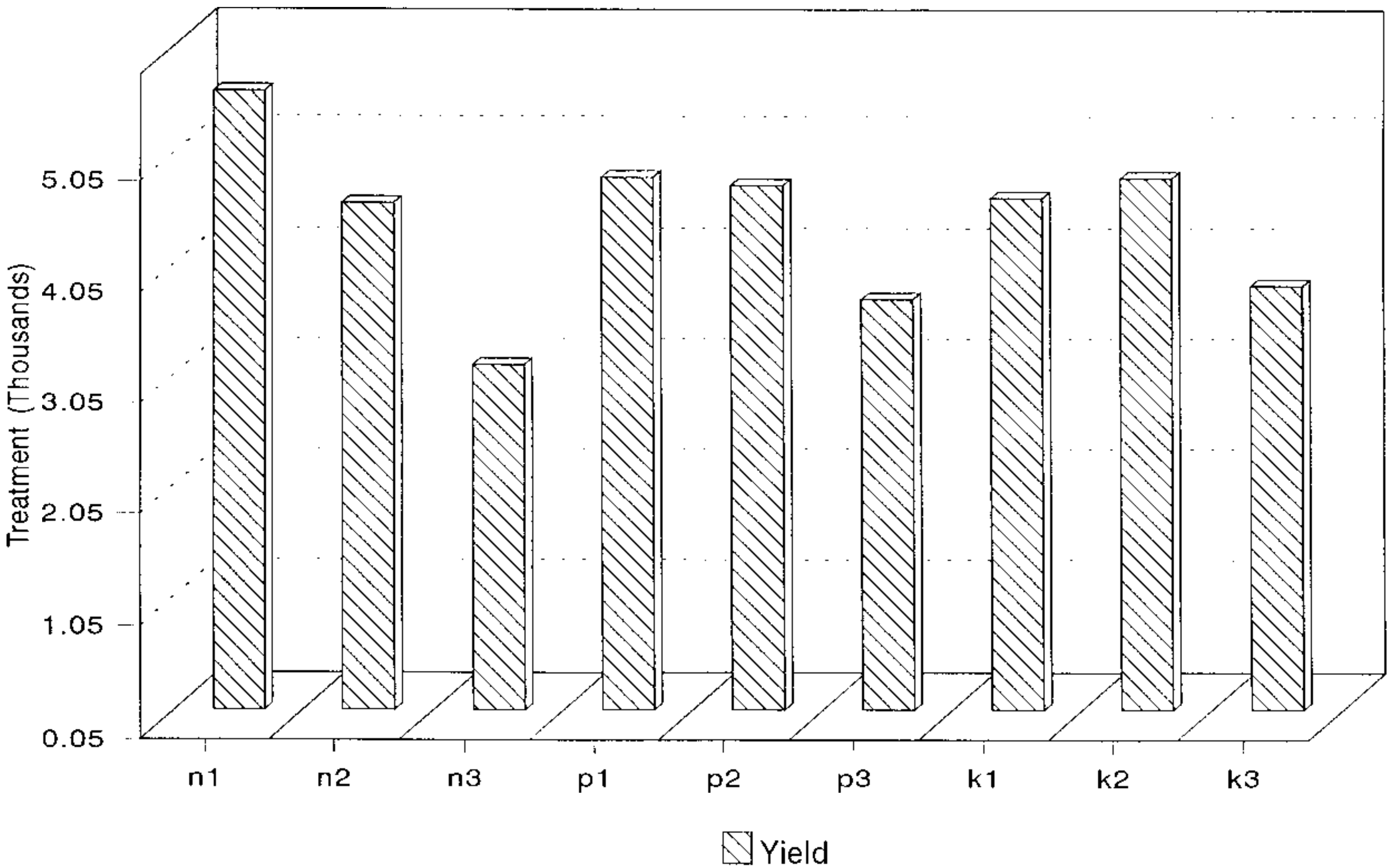

Fig. 1. Effect of N, P, K on flower yield

The treatments were superior over the control plots (Appendix 10).

Regarding monthly yield pattern, yield decreased with increased level of nitrogen. So a nitrogen dose of 300 kg N ha^{-1} influenced the yield. The yield increased from second to fourth month (March to June) and declined there after and again the yield increased towards the months of November to February.

The effect of phosphorus application was effective from the fourth month onwards and continued there after. Phosphorus at the dose of 300 kg P_2O_5 ha^{-1} was more beneficial. During the tenth and twelvth month the effect of phosphorus at p_2 and p_3 level (450 kg P_2O_5 ha^{-1} and 600 kg P_2O_5 ha^{-1}) were similar.

The application of potassium was also found significant. The yield increased from the fourth month and continued there after. The yield declined during sixth and eighth month and continued from the tenth month. The potassium application at the rate of 300 kg K_2O ha^{-1} was superior during the fourth month. During later months potassium application at 450 kg K_2O ha^{-1} was found effective.

N x K interaction was found significant during fourth, eighth and tenth month. During the fourth month N x K interaction was significant at 300 kg N ha^{-1} + 450 kg K_2O ha^{-1}. During the eighth and tenth month the treatment with fertilizer combination of 300 kg N ha^{-1} with 450 kg K_2O ha^{-1}, yielded best.

The treatments yielded higher than the controls (Appendix 9).

Heavy rains in between during the period might be one reason for the fluctuating trend in yield. The foliar application of Zn and Mg could not be utilized by the plant during the rainy season.

The hundred bud weight was influenced by nitrogen application. Application of nitrogen at the lowest dose of 300 Kg N ha^{-1} resulted in the highest weight of 100 buds. This was supported by Srinivasan *et al.*, (1989) in *Jasminum sambac*.

The application of phosphorus significantly increased the 100 bud weight, the dose at 450 Kg P_2O_5 ha^{-1} being the best level to produce maximum weight of buds. Potassium had no significant effect in the 100 bud weight of flowers (Fig. 2).

N x P interaction has influenced the bud weight of the flowers at 300 Kg N ha^{-1} with 450 kg P_2O_5 ha^{-1} recording the maximum weight of 25.47 g. This shows that N and P has got major role in influencing the bud weight whereas there was no significant effect of N x K, P x K interaction for weight of 100 buds.

The time taken for the flower opening is significant with phosphorus application. As the level of phosphorus application increased, there was an increase in the period of time for the flower buds to open indicating the role of P in the flower opening.

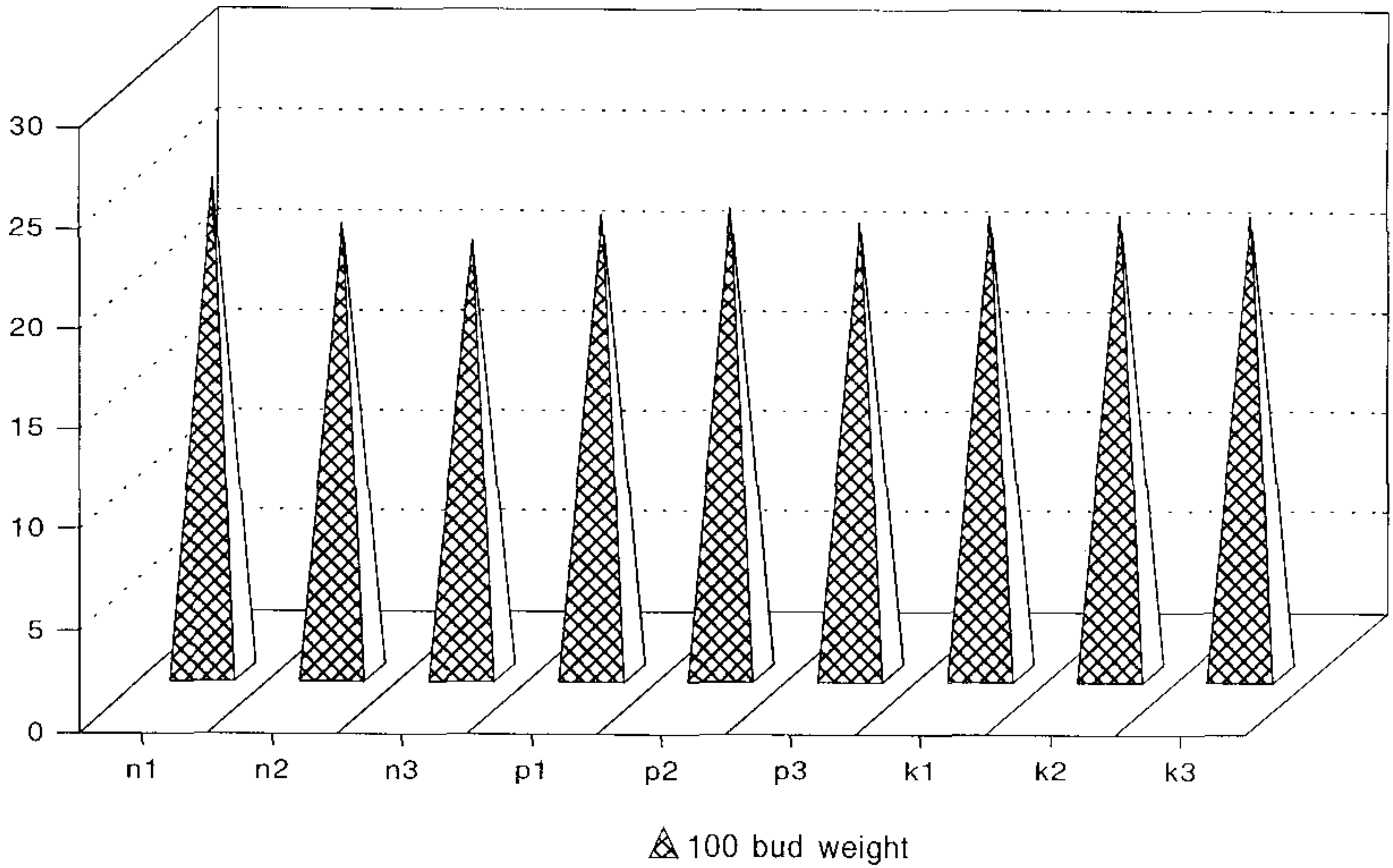

Fig. 2. Effect of N, P, K on 100 weight of buds

The above result was in agreement with Usha kumari (1986) and Nirmala George (1989) that the higher levels of P delayed flower opening in rose. Similarly Asha Raj (1999) also reported that only P has the role in opening of flowers buds. The role of nitrogen and potassium was found non significant.

N x P interaction was significant at 600 kg N ha^{-1} with 600 kg P_2O_5 ha^{-1}, N x K interaction was significant with 300 kg N ha^{-1} with 600 kg K_2O ha^{-1} and 600 kg N ha^{-1} with 450 kg K_2O ha^{-1}. P x K interaction was found superior with 600 kg P_2O_5 ha^{-1} and 300 kg K_2O ha^{-1}.

The highest level of N, P, K was found to influence the maximum leaf nitrogen content (600 kg ha^{-1} of N, P_2O_5 and K_2O). The findings reported by Kamala devi *et al.*, (1979) that leaf nitrogen content rose with the higher application rates of nitrogen and potassium is in agreement with the present findings. The findings of Zillar and Ferman (1961) that N levels were strongly influenced by the application of K is also in conformity with the present findings.

A positive response to foliar P for applied N and P was noted indicating that with increased rates of N and P, the leaf P also increases. Manciot *et al.*, (1980) reported that the application of phosphatic fertilizer is very often accompanied by a significant increase in the leaf P levels. Maximum leaf P was obtained with Nitrogen applied at 450 and 600 kg N ha^{-1} and phosphorus at 600 kg P_2O_5 ha^{-1} and Potassium at 600 kg K_2O ha^{-1}.

Maximum content of leaf K was observed with nitrogen at 450 kg N ha^{-1}, P at 450 kg P_2O_5 ha^{-1} recorded the highest content of leaf K. A regular increase in plant K with increase in levels of K was observed.

The magnesium content in the leaf was found to increase with N and P. Magnesium content was highest with nitrogen 600 kg N ha^{-1} and P with 300 kg P_2O_5 ha^{-1}. Similar results were reported by Sabina George in orchids (1996). K application was found non significant. The reduced Mg level due to applied K can be attributed to K-Mg antagonism (Manciot *et al.*, 1980). Such depressed effect of K was reported by Poole and Seelay (1978) in orchids.

Maximum content of zinc in leaves was obtained at 450 kg N ha^{-1}. Phosphorus applied at the rate of 450 and 600 kg P_2O_5 ha^{-1} recorded the maximum content of zinc in leaves. Application of potassium at 450 kg K_2O ha^{-1} was best. This agreed with the findings of Sabina George (1996) in orchids.

The interaction effect of N x P, N x K and P x K on leaf nitrogen content was found significant. N x P interaction was superior at 600 kg N ha^{-1} with 600 kg P_2O_5 ha^{-1} and also at 600 kg N ha^{-1} with 300 kg P_2O_5 ha^{-1}. N x K interaction was significant at 600 kg N ha^{-1} with 600 kg K_2O ha^{-1}, PK at 600 kg P_2O_5 ha^{-1} with 600 kg K_2O ha^{-1} recorded the maximum leaf nitrogen content.

N x P interaction effect on leaf phosphorus content was significant at 450 kg N ha $^{-1}$ with 600 kg P_2O_5 ha^{-1} and also at 300 kg N ha^{-1} and 600 kg P_2O_5 ha^{-1} and recorded the maximum P content in leaf. N x K interaction was significant at 600 kg N ha^{-1} with 600 kg K_2O ha^{-1} and P x K interaction was significant at 600 kg P_2O_5 ha^{-1} with 300 kg K_2O ha^{-1} and also at 600 kg P_2O_5 ha^{-1} with 450 kg K_2O ha^{-1} and also at 600 kg of K_2O and P_2O_5 ha^{-1} which were the treatment combinations to produce maximum leaf P content.

N x P, N x K and P x K was found significant at 450 Kg N ha^{-1} with 300 kg P_2O_5 ha^{-1}, 450 kg N ha^{-1} with 600 kg K_2O ha^{-1} and 450 kg P_2O_5 ha^{-1} with 600 kg K_2O ha^{-1} recording maximum K content.

In case of Mg content in leaves N x P, N x K and P x K interaction was found significant at 450 kg N ha^{-1} + 300 kg P_2O_5 ha^{-1}, 450 kg N ha^{-1} + 450 kg K_2O ha^{-1}, 300 kg P_2O_5 ha^{-1} + 600 kg K_2O ha^{-1} was found to produce the highest Mg content.

Zn content in leaves was highly influenced by interaction effects of N x P, N x K and P x K at 450 kg N ha^{-1} + 300 kg P_2O_5 ha^{-1}, N x K at 450 kg N ha^{-1} + 450 kg K_2O ha^{-1}, 300 kg N ha^{-1} + 450 kg K_2O ha^{-1} and P x K at , 450 kg P_2O_5 ha^{-1} + 450 kg K_2O ha^{-1} and also 600 kg P_2O_5 ha^{-1} + 450 kg K_2O ha^{-1} was found beneficial.

From the data presented in Table 25 and 26 it is revealed that the carbohydrate content was highest at the lowest dose of Nitrogen applied (300 kg N ha^{-1}). Nitrogen promoted the growth of additional tissues and led to the high vegetative vigour, such plants recorded lower CN ratio value, whereas treatments with lower levels of N, had greater CN values and highest flower yields. P and K did not influence the Carbohydrate content of flowering shoot.

The interaction effects of carbohydrate content of flowering shoot was significant. N x P interaction was significant with 300 kg N ha^{-1} + 300 kg $P_2O_5ha^{-1}$ and NK interaction was found significant at 300 kg N ha^{-1} with 300 kg K_2O ha^{-1} and PK interaction was significant at 450 kg P_2O_5 ha^{-1} with 450 kg K_2O ha^{-1}.

The results presented in Tables 27 and 28 revealed that increasing nitrogen simultaneously increased the uptake of N. The application upto 600 kg N ha^{-1} increased the uptake of N. This improved the vegetative growth of plant. Similarly the uptake of N was also influenced by potassium and phosphorus application at 600 kg P_2O_5 ha^{-1} and 600 kg K_2O ha^{-1}.

It was evident from the results (Tables 27 and 28) that the uptake of phosphorus was significantly influenced by Nitrogen, Phosphorus and Potassium at their highest levels i.e., 600 kg ha^{-1} of N, P_2 O_5 and K_2O. The higher content of P in plants, resulted in good root growth thereby increasing meristematic activity and improving the growth of plants.

Application of Nitrogen (600 kg N ha^{-1}) showed a consistent rise in uptake of potassium. The uptake of potassium was high when K was applied at 450 kg ha^{-1}. The uptake of N, P, K was in conformity with the studies of Asha Raj (1999) in bush Jasmine. Uptake of Magnesium increased with high dose of Nitrogen (600 kg N ha^{-1}). The uptake of Magnesium increased with decreased dose of phosphorus (300 kg P_2O_5 ha^{-1}). Uptake of Mg was highly influenced at 600 kg K_2O ha^{-1} and 300 kg K_2O ha^{-1}. This suggests a synergestic relation between nitrogen and magnesium.

Application of Nitrogen and Phosphorus influenced the uptake of Zinc. The maximum uptake was seen at 600 kg N ha^{-1} and 450 kg N ha^{-1} and 600 kg P_2O_5 ha^{-1}.

The interaction effect of uptake of nitrogen was influenced at highest levels of N x P, N x K interactions whereas P x K interaction was effective at 600 kg P_2O_5 ha^{-1} - 450 kg K_2O ha^{-1}.

The interaction effect of N x P, N x K and P x K was highly significant at 600 kg N ha^{-1} + 600 kg P_2O_5 ha^{-1}, 600 kg N ha^{-1} +600 kg K_2O ha^{-1}, 600 kg P_2O_5 ha^{-1} + 600 kg K_2O ha^{-1} which increased the uptake of phosphorus.

In case of uptake of Potassium N x P, N x K and P x K interaction was highly significant at 600 kg N ha^{-1} + 450 kg P_2O_5 ha^{-1}, 600 kg N ha^{-1} +600 kg K_2O ha^{-1}, 600 kg P_2O_5 ha^{-1}+450 kg K_2O ha^{-1} respectively.

The uptake of Magnesium was highly influenced by N x P, N x K and P x K interactions at 450 kg N ha^{-1} + 300 kg P_2O_5 ha^{-1}, 600 kg N

ha^{-1} + 300 kg K_2O ha^{-1}, 300 kg P_2O_5 ha^{-1} + 600 kg K_2O ha^{-1}. The interaction effect of N x P and N x K was significant on uptake of Zinc at 450 kg N ha^{-1} + 600 kg P_2O_5 ha^{-1}, 600 kg N ha^{-1} + 300 kg K_2O ha^{-1}. The P x K interaction was non significant.

Application of Nitrogen increased the essential oil content of flowers. A maximum oil content was obtained with the N at the rate of 300 kg N ha^{-1} and 600 kg N ha^{-1}. This agrees with the findings of Asha Raj (1999) in *Jasminum Sambac*, and also by Natarajan and Madhava Rao, (1980 a) in *Jasminum grandiflorum*, and in *Mentha piperita* by Dellacecca (1977). In *Majorona hortensis* application of 320 kg ha^{-1} nitrogen gave the highest oil yield (Farooq *et al.,* 1991). Phosphorus and potassium had no significant influence. Pal *et al.*, (1984) agreed with the above result that the essential oil content increased with rising N levels, but P had no beneficial effect in *Jasminum auriculatum.*

N x K interaction was significant at 300 kg N ha^{-1} + 450 kg K_2O ha^{-1}, 300 kg N ha^{-1} + 600 kg K_2O ha^{-1}, 450 kg N ha^{-1} + 300 kg K_2O ha^{-1}, 600 kg N ha^{-1} + 300 kg K_2O ha^{-1}, 600 kg N ha^{-1} + 450 kg K_2O ha^{-1} and 600 kg N ha^{-1} + 600 kg K_2O ha^{-1}. P x K and N x P interactions were found non significant.

The soil analysis revealed higher levels of nutrient status. Control plots registered lower nutrient status after the experiment.

Available soil N increased with higher dose of N application (600 kg N ha^{-1}). The available N status in soil was found to increase with phosphorus, the highest level was more effective at 600 Kg P_2O_5 ha^{-1}. The potassium application at 600 Kg K_2O ha^{-1} produced highest residual soil nitrogen. This confirmed with the findings of Asha Raj (1999) in bush jasmine.

An increased phosphorus content in soil was noted with increased level of nitrogen (600 kg N ha^{-1}). Phosphorus nutrition enhanced P status of soil with phosphorus application at 600 kg P_2O_5 ha^{-1}. Maximum content of available phosphorus was noted in soil with treatment receiving potassium at 600 kg K_2O ha^{-1}. Similar results were obtained by Asha Raj (1999) in *Jasminum sambac.*

Similarly in available soil potassium also the treatments receiving highest amount of N, P, K, contained more residual K. This agreed with the results of Asha Raj (1999) in *Jasminum sambac.*

N x P, N x K and P x K interaction was highly significant with available soil N at 600 kg N ha^{-1} + 600 kg P_2O_5 ha^{-1}, 600 kg P_2O_5 ha^{-1} + 600 kg K_2O ha^{-1}, 600 kg N ha^{-1} + 600 kg K_2O ha^{-1}.

The interaction effect of N x P, N x K and P x K was highly influenced for available soil phosphorus at the maximum level of N & P, N & K and P & K interactions.

The interaction effect of NP, NK and PK was highly significant at the maximum level of NxP, PxK and NxK combinations. The interaction effects was in conformity with the findings of Asharaj (1999) in *Jasminum sambac*.

Experiment II

The post harvest life of flowers depends on both pre harvest and post harvest management practices. Continuing the supply of water and carbohydrates to flowers and retardation of the on set of senescence help to prolong their shelf life (Halevey and Mayak, 1979). To preserve the quality of flowers and to make them resistant to fluctuations in post harvest environment, conditioning or hardening, by use of chemicals, equipment and altering the temperature have been widely recommended. In this study effect of major nutrients on shelf life of flowers, in combination with various post harvest practices viz., newspaper lining, ethylene absorbant and storage temperature along with major nutrients were tried.

The treatments produced significant effects on shelf life of flowers. In treatment (control $V_0E_0S_0$), the shelf life was very much influenced by major nutrient application. The increasing dose of phosphorus application (600 kg ha^{-1}) increased the shelf life of flower buds in the experiment (Table 1). It was clear from the above experiment that high dose of phosphorus in soil increased the water uptake, enhanced flower diameter and lengthened the life of flowers. The above result was in agreement with the findings of Ushakumari (1986) and Nirmala

George (1989) in rose. The time taken for delaying flower opening, preventing loss of turgidity and retention of colour was found maximum at 300 kg N, 600 kg P_2O_5 and 300 kg K_2O ha^1. Similar results were reported in *Polianthus tuberosa* (Amarjeet *et al.*, 1996).

The interaction effects ($V_0E_0S_0$) were found significant for shelf life of flowers. The shelf life was prolonged by N x K interaction by the treatment combination 300 kg N + 300 kg K_2O ha^{-1}. In N x P interaction the time taken for flower opening and retaining turgidity was influenced at 300 kg N + 600 kg P_2O_5 ha^{-1} and colour was retained at 300 kg N + 300 kg P_2O_5 ha^{-1}, the colour was retained by 300 kg of P_2O_5 and 300 kg K_2O ha^{-1} and the turgidity was retained at 600 kg P_2O_5 + 300 kg K_2O ha^{-1}.

As observed in the present experiment that the treatment $V_0E_1S_0$, an increase in phosphorus application increased the shelf life of flowers viz., delayed flower opening, retained colour and prevented loss of turgidity. This was in line with the findings of Asha Raj (1999) in *Jasminum sambac*, Usha Kumari (1986) and Nirmala George (1989) in rose that the shelf life was enhanced by phosphorus application. The time taken for flower opening, the duration of time taken for retention of colour and turgidity were highest at 450 kg N ha^{-1} and 600 kg P_2O_5 ha^{-1}. Potassium when applied as 450 kg K_2O ha^{-1} retained turgidity to the maximum. This was in conformity with the findings of Amarjeet *et al.* (1996) that high rate of N, P and K prolonged shelf life. Contrary to it the role of potassium for time taken for flower opening and time taken for colour fading was found non significant.

The interactive effect of N x P, N x K and P x K on shelf life was significant ($V_0E_1S_0$) in case of time taken for flower opening, loss of turgidity and colour fading. The interactive effects of N x P, N x K and P x K were highly significant in influencing the time taken for flower opening, where the combination 450 kg N + 300 kg P_2O_5 ha^{-1}, 450 kg N + 600 kg K_2O ha^{-1} and 600 kg P_2O_5 + 450 kg K_2O ha^{-1} were found superior. Regarding retention of colour in N x P interaction the combinations 300 kg N + 600 kg P_2O_5 and 450 kg N + 600 kg P_2O_5 were on par with each other and proved superior over other treatments. In N x K interaction the colour was retained to the maximum at 300 kg N + 600 kg K_2O ha^{-1}. There was no significant variation with P x K interaction in colour retention. The interaction effect on time taken for loss of turgidity was found non significant.

The trend of increasing the shelf life was observed with increase in fertilizer application in treatment $V_1E_1S_0$. This is also in agreement with the findings of Asha Raj (1999) in *Jasminum sambac* and Nirmala George (1989) in rose and Amarjeet *et al.* (1996) in Tuberose. Time taken for flower opening increased at n_2, p_3 and k_3 levels. Similar results were obtained in orchids (Bhattacharjee, 1982). Nitrogen and phosphorus applied at 450 kg ha^{-1} and 600 kg ha^{-1} retained the colour of flowers, whereas there was no significant difference between the treatments in case of time taken for loss of turgidity.

The interactive effects were found highly significant ($V_1E_1S_0$) in time taken for flower opening. In N x P interaction the treatment combination 450 kg N ha^{-1} + 600 kg P_2O_5 ha^{-1} delayed the time taken for flower opening. In N x K interaction flower buds delayed to open at 450 kg N + 300 kg K_2O ha^{-1}. In P x K interaction the flower buds took a longer time to open at highest levels of P and K combinations (600 kg P_2O_5 + 600 kg K_2O ha^{-1}).

The colour was retained maximum by N x P interaction at 300 kg N + 600 kg P_2O_5 ha^{-1} and 450 kg N + 600 kg P_2O_5 ha^{-1}. In N x K interaction the treatment combination 300 kg N + 600 kg K_2O ha^{-1} was best to retain the colour. P x K interaction was found non significant. The interaction effects on time taken for loss of turgidity was found non significant.

The treatments subjected to 0°C viz., $V_0E_0S_1$, $V_0E_1S_1$ and $V_1E_1S_1$ failed to open. There was no significant variation between treatments. Skene (1924) reported that opening of crocus, flax and many other flower were inhibited by a decrease in temperature.

In general the post harvest studies on *Jasminum sambac* revealed that the different techniques viz., use of newspaper, lining, ethylene absorbants, and low temperature were found significant. In case of time taken for flower opening the buds treated with ethylene absorbants took a longer time (mean 3.48 hrs.) compared to buds which were not treated with ethylene absorbants (mean 2.81 hrs.). The above findings was in confirmity with the reports of Sudha (1998). The buds kept with and without newspaper lining also showed significant difference in time taken for flower opening. It was found that the mean value recorded was 3.27 hours for V_1 and 3.03 hours for V_0. Skene (1924) stated that opening of Crocus, Flax and many other flowers was inhibited by a decrease in temperature. This was in coincidence with the present findings that the buds stored at 0°C failed to open. It was evident (Table 49) that the time taken to retain colour and turgidity of flowers was maximum in case of buds exposed to low temperature treatment. This was in agreement with the findings of Mukhopadhyay *et al.* (1988), that cold treatment of *Jasminum sambac* buds, enhanced longevity of flowers. This was followed by the buds treated with ethylene absorbants ($KMNO_4$) which prolonged the shelf life which was in accordance with the findings of Sudha (1998). The least shelf life was obtained in buds treated without news paper lining (Fig. 3).

Future line of work

Further studies may be conducted with organic manures. The effect of split application on flower yield needs attention and detailed studies are essential to standardize the optimum number of split applications. As the spread of plant is low, more plants can be accommodated. Post harvest studies should be conducted on colourful packing techniques, and temperature studies to promote flower opening and enhance shelf life.

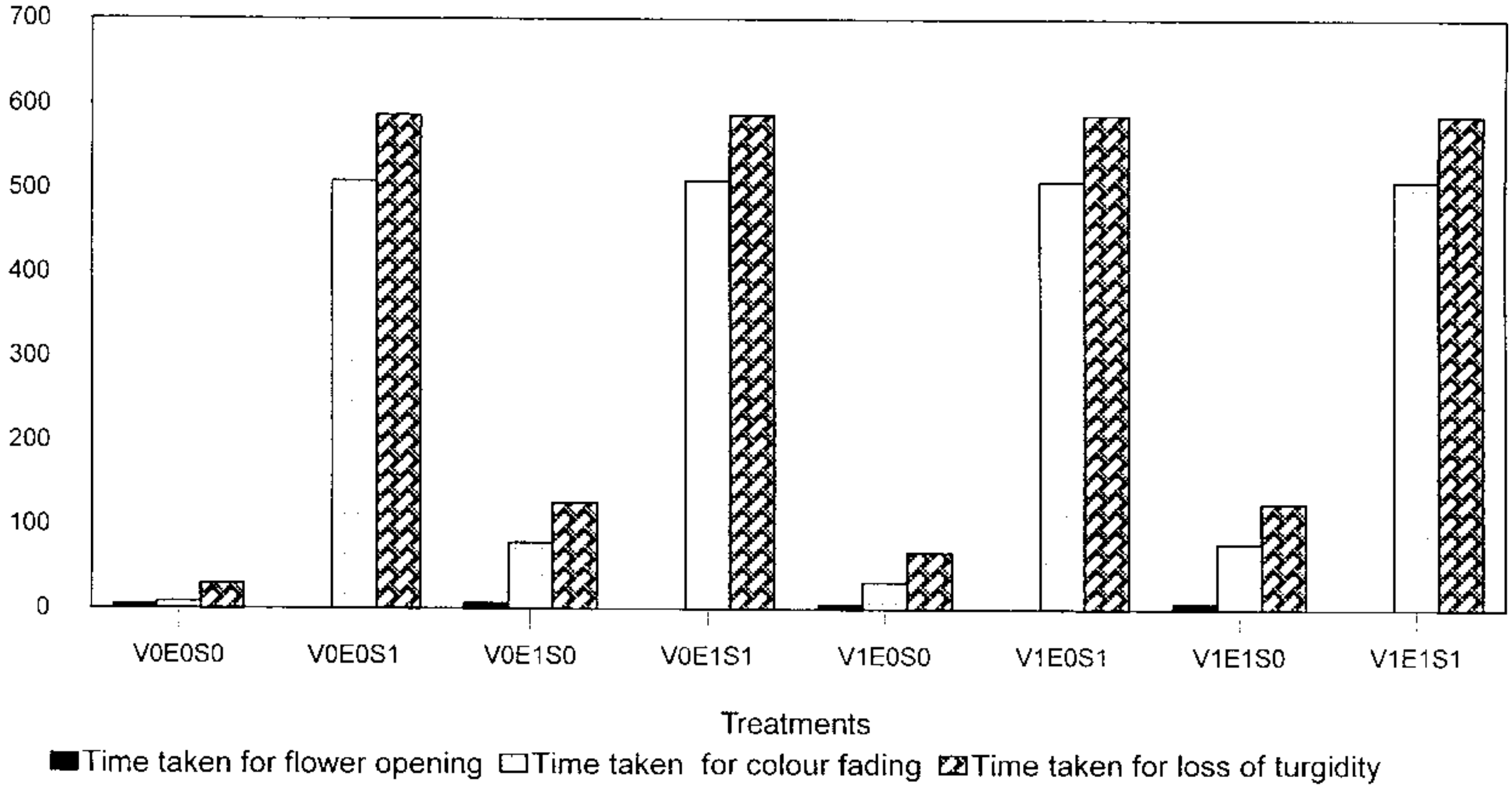

Fig. 3. Shelf life studies of bush Jasmine (hours)

SUMMARY

SUMMARY

A study was made to investigate the nutrient requirement and post harvest studies in bush jasmine. The experiment was conducted at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 1998-1999. The main objective was to standardize the nutrient requirement of bush jasmine and its shelf life studies. The important findings drawn from the field experiment are summarised below.

The experiment I consisted of 27 treatments and two controls. The experiment was laid out as $3^3 + 2$ treatment Randomised Block Design with three replications. The treatments consisted of three levels of nitrogen (300, 450 and 600kg N ha^{-1}), three levels of phosphorus (300, 450, 600 P_2O_5 ha^{-1}) and three levels of potassium (300, 450, 600 kg K_2O ha^{-1}). Control I consisted of N, P, K dose (150 : 150 : 150 kg ha^{-1}), control II consisted of farm yard manure 10 kg per plant.

The second experiment consisted of eight treatment each with two levels. Treatment one included V_0 and V_1 (without and with newspaper lining), E_0 and E_1 (without and with ethylene absorbants), S_0 and S_1 (room temperature and at 0^oC).

The length of main shoot increased significantly with increased N, P, K levels thus showing a positive effect throughout the growth period.

Similarly the number of primary branches and length of primary and secondary branches was found significant at n_3, p_3 and k_3 levels. The maximum number of secondary branches were obtained at n_3, p_2 and k_2 levels.

Application of nitrogen and phosphorus at higher rates resulted in maximum spread of plant in north-south and east-west direction.

The yield of flower buds was found highly significant by application of major nutrients. It was seen that the yield increased with lower doses of N, P, K (n_1, p_1, k_2).

In case of monthly yield pattern the yield decreased with increasing levels of N. The yield showed a positive response during second to fourth month decreasing in between and again increasing towards tenth and twelvth month. Phosphorus application influenced the monthly yield pattern from fourth month and continued throughout the crop period at p_1 level. With respect to potassium the level k_1 was found superior during fourth month of the crop period, k_2 was more effective during other months.

The 100 bud weight was highly influenced by N and P where the levels n_1 and k_1 was found superior. The time taken for flower opening delayed at level p_3.

Application of major nutrients was found to influence the nitrogen content in leaves. The application of nitrogen. phosphorus and potassium at the highest level resulted in maximum content of N in leaves. The phosphorus content in leaves increased due to N application at 600 and 450 kg ha^{-1} and phosphorus and potassium together applied at 600 kg ha^{-1} increased the leaf P content. The leaf K content was highest at n_2, p_2 and k_3 levels. The magnesium content in leaves was found highest when N and P was applied at n_3 and p_1 levels. Zinc content in leaves was recorded maximum at n_2, p_2, p_3 and k_2 levels.

The lowest level of nitrogen applied increased the carbohydrate content of flowering shoot, while P and K did not exert any influence.

Application of major nutrients viz., N, P, K at their highest dose (600 kg N : 600 kg P_2O_5 : 600 kg K_2O ha^{-1}) resulted in maximum uptake of nitrogen and phosphorus. The uptake of potassium was influenced by major nutrients at n_3, p_2 and k_2 levels. Major nutrients applied influenced the uptake of magnesium, the highest being recorded at n_3, p_1, k_1 and k_2 levels. Zinc uptake was maximum at n_2 and n_3 levels which were on par with each other, phosphorus application at 600 kg ha^{-1} and potassium at 300 and 450 kg ha^{-1} increased the uptake of zinc.

The essential oil content of flowers was significantly enhanced by nutrient nitrogen at n_1 and n_3 levels.

Major nutrients applied highly influenced the available nitrogen. phosphorus and potassium in soil. It was confirmed that the highest dose of N, P, K applied left a higher residual soil N, P and K. However, a build up of major nutrients as compared to the initial status was seen in all plots except controls.

In experiment II The effect of major nutrients on shelf life of flowers was found significant. In case of treatment ($V_0E_0S_0$) time taken for flower opening, loss of turgidity and colour fading delayed at the maximum at the nutrient dose of 300 kg N, 600 kg P_2O_5 and 300 kg K_2O ha^{-1}.

In ethylene absorbant treated buds ($V_0E_1S_0$) the major nutrients applied delayed the time taken for flower opening and retained colour at n_2 and p_3 levels. Major nutrients delayed the time taken for loss of turgidity at p_3, k_2 and k_3 levels.

The effect of nutrients on flower buds treated with ethylene absorbants and newspaper lining ($V_1E_1S_0$) delayed the time taken for flower opening at n_2, p_3, k_3 levels. The colour was retained to the maximum at 450 kg N and 600 kg P_2O_5 ha^{-1}.

In general the shelf life of flowers was found highly significant. The buds treated with ethylene absorbants, was the superior treatment in delaying flower opening. Regarding time taken for retaining colour and turgidity, the buds stored at 0°C was found highly significant. This was followed by ethylene absorbant treated buds to retain colour and turgidity.

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APPENDICES

Appendix 1. Weather data during the experimental period

Month	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)	Number of rainy days
February	32.13	23.70	78.50	18.8	2
March	33.3	24.21	75.00	Nil	
April	34.14	25.38	78.00	49.3	7
May	32.8	25.90	83.50	21.3	14
June	30.67	24.60	85.50	370.1	25
July	29.60	24.10	82.51	108.7	17
August	29.90	24.30	84.04	139.3	13
September	29.50	27.70	87.55	312.8	21
October	29.70	23.60	85.00	424.6	18
November	30.10	23.20	82.60	156.0	15
December	30.60	22.80	86.00	142.4	20
January	31.20	21.98	89.74	5.2	3
February	31.40	22.80	78.63	78.6	4

Appendix 2. Initial soil nutrient status

Available soil nutrient	Grade
N	High
P	High
K	High

Appendix 3. Interaction effect of NPK on length of main shoot (cm)

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	33.20	40.01	44.37	49.26	55.09	59.04
$n_1p_1k_2$	30.25	34.63	42.83	48.82	51.81	59.04
$n_1p_1k_3$	38.09	44.66	49.63	53.33	57.58	62.90
$n_1p_2k_1$	35.57	40.40	44.58	49.84	56.33	60.50
$n_1p_2k_2$	40.08	43.51	48.45	52.12	57.23	62.17
$n_1p_2k_3$	35.58	41.41	47.56	55.24	56.97	61.22
$n_1p_3k_1$	40.59	46.19	52.28	58.01	62.24	66.95
$n_1p_3k_2$	39.57	45.10	50.79	57.02	61.41	66.16
$n_1p_3k_3$	42.47	49.48	54.62	57.79	62.79	67.65
$n_2p_1k_1$	42.08	47.61	52.96	65.22	68.76	70.97
$n_2p_1k_2$	41.50	48.49	55.98	60.10	64.05	70.23
$n_2p_1k_3$	41.24	45.36	51.52	58.06	61.70	70.26
$n_2p_2k_1$	38.07	42.56	49.70	58.53	62.73	68.84
$n_2p_2k_2$	43.00	48.94	55.16	60.23	66.91	73.31
$n_2p_2k_3$	50.63	55.94	60.12	64.56	68.81	74.82
$n_2p_3k_1$	40.50	48.49	55.42	61.64	68.31	75.04
$n_2p_3k_2$	38.23	46.66	51.14	57.72	66.97	75.62
$n_2p_3k_3$	44.45	51.10	57.57	65.27	71.76	78.86
$n_3p_1k_1$	50.21	55.77	62.65	69.03	74.56	81.43
$n_3p_1k_2$	50.07	55.23	61.73	66.74	72.83	79.92
$n_3p_1k_3$	54.67	57.67	62.56	65.95	78.10	85.83
$n_3p_2k_1$	52.63	62.66	68.82	78.17	85.24	92.07
$n_3p_2k_2$	59.78	67.13	74.13	82.00	89.65	101.16
$n_3p_2k_3$	62.63	71.56	76.92	86.36	94.78	103.14
$n_3p_3k_1$	56.79	62.59	69.66	78.33	86.21	97.94
$n_3p_3k_2$	64.65	71.55	78.30	90.65	99.26	107.92
$n_3p_3k_3$	76.01	83.96	91.76	97.67	107.51	118.38
CI	30.33	31.66	34.48	37.73	38.81	42.61
CII	29.34	30.36	32.61	34.33	35.61	39.93
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS - Not significant

Appendix 4. Interaction effect of NPK on number of primary branches

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	7.64	8.21	10.14	12.78	14.80	16.47
$n_1p_1k_2$	6.86	8.75	10.41	12.94	14.77	17.25
$n_1p_1k_3$	6.86	8.53	9.65	12.46	14.66	16.62
$n_1p_2k_1$	7.78	9.33	12.12	14.31	16.64	18.71
$n_1p_2k_2$	7.35	9.44	10.32	12.25	14.77	16.69
$n_1p_2k_3$	8.18	10.51	13.45	16.62	18.72	19.82
$n_1p_3k_1$	6.71	9.93	10.55	12.68	14.60	16.57
$n_1p_3k_2$	7.36	9.94	11.17	13.42	15.85	17.45
$n_1p_3k_3$	7.99	9.86	11.83	13.70	16.13	18.48
$n_2p_1k_1$	8.67	10.44	12.15	15.64	17.52	18.63
$n_2p_1k_2$	8.76	9.84	12.62	14.86	16.68	18.58
$n_2p_1k_3$	8.48	8.63	11.61	13.37	16.46	18.56
$n_2p_2k_1$	8.97	10.60	13.40	17.45	19.66	21.48
$n_2p_2k_2$	9.08	12.61	13.50	17.55	19.33	21.67
$n_2p_2k_3$	8.67	9.36	9.49	10.47	13.50	15.75
$n_2p_3k_1$	8.29	9.36	11.14	12.10	17.58	19.28
$n_2p_3k_2$	7.85	9.44	12.63	14.39	16.70	19.48
$n_2p_3k_3$	8.23	10.46	11.72	14.50	17.80	19.63
$n_3p_1k_1$	9.67	14.64	18.37	21.59	24.38	27.43
$n_3p_1k_2$	9.32	11.50	13.53	14.89	19.41	20.81
$n_3p_1k_3$	9.36	10.72	11.33	13.36	16.71	20.57
$n_3p_2k_1$	9.93	11.16	14.59	16.75	18.27	20.36
$n_3p_2k_2$	9.33	11.71	14.50	16.69	18.57	24.50
$n_3p_2k_3$	9.44	12.43	14.46	18.92	21.96	24.56
$n_3p_3k_1$	9.44	12.65	16.64	19.47	23.87	27.40
$n_3p_3k_2$	9.67	14.84	18.68	20.41	23.32	27.73
$n_3p_3k_3$	9.66	14.63	18.37	21.59	24.38	27.45
CI	7.24	9.66	11.65	13.32	14.97	15.39
CII	6.14	7.35	8.88	10.60	11.66	12.13
F	4.86**	38.73**	17.79**	27.32**	108.89**	74.48*
CD	0.43	0.40	0.68	1.08	0.53	0.62

* Significant at 5 per cent level ** Significant at 1 per cent level

Appendix 5. Interaction effect of NPK on number of secondary branches

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	7.40	7.82	8.48	9.63	9.61	11.32
$n_1p_1k_2$	8.88	9.49	10.41	11.23	11.85	12.48
$n_1p_1k_3$	7.95	8.66	9.84	10.81	11.67	12.10
$n_1p_2k_1$	8.30	9.33	10.42	11.40	12.66	13.19
$n_1p_2k_2$	11.06	11.96	12.75	13.91	15.65	16.89
$n_1p_2k_3$	8.73	9.54	10.75	11.67	12.58	13.55
$n_1p_3k_1$	6.82	7.94	8.96	10.03	10.66	11.77
$n_1p_3k_2$	9.94	11.23	12.89	13.71	14.79	15.79
$n_1p_3k_3$	10.95	12.24	13.24	14.83	15.58	17.61
$n_2p_1k_1$	10.54	11.87	13.21	14.57	16.00	17.09
$n_2p_1k_2$	11.06	12.47	13.85	15.57	16.22	17.27
$n_2p_1k_3$	12.30	14.66	14.96	15.62	17.65	18.78
$n_2p_2k_1$	16.42	17.77	19.34	20.94	22.66	23.67
$n_2p_2k_2$	18.94	20.33	21.30	22.84	23.86	25.02
$n_2p_2k_3$	17.79	19.04	20.09	21.00	22.16	23.32
$n_2p_3k_1$	14.94	15.82	17.30	18.45	20.58	22.07
$n_2p_3k_2$	13.33	14.96	15.46	17.66	19.97	22.73
$n_2p_3k_3$	15.07	16.42	17.61	18.29	21.21	22.50
$n_3p_1k_1$	10.89	14.02	12.47	13.03	14.09	22.50
$n_3p_1k_2$	17.13	18.42	19.97	22.43	23.69	25.51
$n_3p_1k_3$	14.55	15.82	16.59	18.19	19.31	25.00
$n_3p_2k_1$	16.25	17.45	18.29	19.11	19.74	19.90
$n_3p_2k_2$	22.00	23.78	26.02	27.25	28.98	31.07
$n_3p_2k_3$	15.50	17.11	18.91	19.66	20.55	31.16
$n_3p_3k_1$	13.76	14.70	15.48	17.98	18.45	22.20
$n_3p_3k_2$	21.00	22.52	23.79	25.35	26.54	29.08
$n_3p_3k_3$	20.51	21.77	22.82	23.57	24.59	27.90
CI	7.36	9.66	12.64	12.88	14.86	16.63
CII	8.34	9.39	11.66	11.94	12.00	12.95
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Appendix 6. Interaction effect of NPK on length of primary branches (cm)

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	28.57	32.15	37.60	42.49	46.53	53.01
$n_1p_1k_2$	31.41	35.91	40.12	44.00	49.29	54.86
$n_1p_1k_3$	32.05	35.65	40.56	45.88	50.77	55.67
$n_1p_2k_1$	38.56	42.66	45.95	49.72	54.04	58.73
$n_1p_2k_2$	33.77	37.46	42.76	46.51	51.17	58.57
$n_1p_2k_3$	35.89	39.38	44.28	48.69	53.44	58.83
$n_1p_3k_1$	35.98	41.70	47.02	52.34	54.76	59.64
$n_1p_3k_2$	35.55	40.66	47.00	51.06	56.27	61.13
$n_1p_3k_3$	35.03	38.92	44.83	49.44	54.09	60.96
$n_2p_1k_1$	31.86	36.69	43.26	47.52	52.85	59.68
$n_2p_1k_2$	38.28	44.92	50.33	56.00	60.87	65.05
$n_2p_1k_3$	37.57	42.68	48.57	53.94	59.51	66.59
$n_2p_2k_1$	37.75	48.07	50.20	53.07	62.35	66.82
$n_2p_2k_2$	40.98	46.85	52.14	56.56	62.36	68.19
$n_2p_2k_3$	40.46	49.09	54.82	58.28	65.68	70.47
$n_2p_3k_1$	41.47	47.58	63.66	64.21	66.74	72.92
$n_2p_3k_2$	42.81	48.64	55.46	62.37	68.60	74.96
$n_2p_3k_3$	43.28	48.83	54.70	60.86	68.45	74.83
$n_3p_1k_1$	42.66	49.44	51.05	65.33	70.82	78.80
$n_3p_1k_2$	47.58	55.76	60.93	69.16	74.83	80.79
$n_3p_1k_3$	47.59	54.64	63.49	69.92	77.49	84.21
$n_3p_2k_1$	55.06	61.29	66.36	72.67	78.22	83.35
$n_3p_2k_2$	52.15	56.87	64.96	71.10	78.64	85.27
$n_3p_2k_3$	58.20	66.20	72.44	79.04	85.44	92.00
$n_3p_3k_1$	51.26	59.58	67.01	72.91	78.55	86.25
$n_3p_3k_2$	58.92	64.03	70.33	76.02	82.71	88.25
$n_3p_3k_3$	55.89	61.07	67.48	73.45	81.64	89.24
CI	35.64	38.89	40.39	43.23	44.08	45.59
CII	25.57	26.68	28.83	29.09	29.98	31.33
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS - Not significant

Appendix 7. Interaction effect of NPK on length of secondary branches (cm)

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	17.81	22.08	27.12	32.33	37.92	44.30
$n_1p_1k_2$	25.50	30.90	35.49	37.25	40.48	46.44
$n_1p_1k_3$	20.96	25.16	30.38	37.03	42.42	48.12
$n_1p_2k_1$	21.26	26.14	30.40	35.66	43.44	46.78
$n_1p_2k_2$	21.35	25.41	31.97	37.58	42.26	47.77
$n_1p_2k_3$	22.62	27.96	33.67	39.03	44.21	48.86
$n_1p_3k_1$	22.27	26.33	32.11	38.44	44.15	49.68
$n_1p_3k_2$	21.47	27.28	33.51	41.71	47.04	52.63
$n_1p_3k_3$	23.97	29.88	37.09	42.12	47.92	51.99
$n_2p_1k_1$	23.91	29.41	34.82	41.15	45.54	52.03
$n_2p_1k_2$	31.09	36.63	43.28	47.16	51.93	56.46
$n_2p_1k_3$	27.59	31.62	37.47	44.73	50.37	53.60
$n_2p_2k_1$	29.56	34.73	40.47	46.02	51.77	56.26
$n_2p_2k_2$	25.31	31.17	35.82	41.83	48.20	54.08
$n_2p_2k_3$	33.58	37.52	43.10	47.54	53.29	59.78
$n_2p_3k_1$	30.06	37.00	42.30	50.72	58.22	62.14
$n_2p_3k_2$	33.26	39.71	44.14	50.47	57.70	63.15
$n_2p_3k_3$	34.79	40.25	45.82	52.77	59.01	66.75
$n_3p_1k_1$	29.82	36.24	45.97	50.40	56.60	63.88
$n_3p_1k_2$	36.15	44.03	50.50	55.06	61.58	67.90
$n_3p_1k_3$	37.47	43.82	50.96	56.77	62.20	67.76
$n_3p_2k_1$	35.74	40.38	46.85	54.27	61.03	67.71
$n_3p_2k_2$	41.02	48.49	54.28	60.95	68.56	75.05
$n_3p_2k_3$	46.19	54.32	58.82	64.27	70.98	75.65
$n_3p_3k_1$	35.81	46.22	51.92	57.50	64.40	70.47
$n_3p_3k_2$	41.22	46.89	52.92	59.42	64.95	70.39
$n_3p_3k_3$	48.06	54.54	60.19	66.43	72.23	77.84
CI	24.42	26.33	29.41	30.33	32.34	33.61
CII	15.48	16.60	17.33	18.14	19.66	22.33
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS - Not significant

Appendix 8. Interaction effect of NPK on North-South spread of plant (cm)

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	28.71	31.49	38.09	38.16	43.71	48.46
$n_1p_1k_2$	31.69	34.54	38.49	43.13	48.04	50.57
$n_1p_1k_3$	31.20	35.07	39.31	43.30	48.01	53.86
$n_1p_2k_1$	35.22	39.54	45.08	47.58	51.11	54.63
$n_1p_2k_2$	35.93	40.39	44.60	48.49	52.95	56.38
$n_1p_2k_3$	39.06	42.85	47.33	52.77	56.39	60.47
$n_1p_3k_1$	38.12	41.87	46.21	50.06	54.33	57.76
$n_1p_3k_2$	37.83	43.01	46.87	51.46	55.56	59.38
$n_1p_3k_3$	38.79	42.68	47.07	51.02	55.27	59.19
$n_2p_1k_1$	41.02	43.39	45.48	54.84	60.94	64.98
$n_2p_1k_2$	43.08	47.59	52.21	58.96	64.27	69.48
$n_2p_1k_3$	48.93	54.25	59.26	64.75	69.57	74.29
$n_2p_2k_1$	47.91	52.34	58.20	63.94	68.55	73.60
$n_2p_2k_2$	47.61	53.54	59.85	65.43	70.12	76.52
$n_2p_2k_3$	48.81	53.08	61.14	66.67	72.34	78.60
$n_2p_3k_1$	51.19	54.78	57.80	63.99	69.91	75.61
$n_2p_3k_2$	52.83	58.84	65.02	69.61	74.02	80.43
$n_2p_3k_3$	54.74	60.59	66.27	74.48	75.59	80.18
$n_3p_1k_1$	51.40	58.72	65.14	70.38	80.15	90.21
$n_3p_1k_2$	51.80	56.14	62.61	68.75	72.61	78.59
$n_3p_1k_3$	53.84	56.21	63.57	68.27	72.61	78.19
$n_3p_2k_1$	52.58	57.53	62.45	68.41	74.83	80.13
$n_3p_2k_2$	55.62	61.39	68.46	74.77	80.61	86.63
$n_3p_2k_3$	52.90	58.07	62.65	67.63	77.30	85.20
$n_3p_3k_1$	51.78	56.81	62.72	69.81	75.70	81.70
$n_3p_3k_2$	53.26	58.43	63.48	72.63	75.77	83.56
$n_3p_3k_3$	51.40	58.71	65.14	75.04	80.15	90.21
CI	30.81	34.61	37.59	37.04	41.12	43.03
CII	29.02	24.86	26.53	27.03	29.28	31.03
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Appendix 9. Interaction effect of NPK on spread of plant in East-West direction (cm)

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	29.03	31.93	35.54	38.41	41.52	43.37
$n_1p_1k_2$	28.25	31.75	35.19	39.96	45.44	46.23
$n_1p_1k_3$	29.90	32.16	35.45	38.25	42.85	46.64
$n_1p_2k_1$	30.89	34.60	40.00	44.02	48.26	51.17
$n_1p_2k_2$	34.38	39.71	44.30	48.81	54.77	58.98
$n_1p_2k_3$	37.99	42.18	45.68	49.86	55.33	60.36
$n_1p_3k_1$	35.84	40.29	45.27	49.54	54.61	59.56
$n_1p_3k_2$	35.77	39.79	43.75	48.21	55.73	57.87
$n_1p_3k_3$	39.40	45.20	48.98	54.16	60.15	66.63
$n_2p_1k_1$	42.83	46.89	51.57	56.38	60.82	66.79
$n_2p_1k_2$	44.31	49.77	55.55	61.68	66.92	70.31
$n_2p_1k_3$	41.31	44.32	48.38	53.37	60.42	70.15
$n_2p_2k_1$	44.70	49.32	53.30	57.77	63.23	70.89
$n_2p_2k_2$	45.84	51.09	56.18	61.17	67.52	73.47
$n_2p_2k_3$	45.67	51.20	56.29	62.49	69.32	73.46
$n_2p_3k_1$	47.88	51.86	56.61	62.19	67.47	76.64
$n_2p_3k_2$	46.72	53.69	59.91	66.83	72.00	77.58
$n_2p_3k_3$	48.35	54.19	60.85	67.27	74.60	76.50
$n_3p_1k_1$	55.06	59.22	63.10	75.91	83.85	92.20
$n_3p_1k_2$	47.32	48.34	63.54	69.90	74.60	76.63
$n_3p_1k_3$	40.02	53.38	60.46	61.03	68.75	69.95
$n_3p_2k_1$	46.64	54.64	60.46	67.45	77.60	78.84
$n_3p_2k_2$	49.68	56.04	60.93	68.36	76.11	78.91
$n_3p_2k_3$	51.67	56.04	63.20	70.55	75.70	76.38
$n_3p_3k_1$	54.72	60.64	65.85	72.53	80.59	84.69
$n_3p_3k_2$	57.03	62.58	69.77	75.84	82.87	88.33
$n_3p_3k_3$	55.06	63.22	69.10	75.91	83.85	86.68
CI	25.74	27.28	27.44	31.90	33.82	36.33
CII	21.10	23.39	25.58	26.82	28.68	29.14
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Appendix 10. Interaction effect of NPK on yield of flowers (kg ha^{-1})

Treatments	Yield
$n_1p_1k_1$	6176.16
$n_1p_1k_2$	6996.73
$n_1p_1k_3$	4376.69
$n_1p_2k_1$	6543.11
$n_1p_2k_2$	6930.56
$n_1p_2k_3$	4393.19
$n_1p_3k_1$	4657.34
$n_1p_3k_2$	5864.89
$n_1p_3k_3$	4424.63
$n_2p_1k_1$	5655.45
$n_2p_1k_2$	4835.88
$n_2p_1k_3$	4775.41
$n_2p_2k_1$	5889.14
$n_2p_2k_2$	5174.97
$n_2p_2k_3$	3867.22
$n_2p_3k_1$	3654.81
$n_2p_3k_2$	4129.23
$n_2p_3k_3$	3396.07
$n_3p_1k_1$	3310.71
$n_3p_1k_2$	3916.35
$n_3p_1k_3$	3410.31
$n_3p_2k_1$	3474.99
$n_3p_2k_2$	2933.77
$n_3p_2k_3$	3609.07
$n_3p_3k_1$	2441.10
$n_3p_3k_2$	2644.10
$n_3p_3k_3$	2476.07
CI	2492.45
CII	2392.603
F	NS
CD	—

NS Not significant

Appendix 11. Interaction effect of NPK on monthly yield pattern (kg ha^{-1})

Treatments	Months					
	2	4	6	8	10	12
$n_1p_1k_1$	503.64	684.92	438.51	521.98	570.04	688.00
$n_1p_1k_2$	516.24	691.37	511.45	623.30	693.04	743.40
$n_1p_1k_3$	391.94	277.60	289.08	356.26	441.36	552.67
$n_1p_2k_1$	547.88	555.03	457.49	509.55	617.51	759.65
$n_1p_2k_2$	558.80	579.76	485.48	503.31	656.83	807.56
$n_1p_2k_3$	416.10	370.37	280.13	360.53	430.87	500.88
$n_1p_3k_1$	438.83	451.29	298.64	347.10	416.53	578.41
$n_1p_3k_2$	474.66	473.20	370.39	429.70	509.08	744.04
$n_1p_3k_3$	419.27	272.11	334.77	331.70	445.86	555.70
$n_2p_1k_1$	496.06	475.18	401.19	455.71	558.54	658.49
$n_2p_1k_2$	371.39	312.45	345.78	376.38	481.73	674.10
$n_2p_1k_3$	324.18	401.30	329.93	381.03	442.55	574.77
$n_2p_2k_1$	355.82	567.55	394.76	476.55	595.62	691.44
$n_2p_2k_2$	328.35	418.43	360.02	416.92	491.52	652.32
$n_2p_2k_3$	322.98	290.63	252.77	297.92	440.50	477.78
$n_2p_3k_1$	309.33	264.92	285.29	262.85	391.03	472.54
$n_2p_3k_2$	321.41	270.38	289.84	297.66	391.03	472.54
$n_2p_3k_3$	248.41	232.67	249.66	241.68	424.89	440.48
$n_3p_1k_1$	222.33	171.43	169.61	198.02	221.68	276.90
$n_3p_1k_2$	288.99	255.58	261.61	267.73	363.97	417.27
$n_3p_1k_3$	262.59	239.48	237.76	253.59	413.45	461.43
$n_3p_2k_1$	263.38	244.33	248.64	253.59	413.46	437.97
$n_3p_2k_2$	244.83	197.52	225.29	257.73	313.35	372.15
$n_3p_2k_3$	275.53	274.37	256.17	292.20	387.25	449.01
$n_3p_3k_1$	218.28	169.02	163.48	250.14	258.78	290.27
$n_3p_3k_2$	208.69	191.94	185.61	197.78	249.01	299.94
$n_3p_3k_3$	222.33	171.43	169.62	198.02	221.61	202.05
CI	225.03	213.80	184.05	230.67	273.58	389.46
CII	156.77	138.82	139.23	138.74	156.01	175.66
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—

NS Not significant

Appendix 12. Interaction effect of NPK on 100 bud weight (g)

Treatments	100 bud weight
$n_1p_1k_1$	24.91
$n_1p_1k_2$	25.52
$n_1p_1k_3$	24.04
$n_1p_2k_1$	26.86
$n_1p_2k_2$	25.35
$n_1p_2k_3$	24.27
$n_1p_3k_1$	23.68
$n_1p_3k_2$	22.70
$n_1p_3k_3$	23.99
$n_2p_1k_1$	21.86
$n_2p_1k_2$	22.37
$n_2p_1k_3$	22.65
$n_2p_2k_1$	22.13
$n_2p_2k_2$	22.21
$n_2p_2k_3$	23.46
$n_2p_3k_1$	22.63
$n_2p_3k_2$	22.76
$n_2p_3k_3$	21.44
$n_3p_1k_1$	21.11
$n_3p_1k_2$	21.79
$n_3p_1k_3$	21.50
$n_3p_2k_1$	21.28
$n_3p_2k_2$	21.15
$n_3p_2k_3$	22.09
$n_3p_3k_1$	21.10
$n_3p_3k_2$	22.63
$n_3p_3k_3$	21.82
CI	22.24
CII	19.70
F	NS
CD	—

NS Not significant

Appendix 13. Interaction effect of NPK on time taken for flower opening (hours)

Treatments	Time taken for flower opening
$n_1p_1k_1$	4.21
$n_1p_1k_2$	4.08
$n_1p_1k_3$	4.24
$n_1p_2k_1$	4.55
$n_1p_2k_2$	4.52
$n_1p_2k_3$	4.38
$n_1p_3k_1$	4.57
$n_1p_3k_2$	4.39
$n_1p_3k_3$	4.59
$n_2p_1k_1$	4.16
$n_2p_1k_2$	4.25
$n_2p_1k_3$	4.27
$n_2p_2k_1$	4.32
$n_2p_2k_2$	4.11
$n_2p_2k_3$	4.47
$n_2p_3k_1$	4.52
$n_2p_3k_2$	4.55
$n_2p_3k_3$	4.39
$n_3p_1k_1$	4.11
$n_3p_1k_2$	4.24
$n_3p_1k_3$	4.25
$n_3p_2k_1$	4.26
$n_3p_2k_2$	4.51
$n_3p_2k_3$	4.53
$n_3p_3k_1$	4.54
$n_3p_3k_2$	4.65
$n_3p_3k_3$	4.51
CI	4.30
CII	4.12
F	4.19^{**}
CD	0.152

** Significant at 1 per cent level

Appendix 14. Interaction effect of N, P, K, Mg, Zn on leaf nutrient content (per cent)

Treatments	N	P	K	Mg	Zn
$n_1p_1k_1$	2.19	0.71	4.51	0.052	0.03
$n_1p_1k_2$	2.12	0.63	5.34	0.056	0.031
$n_1p_1k_3$	2.85	0.67	5.86	0.063	0.025
$n_1p_2k_1$	2.17	0.74	4.84	0.056	0.024
$n_1p_2k_2$	2.44	0.71	5.83	0.063	0.035
$n_1p_2k_3$	2.64	0.73	6.13	0.042	0.028
$n_1p_3k_1$	2.24	0.77	4.63	0.048	0.029
$n_1p_3k_2$	2.14	0.79	5.66	0.036	0.035
$n_1p_3k_3$	2.32	0.76	6.08	0.037	0.023
$n_2p_1k_1$	2.92	0.70	4.84	0.057	0.029
$n_2p_1k_2$	2.84	0.71	5.85	0.071	0.037
$n_2p_1k_3$	3.05	0.73	6.63	0.061	0.031
$n_2p_2k_1$	2.75	0.74	4.71	0.062	0.028
$n_2p_2k_2$	2.35	0.72	5.44	0.058	0.033
$n_2p_2k_3$	2.63	0.76	6.41	0.048	0.024
$n_2p_3k_1$	2.87	0.78	4.71	0.052	0.028
$n_2p_3k_2$	2.92	0.77	5.35	0.053	0.030
$n_2p_3k_3$	3.13	0.77	6.26	0.052	0.027
$n_3p_1k_1$	3.36	0.72	4.44	0.063	0.028
$n_3p_1k_2$	3.32	0.71	5.42	0.054	0.023
$n_3p_1k_3$	3.07	0.73	6.26	0.064	0.032
$n_3p_2k_1$	2.84	0.73	4.83	0.066	0.036
$n_3p_2k_2$	3.09	0.73	5.61	0.055	0.026
$n_3p_2k_3$	3.41	0.78	5.55	0.061	0.026
$n_3p_3k_1$	3.15	0.77	4.52	0.055	0.027
$n_3p_3k_2$	3.08	0.74	4.97	0.057	0.028
$n_3p_3k_3$	3.54	0.74	6.30	0.062	0.032
CI	2.00	0.55	3.05	0.014	0.012
CII	1.33	0.34	2.10	0.004	0.002
F	1.035	0.242	2.16	0.006	0.002
CD	0.057	0.016	0.221	0.075	0.057

** Significant at 1 per cent level * Significant at 5 per cent level

Appendix 15. Interaction effect of NPK on carbohydrate content of flowering shoot (per cent)

Treatments	Carbohydrate content
$n_1p_1k_1$	23.03
$n_1p_1k_2$	21.21
$n_1p_1k_3$	21.42
$n_1p_2k_1$	20.03
$n_1p_2k_2$	20.74
$n_1p_2k_3$	16.29
$n_1p_3k_1$	21.29
$n_1p_3k_2$	17.04
$n_1p_3k_3$	17.53
$n_2p_1k_1$	17.25
$n_2p_1k_2$	18.44
$n_2p_1k_3$	17.53
$n_2p_2k_1$	17.50
$n_2p_2k_2$	19.05
$n_2p_2k_3$	19.31
$n_2p_3k_1$	17.77
$n_2p_3k_2$	17.61
$n_2p_3k_3$	17.40
$n_3p_1k_1$	17.34
$n_3p_1k_2$	17.93
$n_3p_1k_3$	16.50
$n_3p_2k_1$	16.37
$n_3p_2k_2$	19.68
$n_3p_2k_3$	18.69
$n_3p_3k_1$	17.65
$n_3p_3k_2$	16.60
$n_3p_3k_3$	18.20
CI	16.40
CII	11.30
F	17.38**
CD	0.912

** Significant at 1 per cent level

Appendix 16. Interaction effect of NPK on uptake of nutrients (kg ha^{-1})

Treatments	N	P	K	Mg	Zn
$n_1p_1k_1$	3.37	2.85	5.83	0.062	0.033
$n_1p_1k_2$	4.20	2.79	7.87	0.063	0.033
$n_1p_1k_3$	4.14	2.89	6.64	0.063	0.034
$n_1p_2k_1$	4.27	3.01	6.65	0.059	0.034
$n_1p_2k_2$	4.10	4.28	7.77	0.071	0.045
$n_1p_2k_3$	4.03	4.77	6.21	0.075	0.042
$n_1p_3k_1$	4.16	5.26	5.54	0.063	0.039
$n_1p_3k_2$	3.91	5.35	8.81	0.075	0.046
$n_1p_3k_3$	3.46	5.48	7.11	0.069	0.044
$n_2p_1k_1$	4.07	4.04	8.83	0.073	0.042
$n_2p_1k_2$	4.27	3.95	8.82	0.079	0.043
$n_2p_1k_3$	6.15	3.25	7.95	0.080	0.044
$n_2p_2k_1$	6.88	3.51	5.58	0.081	0.042
$n_2p_2k_2$	6.64	4.27	6.65	0.063	0.035
$n_2p_2k_3$	6.04	4.09	6.02	0.063	0.039
$n_2p_3k_1$	6.21	4.41	7.84	0.064	0.047
$n_2p_3k_2$	6.59	4.14	7.80	0.063	0.047
$n_2p_3k_3$	6.71	4.35	5.96	0.067	0.046
$n_3p_1k_1$	6.65	4.20	6.67	0.082	0.044
$n_3p_1k_2$	7.68	4.30	6.83	0.066	0.039
$n_3p_1k_3$	7.15	4.76	6.81	0.082	0.036
$n_3p_2k_1$	7.88	4.86	9.04	0.082	0.048
$n_3p_2k_2$	7.76	4.85	8.92	0.061	0.044
$n_3p_2k_3$	9.81	5.62	10.08	0.082	0.037
$n_3p_3k_1$	9.85	5.43	6.54	0.064	0.046
$n_3p_3k_2$	10.62	5.93	7.48	0.064	0.046
$n_3p_3k_3$	10.60	5.96	9.80	0.064	0.044
CI	4.92	2.616	3.143	0.027	0.024
CII	2.0	2.2	2.5	0.004	0.002
F	6.30**	7.03**	60.74**	24.27**	NS
CD	0.797	0.332	0.285	0.039	—

** Significant at 1 per cent level NS Not significant

Appendix 17. Interaction effect of NPK on essential oil content (per cent)

Treatments	Essential oil content
$n_1p_1k_1$	0.29
$n_1p_1k_2$	0.29
$n_1p_1k_3$	0.29
$n_1p_2k_1$	0.29
$n_1p_2k_2$	0.29
$n_1p_2k_3$	0.29
$n_1p_3k_1$	0.28
$n_1p_3k_2$	0.28
$n_1p_3k_3$	0.28
$n_2p_1k_1$	0.28
$n_2p_1k_2$	0.28
$n_2p_1k_3$	0.28
$n_2p_2k_1$	0.28
$n_2p_2k_2$	0.29
$n_2p_2k_3$	0.29
$n_2p_3k_1$	0.28
$n_2p_3k_2$	0.27
$n_2p_3k_3$	0.29
$n_3p_1k_1$	0.28
$n_3p_1k_2$	0.28
$n_3p_1k_3$	0.29
$n_3p_2k_1$	0.29
$n_3p_2k_2$	0.29
$n_3p_2k_3$	0.29
$n_3p_3k_1$	0.29
$n_3p_3k_2$	0.28
$n_3p_3k_3$	0.251
CI	0.287
CII	0.251
F	2.136**
CD	0.008

** Significant at 1 per cent level

Appendix 18. Interaction effect of NPK on available soil nutrients (kg ha^{-1})

Treatments	N	P	K
$n_1p_1k_1$	144.50	435.53	318.63
$n_1p_1k_2$	134.25	407.32	660.03
$n_1p_1k_3$	175.27	441.78	702.57
$n_1p_2k_1$	191.99	573.04	437.15
$n_1p_2k_2$	210.74	554.09	519.91
$n_1p_2k_3$	213.41	605.47	551.70
$n_1p_3k_1$	177.58	699.06	541.01
$n_1p_3k_2$	230.90	737.61	666.18
$n_1p_3k_3$	253.94	591.65	720.80
$n_2p_1k_1$	246.19	362.62	388.80
$n_2p_1k_2$	269.29	441.57	499.62
$n_2p_1k_3$	258.89	477.22	683.11
$n_2p_2k_1$	193.10	572.91	546.95
$n_2p_2k_2$	268.68	537.06	710.74
$n_2p_2k_3$	257.34	607.70	640.72
$n_2p_3k_1$	297.82	618.49	458.78
$n_2p_3k_2$	314.26	688.49	568.95
$n_2p_3k_3$	270.05	494.98	630.83
$n_3p_1k_1$	320.55	376.40	759.85
$n_3p_1k_2$	314.01	551.89	749.72
$n_3p_1k_3$	314.62	500.22	470.79
$n_3p_2k_1$	259.88	601.50	442.05
$n_3p_2k_2$	349.93	579.96	584.92
$n_3p_2k_3$	371.78	756.89	550.94
$n_3p_3k_1$	386.08	724.59	656.43
$n_3p_3k_2$	290.20	736.40	720.41
$n_3p_3k_3$	385.96	756.14	737.44
CI	150.07	314.68	397.68
CII	105.733	65.94	115.00
F	71.174**	11.66**	10.26**
CD	11.49	37.82	95.30

** Significant at 1 per cent level

Appendix 19. Interaction effectof NPK on shelf life of flowers ($V_0E_0S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	5.33	9.35	28.00
$n_1p_1k_2$	5.34	9.87	28.00
$n_1p_1k_3$	5.32	9.37	28.00
$n_1p_2k_1$	5.67	9.38	28.00
$n_1p_2k_2$	5.35	9.38	28.00
$n_1p_2k_3$	5.36	9.38	28.00
$n_1p_3k_1$	5.75	30.13	29.52
$n_1p_3k_2$	5.84	9.38	28.00
$n_1p_3k_3$	5.33	9.38	28.00
$n_2p_1k_1$	5.34	9.38	28.00
$n_2p_1k_2$	5.36	9.38	28.00
$n_2p_1k_3$	5.32	9.38	28.00
$n_2p_2k_1$	5.46	9.38	28.00
$n_2p_2k_2$	5.33	9.38	28.00
$n_2p_2k_3$	5.33	9.38	28.00
$n_2p_3k_1$	5.32	9.38	28.00
$n_2p_3k_2$	5.32	9.38	28.00
$n_2p_3k_3$	5.32	9.38	28.00
$n_3p_1k_1$	5.33	9.38	28.00
$n_3p_1k_2$	5.31	9.38	28.00
$n_3p_1k_3$	5.33	9.38	28.00
$n_3p_2k_1$	5.32	9.38	28.00
$n_3p_2k_2$	5.31	9.38	28.00
$n_3p_2k_3$	5.33	9.38	28.00
$n_3p_3k_1$	5.32	9.38	28.00
$n_3p_3k_2$	5.30	9.38	28.00
$n_3p_3k_3$	5.30	9.38	28.00
CI	5.34	19.38	58.00
CII	4.14	14.46	49.86
F	125.14^{**}	135.24^{**}	83.42^{**}
CD	0.02	0.02	0.02

** Significant at 1 per cent level

Appendix 20. Interaction effect of NPK on shelf life of flowers ($V_0E_0S_1$) hours

Treatments	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	516.00	586.80
$n_1p_1k_2$	516.00	586.80
$n_1p_1k_3$	516.00	586.80
$n_1p_2k_1$	516.00	586.80
$n_1p_2k_2$	516.00	586.80
$n_1p_2k_3$	516.00	586.80
$n_1p_3k_1$	516.00	586.80
$n_1p_3k_2$	516.00	586.80
$n_1p_3k_3$	516.00	586.80
$n_2p_1k_1$	516.00	586.80
$n_2p_1k_2$	516.00	586.80
$n_2p_1k_3$	516.00	586.80
$n_2p_2k_1$	516.00	586.80
$n_2p_2k_2$	516.00	586.80
$n_2p_2k_3$	516.00	586.80
$n_2p_3k_1$	516.00	586.80
$n_2p_3k_2$	516.00	586.80
$n_2p_3k_3$	516.00	586.80
$n_3p_1k_1$	516.00	586.80
$n_3p_1k_2$	516.00	586.80
$n_3p_1k_3$	516.00	586.80
$n_3p_2k_1$	516.00	586.80
$n_3p_2k_2$	516.00	586.80
$n_3p_2k_3$	516.00	586.80
$n_3p_3k_1$	516.00	586.80
$n_3p_3k_2$	516.00	586.80
$n_3p_3k_3$	516.00	586.80
CI	516.00	586.80
CII	500.02	586.80
F	NS	NS
CD	—	—

NS - Not significant

Appendix 21. Interaction effect of NPK on shelf life flowers ($V_0E_1S_0$) hours

Treatment	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	6.38	78.48	126.85
$n_1p_1k_2$	6.38	78.48	126.85
$n_1p_1k_3$	6.38	78.48	126.85
$n_1p_2k_1$	6.38	78.48	126.85
$n_1p_2k_2$	6.38	78.48	126.85
$n_1p_2k_3$	6.38	78.48	126.85
$n_1p_3k_1$	6.38	78.77	126.85
$n_1p_3k_2$	7.28	78.77	126.85
$n_1p_3k_3$	7.28	78.77	126.85
$n_2p_1k_1$	7.24	78.48	126.85
$n_2p_1k_2$	6.95	78.48	126.85
$n_2p_1k_3$	6.95	78.63	126.85
$n_2p_2k_1$	6.95	78.63	126.85
$n_2p_2k_2$	6.95	78.63	126.85
$n_2p_2k_3$	6.95	78.77	126.85
$n_2p_3k_1$	6.95	78.77	126.85
$n_2p_3k_2$	6.83	78.77	127.00
$n_2p_3k_3$	6.84	78.48	127.00
$n_3p_1k_1$	6.84	78.48	126.85
$n_3p_1k_2$	6.38	78.48	126.85
$n_3p_1k_3$	6.38	78.48	126.85
$n_3p_2k_1$	6.38	78.48	126.85
$n_3p_2k_2$	6.38	78.48	126.85
$n_3p_2k_3$	6.94	78.48	126.85
$n_3p_3k_1$	6.93	78.48	126.85
$n_3p_3k_2$	6.94	78.48	126.85
$n_3p_3k_3$	6.38	78.48	126.85
CI	6.25	78.48	125.00
CII	6.05	75.56	120.38
F	4.39^{**}	2.84^{**}	0.11
CD	0.37	0.14	0.11

** Significant at 1 per cent level

Appendix 22. Interaction effect of NPK on shelf life of flowers ($V_0E_1S_1$) hours

Treatment	Time taken for colour fading	Time take for loss of turgidity
$n_1p_1k_1$	516.00	586.80
$n_1p_1k_2$	516.00	586.80
$n_1p_1k_3$	516.00	586.80
$n_1p_2k_1$	516.00	586.80
$n_1p_2k_2$	516.00	586.80
$n_1p_2k_3$	516.00	586.80
$n_1p_3k_1$	516.00	586.80
$n_1p_3k_2$	516.00	586.80
$n_1p_3k_3$	516.00	586.80
$n_2p_1k_1$	516.00	586.80
$n_2p_1k_2$	516.00	586.80
$n_2p_1k_3$	516.00	586.80
$n_2p_2k_1$	516.00	586.80
$n_2p_2k_2$	516.00	586.80
$n_2p_2k_3$	516.00	586.80
$n_2p_3k_1$	516.00	586.80
$n_2p_3k_2$	516.00	586.80
$n_2p_3k_3$	516.00	586.80
$n_3p_1k_1$	516.00	586.80
$n_3p_1k_2$	516.00	586.80
$n_3p_1k_3$	516.00	586.80
$n_3p_2k_1$	516.00	586.80
$n_3p_2k_2$	516.00	586.80
$n_3p_2k_3$	516.00	586.80
$n_3p_3k_1$	516.00	586.80
$n_3p_3k_2$	516.00	586.80
$n_3p_3k_3$	516.00	586.80
CI	516.00	586.80
CII	500.01	586.80
F	NS	NS
CD	—	—

Appendix 23. Interaction effect of NPK on shelf life of flowers ($V_1E_0S_0$) hours

Treatments	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	5.86	31.48	67.13
$n_1p_1k_2$	5.86	31.48	67.13
$n_1p_1k_3$	5.86	31.48	67.13
$n_1p_2k_1$	5.86	31.48	67.13
$n_1p_2k_2$	5.86	31.48	67.13
$n_1p_2k_3$	5.86	31.48	67.13
$n_1p_3k_1$	5.86	33.42	67.13
$n_1p_3k_2$	5.86	31.48	67.13
$n_1p_3k_3$	5.80	31.48	67.13
$n_2p_1k_1$	5.86	31.48	67.13
$n_2p_1k_2$	5.86	31.48	67.13
$n_2p_1k_3$	5.86	31.48	67.13
$n_2p_2k_1$	5.86	31.48	67.13
$n_2p_2k_2$	5.86	31.48	67.13
$n_2p_2k_3$	5.86	31.48	67.13
$n_2p_3k_1$	5.86	31.48	67.13
$n_2p_3k_2$	5.86	31.48	67.13
$n_2p_3k_3$	5.86	31.48	67.13
$n_3p_1k_1$	5.86	31.48	67.13
$n_3p_1k_2$	5.86	31.48	67.13
$n_3p_1k_3$	5.86	31.48	67.13
$n_3p_2k_1$	5.86	31.48	67.13
$n_3p_2k_2$	5.86	31.48	67.13
$n_3p_2k_3$	5.86	31.48	67.13
$n_3p_3k_1$	5.86	31.48	67.13
$n_3p_3k_2$	5.86	31.48	67.13
$n_3p_3k_3$	5.86	31.48	67.13
CI	5.86	31.48	67.13
CII	5.86	31.48	67.13
F	NS	NS	NS
CD	—	—	—

NS - Not significant

Appendix 24. Interaction effect of NPK on shelf life of flower ($V_1E_0S_1$) hours

Treatments	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	516.00	586.80
$n_1p_1k_2$	516.00	586.80
$n_1p_1k_3$	516.00	586.80
$n_1p_2k_1$	516.00	586.80
$n_1p_2k_2$	516.00	586.80
$n_1p_2k_3$	516.00	586.80
$n_1p_3k_1$	516.00	586.80
$n_1p_3k_2$	516.00	586.80
$n_1p_3k_3$	516.00	586.80
$n_2p_1k_1$	516.00	586.80
$n_2p_1k_2$	516.00	586.80
$n_2p_1k_3$	516.00	586.80
$n_2p_2k_1$	516.00	586.80
$n_2p_2k_2$	516.00	586.80
$n_2p_2k_3$	516.00	586.80
$n_2p_3k_1$	516.00	586.80
$n_2p_3k_2$	516.00	586.80
$n_2p_3k_3$	516.00	586.80
$n_3p_1k_1$	516.00	586.80
$n_3p_1k_2$	516.00	586.80
$n_3p_1k_3$	516.00	586.80
$n_3p_2k_1$	516.00	586.80
$n_3p_2k_2$	516.00	586.80
$n_3p_2k_3$	516.00	586.80
$n_3p_3k_1$	516.00	586.80
$n_3p_3k_2$	516.00	586.80
$n_3p_3k_3$	516.00	586.80
CI	516.00	586.80
CII	500.62	586.80
F	NS	NS
CD	—	—

NS - Not significant

Appendix 25. Interaction effect of NPK on shelf life of flowers ($V_1E_1S_0$) hours

Treatments	Time taken for flower opening	Time taken for colour fading	Time taken for loss of turgidity
$n_1p_1k_1$	7.15	78.48	125.27
$n_1p_1k_2$	7.15	78.48	125.27
$n_1p_1k_3$	7.25	78.48	125.27
$n_1p_2k_1$	7.25	78.48	125.27
$n_1p_2k_2$	7.13	78.48	125.27
$n_1p_2k_3$	7.13	78.48	125.27
$n_1p_3k_1$	7.30	78.77	125.27
$n_1p_3k_2$	7.30	78.77	125.27
$n_1p_3k_3$	7.30	78.77	125.27
$n_2p_1k_1$	7.25	78.48	125.27
$n_2p_1k_2$	7.25	78.48	125.27
$n_2p_1k_3$	7.25	78.63	125.27
$n_2p_2k_1$	7.25	78.63	125.27
$n_2p_2k_2$	7.25	78.63	125.27
$n_2p_2k_3$	7.25	78.77	125.27
$n_2p_3k_1$	7.30	78.77	125.27
$n_2p_3k_2$	7.30	78.77	125.27
$n_2p_3k_3$	7.30	78.48	125.27
$n_3p_1k_1$	7.25	78.48	125.27
$n_3p_1k_2$	7.25	78.48	125.27
$n_3p_1k_3$	7.25	78.48	125.27
$n_3p_2k_1$	7.25	78.48	125.27
$n_3p_2k_2$	7.25	78.48	125.27
$n_3p_2k_3$	7.25	78.48	125.27
$n_3p_3k_1$	7.25	78.48	125.27
$n_3p_3k_2$	7.25	78.48	125.27
$n_3p_3k_3$	7.25	78.48	125.27
CI	7.25	78.48	21.00
CII	7.25	78.56	19.75
F	435.00**	2.84**	NS
CD	0.01	0.14	---

** Significant at 1 per cent level NS - Not significant

Appendix 26. Interaction effect of NPK on shelf life of flowers ($V_1E_1S_1$) hours

Treatments	Time taken for colour fading	Time for taken for loss of turgidity
$n_1p_1k_1$	516.00	586.80
$n_1p_1k_2$	516.00	586.80
$n_1p_1k_3$	516.00	586.80
$n_1p_2k_1$	516.00	586.80
$n_1p_2k_2$	516.00	586.80
$n_1p_2k_3$	516.00	586.80
$n_1p_3k_1$	516.00	586.80
$n_1p_3k_2$	516.00	586.80
$n_1p_3k_3$	516.00	586.80
$n_2p_1k_1$	516.00	586.80
$n_2p_1k_2$	516.00	586.80
$n_2p_1k_3$	516.00	586.80
$n_2p_2k_1$	516.00	586.80
$n_2p_2k_2$	516.00	586.80
$n_2p_2k_3$	516.00	586.80
$n_2p_3k_1$	516.00	586.80
$n_2p_3k_2$	516.00	586.80
$n_2p_3k_3$	516.00	586.80
$n_3p_1k_1$	516.00	586.80
$n_3p_1k_2$	516.00	586.80
$n_3p_1k_3$	516.00	586.80
$n_3p_2k_1$	516.00	586.80
$n_3p_2k_2$	516.00	586.80
$n_3p_2k_3$	516.00	586.80
$n_3p_3k_1$	516.00	586.80
$n_3p_3k_2$	516.00	586.80
$n_3p_3k_3$	516.00	586.80
CI	516.00	586.80
CII	500.02	586.80
F	NS	NS
CD	—	—

NS - Not significant

NUTRIENT REQUIREMENT AND POST HARVEST STUDIES ON BUSH JASMINE (*Jasminum sambac* Ait)

By

J. D. NIRMALATHA

ABSTRACT OF THE THESIS
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THE REQUIREMENT FOR THE DEGREE OF
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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

The experiment was conducted at the Department of Horticulture, College of Agriculture, Vellayani during 1998-1999 with the objective to standardise the nutrient requirement in bush jasmine and its post harvest studies.

The results of experiment I revealed that the growth characters like length of main shoot, number of primary branches, length of primary and secondary branches, spread of plant in East-West and North-South direction performed well at the highest dose of major nutrients applied viz., 600 kg N, 600 kg P_2O_5 and 600 kg K_2O ha^{-1}. The maximum number of secondary branches was obtained at 450 kg ha^{-1} of K_2O and P_2O_5.

The yield of flowers was highest at lower doses of major nutrients applied viz., 300 kg N, 300 kg P_2O_5 and 450 kg K_2O ha^{-1}.

Regarding monthly yield pattern lower levels of nutrients (N and P) gave better yield in general, potassium was effective at 450 kg K_2O ha^{-1}. During the growth period the effect of nutrients applied was significant initially then declined in between and finally the yield increased in tune with the season.

The 100 bud weight of flower buds was maximum at 300 kg ha^{-1} and 300 kg P_2O_5 ha^{-1}. The time taken for flower opening delayed at 600 kg P_2O_5 ha^{-1}.

Foliar nitrogen was maximum at highest levels of major nutrients applied. The leaf phosphorus content was maximum at 450 and 600 kg N ha^{-1}, 600 kg ha^{-1} of P_2O_5 and K_2O. Content of leaf potassium was highest at 450 kg ha^{-1} of N and P_2O_5 and 600 kg K_2O ha^{-1}. Foliar magnesium was high when nitrogen was applied at 600 kg N ha^{-1}, phosphorus at 300 kg ha^{-1}. Foliar zinc content was recorded the highest when 450 kg ha^{-1} of nitrogen and potassium was applied. Phosphorus applied at 450 and 600 kg P_2O_5 ha^{-1} increased the foliar zinc content.

Lowest dose of nitrogen (300 kg ha^{-1}) increased the carbohydrate content of flowering shoot.

Uptake of nitrogen and phosphorus was found effective at 600 kg N : 600 kg P_2O_5 : 600 kg K_2O ha^{-1}. But uptake of potassium was maximum at 600 kg N : 450 kg P_2O_5 : 450 kg K_2O ha^{-1}. The uptake of magnesium recorded highest value at 600 kg N : 300 kg P_2O_5 : 300 kg K_2O ha^{-1} and 450 kg K_2O ha^{-1}. Zinc uptake was maximum with highest dose of nitrogen and phosphorus applied and 300 and 450 kg K_2O ha^{-1} applied.

The essential oil content was maximum at n_1 and n_3 levels. The available soil N, P, K content was maximum at the highest dose of nutrient applied (600 kg N : 600 kg P_2O_5 : 600 kg K_2O ha^{-1}).

The experiment II on post harvest studies on bush jasmine proved significant effects between the treatments. For the treatment $V_0E_0S_0$ time taken for flower opening was delayed and the time taken for retention of colour and turgidity was maximum at lowest dose of N and K (300 kg ha^{-1}) and highest dose of P applied (600 kg P_2O_5 ha^{-1}).

The buds given ethylene absorbant treatment ($V_0E_1S_0$) along with major nutrients applied delayed the time taken for flower opening, retained colour at 450 kg ha^{-1} N and 600 kg P_2O_5 ha^{-1}. Time taken to retain turgidity was influenced by nitrogen at n_2. phosphorus at p_3 and potassium at k_2 and k_3 levels.

Post harvest treatment of buds with ethylene absorbants and newspaper lining ($V_1E_1S_0$) along with major nutrients applied increased shelf life. The time taken for flower opening (n_2. p_3, k_3) and the colour of flowers was retained longer at n_2 and p_3 levels.

In general the shelf life of flowers was extended by the various post harvest treatments compared to control. The time taken for flower opening was delayed maximum by ethylene absorbant treated buds. Low temperature treatment was best to increase the longevity of buds by retaining colour and turgidity,.

The present study revealed that lowest dose of fertilizer application (300 kg N : 300 kg P_2O_5 : 450 kg K_2O ha^{-1}) favoured the floral characters, whereas highest dosage increased vegetative growth. The shelf life of flowers can be enhanced by post harvest treatmens (ethylene absorbants and low temperature) along with fertilizer application.