NUTRIENT REQUIREMENT FOR BUSH JASMINE (*Jasminum sambac* Ait.)

By

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1999

Dedicated
to my beloved
Parents

DECLARATION

I hereby declare that this thesis entitled **"Nutrient requirement for 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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Vellayani,
1999.

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CERTIFICATE

Certified that this thesis entitled **"Nutrient requirement for bush jasmine (*Jasminum sambac* Ait.)"** is a record of research work done independently by **Mrs. Asha Raj** 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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ACKNOWLEDGEMENT

With immense pleasure, I wish to express my sincere and deep sense of gratitude and indebtedness to Dr. V.L. Sheela, Assistant Professor, Department of Horticulture, College of Agriculture, Vellayani and chairman of my Advisory committee for her sincere guidance, consistent and inspiring encouragement, constructive criticism and valuable suggestions throughout the course of investigation and preparation of the manuscript.

I would like to thank Dr. S. Ramachandran Nair, Professor and Head, Department of Horticulture, for his timely help, valuable suggestions at all stages of the study and critical scrutiny of the manuscript of the thesis.

I wish to acknowledge my sincere thanks to Dr. G. Sreekandan Nair, Professor and Head, Department of Plantation crops and Spices for his sincere help and co-operation during the period of study.

I wish to express my sincere thanks to Dr. Venugopal, Associate professor, Department of Soil science and Agriculture chemistry for the active assistance, sincere guidance and timely help during the course of research, chemical analysis and critical evaluation of the thesis.

My sincere thanks are due to Dr. Sabeena George. T, Associate Professor, Department of Horticulture, for her generous help and co-operation during the entire period of research work.

I am grateful to Dr. Saraswathi, Professor and Head of Department of Agricultural statistics for her help in the statistical analysis and interpretation of the experimental data.

My thanks are due to all the teaching and non teaching staff, Department of Horticulture, for the help rendered during the course of research work.

I am thankful to the Kerala Agricultural University for awarding a fellowship for the PG programme.

I sincerely thank M/s. Athira Computers, Kesavadasapuram, Thiruvananthapuram, for the sincere and careful computer work.

My heartful thanks to Priya, Preethi, Gayathri, Jubina, Resmi, Radhika, Sarada, Anu and all my friends for their valuable help and loving wishes for completing the study.

Last but not the least, I wish to acknowledge my sincere thanks for the encouragement and moral support provided to me by my husband Dr. S. Jayachandran and members of my family especially my son Master Shambu, brother Dr. R. S. Bimal, sister in law Mrs. Sheeba Jayadev and cousins Miss Parvathi and Miss. Lekshmy without which I would not have succeeded to complete this work.

Above all to God, the Almighty for making me optimistic, giving good health and confidence for successful completion of this work.

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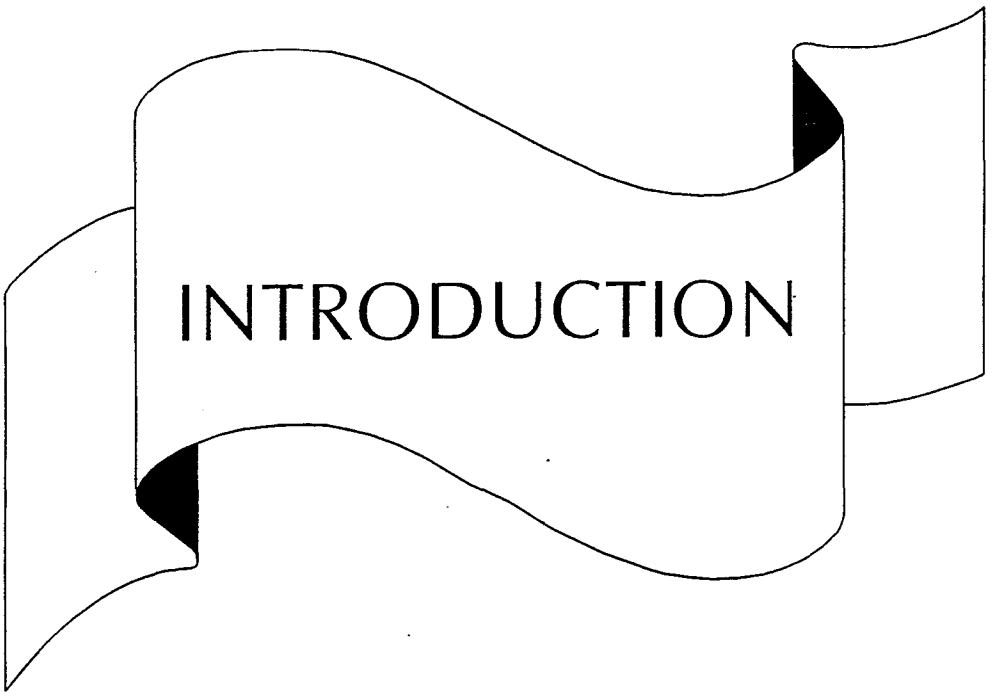

INTRODUCTION

INTRODUCTION

In the present agricultural scenario of the country, commercial floriculture is gaining more and more importance. Jasmine is one of the most important commercial flower crops cultivated throughout India and is esteemed for its attractive fragrant flowers. One of the most important traditional flower crops of the country, jasmine offers excellent uses in garland making, religious offerings, personal adorning by women etc. In the important flower markets of the five big cities of India, such as Calcutta, Bombay, Delhi, Madras and Bangalore, it is estimated that about 15,000 kg of loose flowers of jasmine are sold every day (Dohare *et al.*, 1978). The essential oil extracted from jasmine flowers is of high value in perfume industry. Currently India exports jasmine flowers to Singapore, Malaysia, Srilanka and West Asian countries.

The genus Jasminum belongs to family Oleaceae and about forty species of this genus are found to occur in India (Natarajan, 1977). The three major cultivated species are *J. auriculatum*, *J. grandiflorum* and *J. sambac*. Of these, the cultivation of bush jasmine (*Jasminum sambac* Ait.) is an emerging business for small and marginal cultivators, and in homesteads as a source of income or small scale enterprise for housewives. Expanding the area under cultivation of jasmine would also

enable us to meet atleast partially the demand for this flower which is now met almost entirely by our neighbouring states.

Practically no studies have so far been conducted regarding the nutrient requirements for bush jasmine in Kerala. Majority of farmers who have started cultivation of this crop are now facing difficulties due to lack of sufficient information regarding the management practices for the crop. With these points in view, a study was undertaken with the objective to standardise the requirement of major nutrients (N, P and K) for the growth and flowering of bush jasmine.


REVIEW OF
LITERATURE

REVIEW OF LITERATURE

The Literature on nutrition of ornamental plants relevant to the present study has been reviewed in these pages

2.1. Effect of nutrients on morphological characters

2.1.1. Nitrogen (N)

Effect of N on vegetative characters was reported by several research workers.

Maximum length of primary and secondary laterals (75.35 cm and 67.04 cm respectively) at 90 g N plant^{-1} was reported by Srinivasan *et al.* (1989) in *Jasminum sambac* Ait. cv. Gundumalli. However N at 30 g plant^{-1} recorded only 61.33 cm and 42.79 cm.

Increased application of nitrogen increased the height and number of branches in *Jasminum sambac* (Bhattacharjee, 1985a).

The height of *Jasminum sambac* sol. var. Khoya increased as a function of applied nitrogen irrespective of level of phosphorus as reported by Pal *et al.* (1985). They also found a beneficial effect of N on the number of branches produced.

Bhattacharjee (1983) also supported increased vegetative growth as a consequence of N application in *Jasminum grandiflorum* L. He also conducted another trial in *Jasminum grandiflorum* (1988) and found that application of N at 33.3 g each during December, April and August promoted shoot length by 8.51 per cent whereas, production of more shoots was stimulated by 35.85 per cent.

Natarajan (1977) in his studies with *Jasminum grandiflorum* observed that the plant height varied significantly with increasing N levels. The number of secondary laterals was found higher upto 60 g N plant^{-1}.

Height of *Jasminum auriculatum* showed significant variation on applying nitrogenous fertilizers (Pal *et al.*, 1984). The plants treated with 35g N per square meter produced 173 branches plant^{-1} compared to 85 branches in untreated ones. Also, spread of the upper portion of plants was found to increase with higher levels of nitrogen.

Jayaprakash and Sulladmath (1978) in their studies with rose cv. "Superstar" noted that the height and number of branches increased due to the application of nitrogenous fertilizers.

With respect to height of *Gladiolus grandiflora*, Deswal *et al.* (1982) found the most effective dose of N as 50 kg ha^{-1}. According to Bik (1972) increasing N levels had a favourable effect on stem length of roses.

Young *et al.* (1973) obtained longest stem in roses when N rate was slightly lower than 2576 kg ha^{-1}.

2.1.2. Phosphorus (P)

Srinivasan *et al.* (1989) reported significant increase in the length of both primary and secondary lateral shoots by P treatment in *Jasminum Sambac* Ait. cv. Gundumalli. Phosphorus at 120g recorded the highest shoot length of 68.72 cm and 58.99 cm for primary and secondary laterals, whereas P at 60 g recorded only 66.06 and 52.10 cm respectively. In *Jasminum auriculatum* a general reduction in number of branches was observed with P application (Pal *et al.*, 1984). Maximum branching was recorded in plant without P treatment.

Young *et al.* (1973) in an experiment to assess the effect of P on performance of rose, noted that independent effects of P on stem length was minor and lower levels seemed best. The doses of P applied were 0, 97.5 and 195 kg ha^{-1}. In bougainvilleas P application increased shoot length (Bose and Jana, 1978).

In chrysanthemum, Joiner (1967) obtained an increased stem length and flower diameter with increasing P levels. However Deswal *et al.* (1982) obtained no significant increase in final height of gladiolus plants with P application.

2.1.3. Potassium (K)

Deswal *et al.* (1982) registered significant increase in plant height of gladiolus with K application.

2.1.4. Nitrogen, phosphorus and potassium

In a fertilizer trial Amarjeet *et al.* (1996) found that application of high rates of N, P and K (N - 0, 100, 200, 300 and 400 kg ha^{-1}, P and K both at 0, 100 and 200 kg ha^{-1}) significantly increased length of spike and rachis while increase in K application increased rachis length in *Polianthes tuberosa* cv. Single.

Jhon *et al.* (1997) in an experiment with gladiolus cv. 'Oscar' found that at nitrogen dose of 100 kg ha^{-1} and P_2O_5 and K_2O at 50 kg ha^{-1} each produced tallest plants with the longest spikes.

2.2. Effect of nutrients on yield

2.2.1. Nitrogen

Pal *et al.* (1985) reported highest flower yield in *Jasminum sambac* obtained on a plot with 40,000 plants per hectare receiving N at 350 kg ha^{-1}. Rameshkumar and Gill (1983) studied the effect of N application on the flower yield of young plants of *Jasminum sambac* and recorded that plants receiving N at 30 g $plant^{-1}$ gave the highest yield of flower buds (635.8 g $plant^{-1}$) whereas the control yielded only 353.7 g $plant^{-1}$.

Effect of N application on flower yield of *Jasminum sambac* was further studied by Rameshkumar and Gill (1983). They concluded that flower yield was maximum both by number and weight with N at 30 g plant^{-1}.

In *Jasminum sambac* it was observed that the application of N as foliar spray at 30 g plant^{-1} is more economical than the conventional method of applying N at 120 g plant^{-1} through the soil (Anon 1975).

Srinivasan *et al.* (1989) was of opinion that application of N had a significant influence on flower bud length, bud diameter and weight of hundred buds in *Jasminum sambac*. Maximum flower bud length was noted with N at 30 g (1.261 cm) while increase in dose from 30 to 90 g reduced the weight of flower buds.

Natarajan *et al.* (1981) recorded highest flower yield (2.19 t ha^{-1}) with 40 g N plant^{-1} in *Jasminum sambac* Ait cv. Gundumalli.

In a field trial with *Jasminum grandiflorum*, Bhattacharjee (1985) reported significant improvement in yield as a function of N dose.

Nofal and Marvan (1982) in *Jasminum grandiflorum* reported that the flower yield was highest at medium N level of 600 kg per feddan. This dose is followed by the low N level of 300 kg/feddan (1 Feddan = 1.038 acres).

In *Jasminum grandiflorum*, Bhattacharjee (1988) found, application of N at 33.3 g each during December, April and August increased flower yield by 28.67 per cent over single application of 100 g N plant^{-1} during December.

Natarajan and Rao (1979) reported that N at 60 g plant^{-1} gave better flower yield in *Jasminum grandiflorum*.

In a study with the effects of foliar application of N in *Jasminum grandiflorum*, Bhattacharjee (1989) recorded maximum yield of flowers with 50 g N as foliar spray. However the requirement of N can be reduced to half the recommended dose in soil with much better results than if applied as foliar spray.

Srinivasan *et al.* (1989) reported that increasing level of N generally delayed onset of flowering in *Jasminum sambac*. Similar results was also observed by Natarajan and Rao (1979) in *Jasminum grandiflorum*.

Yield increase of 28.67 per cent over the control in *Jasminum grandiflorum* was reported by Bhattacharjee (1988). His finding was resulted from a trial in applying N at 33.3 g each in December, April and August. However, with *Jasminum auriculatum*, Muthuswamy and Pappiah (1976) reported that plants receiving N at 120 g recorded more flower yield compared to N at 240 g or with no N.

Pal *et al.* (1984) observed that flower the yield was increased with increasing N rates in *Jasminum auriculatum.* The maximum yield (1985.5 kg ha^{-1}) of flowers was obtained by treatment with 35 g N per square meter (350 kg ha^{-1}) whereby the untreated plants produced 392 kg ha^{-1}. In an evaluation study with *Jasminum auriculatum,* Muthuswamy and Pappiah (1980) observed highest flower yield over control by foliar spray of N at 60 g $plant^{-1}$. For maximum flower yield Venkatakrishna (1982) recommended 120 g N $plant^{-1}$ in *Jasminum multiflorum.*

Baiman *et al.* (1997) conducted an experiment with *Polianthes tuberosa* var. Single and found that tallest plants were obtained when 25 per cent of N (total dose = 200 kg ha^{-1}) was applied at planting, and 75 per cent applied 60 days later. Split application of N however was not found to affect bulb production and flowering.

Tuberose cultivars were tested by Wange and Patil (1994) who observed a significant increase in the number of flower stalk and number of flowers per stalk on application of 100 kgh a^{-1} N alone or inoculating with biofertilizer (Azetobacter + Azospirillum).

In Rose, Tajuddin *et al.* (1995) obtained an increase in number of flowers $plant^{-1}$ with increasing rate of N application although only the difference between 0 and 150 kg nitrogen ha^{-1} were significant (N rates - 0, 75 or 150 kg ha^{-1}).

Damke and Bhattacharjee (1995) conducted a field trial on Rosa hybrids cv. 'Superstar' and found that flower yields were highest at 125 g P_2O_5 + 100 g K_2O and 75 g N m^{-2}.

Deswal *et al.* (1982) registered maximum response in flower yield of *Gladiolus grandiflora* at 100 kg N ha^{-1}. Greatest number of flowers with 2576 kg N ha^{-1} in rose cultivar 'Christion Dior' and in 'Happiness' with 2352 kg N ha^{-1} was obtained by Young *et al.* (1973).

2.2.2. Phosphorus

Pal *et al.* (1985) on *Jasminum sambac* sol. var. 'Khoya' suggested although the effect of phosphorus on flower yield was not statistically significant, an appreciable increase in yield was recorded at 30 g P_2O_5 per square meter.

In *Jasminum grandiflorum*, Natarajan and Rao (1983) obtained early flowering by a low N and high P levels, while Bhattacharjee (1985) reported P_2O_5 at 150 g $plant^{-1}$ $annum^{-1}$ improved flowering. However, application of P at 0, 120 and 240 g $plant^{-1}$ per year did not increase yield in *Jasminum auriculatum* (Muthuswamy and Pappiah, 1976).

Bankar and Amitabha Mukhopadhyay (1985) registered higher spike yield at 80 g P_2O_5 than that of 60 g P_2O_5 in *Polianthes tuberosa*. Pal *et al.* (1984) obtained no beneficial effect in *Jasminum auriculatum* with increasing P rates.

High P increased spikes and florets in tuberose (Jana *et al.*, 1974). Nanjan *et al.* (1980) on the other hand was of opinion that a dose of 60 kg P_2O_5 ha^{-1} may be sufficient to have a good crop in tuberose, provided the N applied is adequate.

Young *et al.*, (1973) in an experiment to assess the effect of P on performance of rose observed independent effects of P on stem length was minor and lower levels seemed sufficient. The doses of applied phosphorus was 0, 97.5 and 195 kg ha^{-1}.

2.2.3. Potassium

Natarajan *et al.* (1981) got maximum flower yield (12.19 t ha^{-1}) in *Jasminum sambac* at 40 g K $plant^{-1}$ along with equal dose of N and P. Also Bhattacharjee (1985) found that in *Jasminum grandiflorum* L. K_2O at 100 g $plant^{-1}$ $annum^{-1}$ improved flowering. The results confirmed those of a previous trial carried out in 1980-81 in same species by Bhattacharjee (1983).

No significant increase in yield of flowers was observed when K was applied independently at 0, 120 and 240 g $plant^{-1}$ $year^{-1}$ in *Jasminum auriculatum* Vahl. (Muthuswamy and Pappiah, 1976).

Deswal *et al.* (1982) in *Gladiolus grandiflorum* cv. H.B. Pitt. registered increased production of florets per spike with K application, while in *Polianthes tuberosa*, Bankar and Amitabha Mukhopadhyay (1985) proved K_2O fertilization had not much effect on spike yield.

Bik (1970) and (1972) found no effect of K levels on the flower production and yield of roses. On the other hand Young *et al.* (1973) reported decreasing yield with increasing rates of K from 279 to 2111 kg ha^{-1} in 'Happiness' and 'Christian Dior' rose cultivars.

2.3. Effect of split application of Nitrogen, Phosphorus and Potassium on yield

According to Natarajan *et al.* (1981), bimonthly applications of 40 g each of N, P and K $plant^{-1}$ gave the highest flower yield (12.19 t ha^{-1}) in *Jasminum sambac* Ait. cv. Gundumalli.

In *Jasminum sambac* cv. JSL-1, Rameshkumar and Gill (1983) observed that those receiving N at 30 g $plant^{-1}$ in split doses, half the amount at pruning and remaining half at the end of first flowering flush (late May) gave the highest yield of flower buds (635.8 g $plant^{-1}$). The control, yielded only 353.7 g $plant^{-1}$. Pal *et al.* (1985) obtained the highest flower yield in *Jasminum sambac* with N and P_2O_5 at 350 and 300 kg ha^{-1} respectively.

According to Srinivasan *et al.* (1989) applying N and P in four bimonthly doses resulted in the earliest flowering but other floral characteristics were not affected by split application in *Jasminum sambac* Ait. cv. Gundumalli.

In a trial with *Jasminum grandiflorum*, Muthuswamy and Pappiah (1977a) reported that yield, flower bud diameter and weight of hundred flower buds were maximum with Farm Yard Manure and NPK applied together in six split doses. In another trial, the same authors (1977b), reported foliar application of N at 30-120 g $plant^{-1}$ + soil applied P and K each at 240 g $plant^{-1}$ $year^{-1}$ in two split doses was compared with soil application of FYM and N, P, K in two, six and twelve split doses. Flower bud yield, weight of 100 flower buds and the percentage recovery of essential oil were highest with FYM + NPK in 12 split doses. Foliar N was found to depress flower yields, even at the lowest N level.

Natarajan and Madhava Rao (1980a) studied the effect of frequency of fertilizer application on *Jasminum grandiflorum* and observed that split application showed little effect on vegetative growth and floral characteristics, but the maximum flower yield (3.642 kg $plant^{-1}$) and essential oil content (9.69 g $plant^{-1}$) were recorded when 15 kg FYM, 60 g N, 120 g P and 120 g K were applied $plant^{-1}$ in 12 monthly applications followed by the same dose in bimonthly application.

In another trial, Natarajan and Madhava Rao (1980b) reported that application of N at 60 g and P_2O_5 at 120 g singly and together markedly enhanced the flower yield in *Jasminum grandiflorum*. The best result, however was obtained when N and P rates were combined with 240 g K_2O and 30 kg FYM $plant^{-1}$. They obtained early flowering at low N and high P levels.

In *J. grandiflorum*, Natarajan and Rao (1983) applied 15 kg Farm Yard Manure. 60 g N, 120 g P_2O_5 and 120 g K_2O plant^{-1} year^{-1} in twelve split doses. According to them, the split application of fertilizer did not affect floral characters over single annual application. They obtained early flowering with low N and high P levels.

In *Jasminum grandiflorum* better flower yield resulted when N and P_2O_5 were applied at 60, 120 and 240 g K_2O plant^{-1} year^{-1} (Natarajan and Rao, 1979).

Kumaraguruparan (1974) registered increased flower yield in *Jasminum grandiflorum* with the foliar application of P and K at 120 g plant^{-1}. Highest flower yield was reported in *Jasminum grandiflorum* at 578 kg N acre^{-1} followed by 300 kg N acre^{-1} by Nofal and Marwan, 1982.

In *Jasminum grandiflorum*, low N levels and high P levels ie., 15 kg FYM plant^{-1} and 60 g N, 120 g P and 120 g K plant^{-1} applied in 12 split doses annually have been found to promote earliness in flowering. Nevertheless, split application of fertilizers did not affect other floral characters as compared with a single annual application. Treatment with 100 g N, 150 g P_2O_5 and 100 g K_2O plant^{-1} annually resulted in the highest flower yield (Bhattacharjee, 1985).

Application of NPK at 60:120:120 g plant^{-1} along with 10 kg FYM applied in 2 splits was found to be optimum in *Jasminum grandiflorum* (Muthuswamy and Abdul Khader, 1986).

The results of a four year trial with *Jasminum auriculatum* receiving N, P and K each at 0, 120 and 240 g plant^{-1} annually in all possible combinations showed that flower yield was highest with N at 120 or 240 g plant^{-1}. The effects of P and K alone were not very pronounced, but with N at 120 g plant^{-1}, there was response to K at 120 g plant^{-1}. The level of N could be reduced to half the recommended dose of 120 g plant^{-1} if applied as foliar spray at monthly intervals (Muthuswamy and Pappiah, 1976).

It was observed in a field experiment in *Jasminum auriculatum* Vahl. that greater length, diameter of flower bud at peak harvest, maximum number of flowers plant^{-1} and flower yield were obtained on pruning in the last week of November along with applying 60 g N; 120 g P, 120 g K plant^{-1} (Hugar and Nalawadi, 1994).

Amarjeet *et al.* (1996) in a fertilizer trial with *Polianthes tuberosa* cv. 'Single', found application of high rates of N, P and K (N - 0, 100, 200, 300 and 400 kg ha^{-1}, P and K each at 0, 100 and 200 kg ha^{-1}) delayed spike emergence and considerably prolonged the flowering period and shelf life of flowers.

Tajuddin *et al.* (1995) in one year old rose cv. Trigintipetala conducted fertilizer trial with P_2O_5 (0, 40, 80 kg ha^{-1}) and K_2O (0, 60 kg ha^{-1}) applied as basal and N (0, 75, 150 kg ha^{-1}) applied in 3 equal splits

and found that N had a significant effect on number of flowers per plant although difference between 0 and 150 kg N ha^{-1} were significant.

In *Polianthes tuberosa* L. var. 'Single', Gopalakrishnan *et al.* (1995) found that average number of flowers / spike and flower diameter were greatest with 120 kg N + 60 kg P_2O_5 + 30 kg K_2O ha^{-1}.

Damke and Bhattacharjee (1995) in *Rosa hybrida* cv. 'Superstar' obtained highest flower yield (53.75 flowers $plant^{-1}$) with 75 g N, 125 g P and 100 g K per plot. In gladiolus cv. 'Oscar', longest spikes and more florets per spike were obtained by Jhon *et al.* (1997) with 100 kg ha^{-1} of N, P_2O_5 and K_2O each at 50 kg ha^{-1}.

2.4. Interaction effects of nutrients

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

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

In *Jasminum auriculatum* Vahl., Muthuswamy and Pappiah (1976) did not register any significant effects of N x P interaction on yield of flower. But the highest yield of 4015 g was registered under 120 g N and 240 g phosphorus plant^{-1}. 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 registered a slightly 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 each) 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).

Maximum weight of flowers plant^{-1} and diameter of flowers were recorded with 200 kg each of N and P in chrysanthemums by Begalonkar *et al.* (1997).

Khankhana *et al.* (1997) obtained from a field experiment, high yield (8.65 and 7.32 t ha^{-1} respectively) and quality of flowers on applying 30 g N and 20 g P_2O_5 m^{-2} in 'Yellow Bijali' chrysanthemum.

Singh *et al.* (1996) in *Polianthes tuberosa* L. studied the effect of NPK on bulb production. It was found that there was significant interaction between N and P in bulb yield.

In *Gladiolus grandiflora* cv. 'H.B. Pitt', Deswal *et al.* (1982) found the interactions of N x P and N x P x K were significant, in

increasing the plant height and yield of florets. It was also found that effect of N was enhanced in the presence of P and individual response of N, P and K were increased in presence of all these nutrients.

2.5. Effect of nutrients on essential oil content

In *Jasminum sambac* it was observed that application of N doses does not affect the concrete recovery (Rameshkumar and Gill, 1988).

Nofal and Marwan (1982) in a two season study in *Jasminum grandiflorum* with N at 300, 600 and 900 kg per feddan (1 Feddan = 1.038 acres), found concrete content was unaffected by N levels, but a slight increase in absolute content was noted in plants receiving highest N level. The quality of concrete and absolute was not affected by the treatments.

In *Jasminum grandiflorum*, Bhattacharjee and Divakar (1983) recorded that, treatment with increased doses of N (0 to 100 g) and P (0 to 150 g) significantly increased the percentage of floral concrete, while addition of K did not improve the concrete content. The percentage of floral absolute also increased significantly with increased doses of N (0 to 150 g), but no significant difference was resulted with addition of P and K.

Natarajan and Rao (1983) also reported that high oil content in *Jasminum grandiflorum* was generally obtained with high N and P levels.

30 kg FYM, 120 g N 240 g each of P and K plant^{-1} year^{-1} was found by them as best dose with regard to high oil recovery.

The requirement of nutrients for essential oil recovery was found reduced with split application of fertilizers was reported by Natarajan and Madhava Rao (1980) in *Jasminum grandiflorum*. Accordingly essential oil content was highest (9.69 g plant^{-1}) when 15 kg Farm Yard Manure, 60 g N, 120 g P and 120 g K were applied once in a month in 12 splits.

Nandakumar (1976) reported no increase in essential oil content due to application of 120 g N, 240 g P and 240 g K plant^{-1} year^{-1} in *Jasminum auriculatum* Vahl.

Pal *et al.* (1984) registered high flower yield of *Jasminum auriculatum* and essential oil content with rising N levels, but P had no beneficial effect.

Maximum content and yield of essential oil in *Menta pipperita* was reported by Dellacecca *et al.* (1997) with application of N at 200 kg ha^{-1}. Eventhough P was found to have no effect on yield, menthol and methyl acetate contents in essential oil were maximum in crops grown with 150 kg P_2O_5 ha^{-1}.

Subina and Masanova (1970) reported that by applying N and P

each at 90 kg hectare^{-1} increased the content of essential oil in flowers of 'Red Crimea' roses, whereas K reduced the oil yields.

Increased oil content by 35 per cent was noted by application of N and reduction by 37 per cent was noted when K was applied in pot cultured *Menta pipperita* Linn. plants (Franz, 1979).

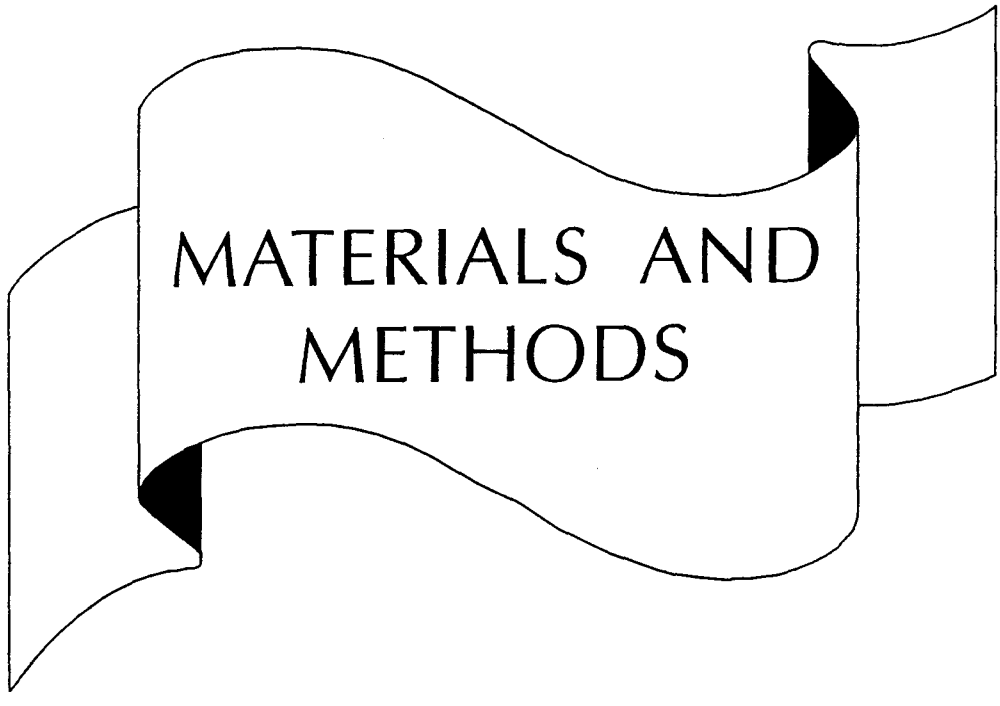
However, Harnok (1974) did not observe changes in essential oil content due to supply of nutrients in peppermint.

2.6. Effect of fertilizers on chemical composition

The studies of Kumaraguruparan (1974) on *Jasminum grandiflorum* Linn revealed the following:

The leaf N content increased during the preflowering, peak flowering and post flowering phases by foliar application of N at 60 g and 120 g plant^{-1} year^{-1}. The leaf N content was found reduced in foliar applications combining N and K, while there occured an increase at peak flowering and post flowering phases by foliar spray of P at 240 g plant^{-1} year^{-1}. The foliar P alone did not affect the leaf P content, but in combination with N, there occurred an increase. A linear relation was found between the applied K and content of K in leaves. N also influenced the carbohydrate content when applied either alone or in combination with P and K.

Bik (1970) showed that leaf analysis gave a better indication of the flower yield in roses. Optimum leaf contents of N and K appeared to be 3.8 per cent and 2.1 per cent respectively and that the optimum N:K ratio 1:1.


MATERIALS AND
METHODS

MATERIALS AND METHODS

The field trial for the present investigation was laid out in the garden attached to the Department of Horticulture, College of Agriculture, Vellayani. The trial was undertaken for standardising the requirement of major nutrients (N, P and K) for optimum growth and flowering of bush jasmine.

The materials and methods used for the study are detailed below.

Location

The experimental site was a part of college garden under department of Horticulture. The site was located 29 meter above MSL with latitude 8.5° N and longitude 76.9° E.

Climate

Parameters like minimum and maximum temperature, relative humidity, rainfall and sunshine intensity were recorded during the period under study. (Appendix - 1).

Materials for study

Young rooted cuttings of *Jasminum sambac* formed the material for the investigation.

Field preparation and planting

The field was thoroughly dug and the weeds removed. After levelling, pits of size 45 cm x 45 cm x 30 cm were taken. Spacing adopted was 1 x 1.25 m. 10 kg FYM was applied in each pit and was incorporated with top soil before planting. Planting was done in rows in such a way that there were seven plants in one row. In between two adjacent plants, a distance of 1 m was given and in between adjacent rows 1.25 m was left. To prevent attack of termite Sevidol was applied.

Experimental design and layout

The experiment was 3^3 + 2 Factorial and the design adopted was Randomised Block Design. The details of layout are as follows.

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

Treatments consisted of all possible combinations of three levels each of nitrogen, phosphorus and potassium.

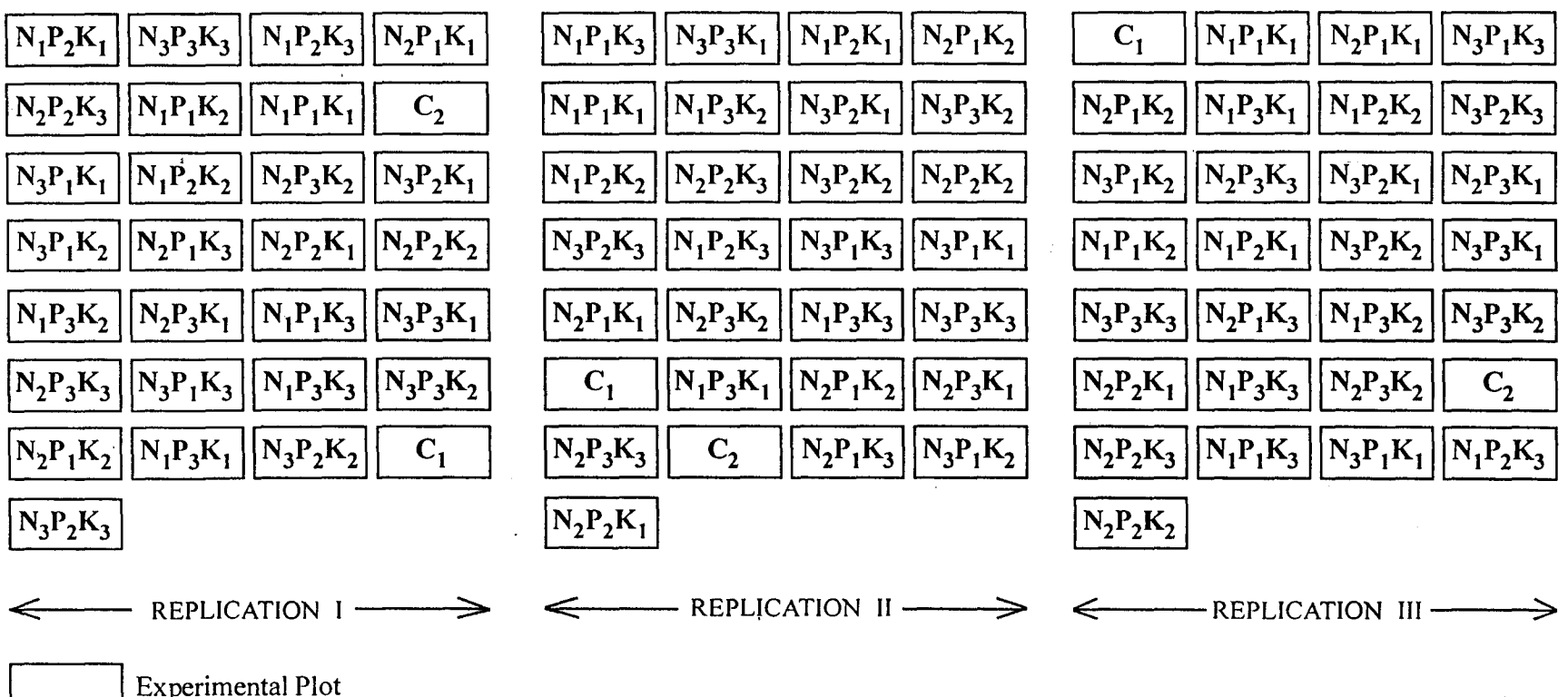


Fig. 1. LAYOUT PLAN 3^3+2 FACTORIAL RANDOMISED BLOCK DESIGN

Plate 1. Field view of the experimental plot


Design: RBD
Treatment: 3*1-19
Replications: 3
Date of planting: May 21

(i) Levels of nitrogen

1. n_1 - 50 kg ha^{-1}
2. n_2 - 100 kg ha^{-1}
3. n_3 - 150 kg ha^{-1}

(ii) Levels of phosphorus

1. p_1 - 50 kg ha^{-1}
2. p_2 - 100 kg ha^{-1}
3. p_3 - 150 kg ha^{-1}

(iii) Levels of potassium

1. k_1 - 50 kg ha^{-1}
2. k_2 - 100 kg ha^{-1}
3. k_3 - 150 kg ha^{-1}

(iv) Controls

1. C_1 - Absolute control - with no Farm Yard Manure (FYM) and no fertilizers.
2. C_2 - Control with only Farm Yard Manure (FYM 10 kg $plant^{-1}$)

Soil nutrient status

The soil was red laterite, acidic and low in available nitrogen and potassium but high in available phosphorus. (Appendix - 2).

Fertilizer application

The fertilizers applied were urea, rock phosphate and muriate of potash, in six equal split doses at bimonthly intervals.

Observations

Observations were recorded from the date of planting at monthly intervals.

3.1 Vegetative characters

3.1.1 Length of main shoot

The length of longest central shoot was measured from the base of shoot upto the base of terminal pair of leaves 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 were counted. The number of lateral shoots that were seen to develop from main shoot was recorded as primary branches.

3.1.3 Number of secondary branches

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

3.1.4 Length of primary branches

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

3.1.7 East-West spread of the plant

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

3.2 Flowering and floral characters

3.2.1 Number of days taken for first flower picking

The days after pinching the flower buds formed were ready for harvesting was counted.

3.2.2 Weight of hundred buds

Fully developed unopened flowerbuds were picked at 2 pm. Weight of hundred flower buds were recorded for the observation period of six months. The average weight of buds in each treatment was taken and expressed in grams.

3.2.3 Time taken for opening of flowers after harvest

Flowers were harvested at 2 p.m. and time for opening of flowers after harvest was recorded.

3.2.4 Flower yield

As the plants were very young at the time of planting, flowering observations were taken after 6 months from planting, when flowering was started. The total weight of flower buds received during every day for each of the treatments were recorded and yield expressed in kg ha^{-1} yr^{-1}. 8000 plants could be accommodated per hectare according to spacing of 1.25 x 1 m.

3.2.5 Monthly yield pattern

The weight of flower buds recorded from each plant receiving particular treatment were recorded. From this daily yield, monthly yields were arrived and expressed in kg ha^{-1} per month.

3.3 Content of nutrients in leaves

Leaf samples were analysed before and after the application of fertilizer.

The technique of sampling suggested for shrubs by Davidson (1960), Cannon *et al.* (1960) and Smith (1972) was followed. The dried powdered samples were used for determining nutrient status of leaves.

Leaf analysis

No.	Nutrient	Method	Reference
3.3.1	**Nitrogen**	Microkjeldal method	Jackson (1970)
3.3.2	**Phosphorus**	Vanado-molybdate yellow colour method	Jackson (1970)
3.3.3.	**Potassium**	Flame photometer	Jackson (1970)

3.4 Content of nutrients in soil

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

Soil analysis

No.	Available nutrients	Method	Reference
3.4.1	**Nitrogen**	Alkaline permanganate method	Subbiah and Asija (1956)
3.4.2	**Phosphorus**	Ascorbic acid method	Watanabe and Olsen (1965)
3.4.3	**Potassium**	Flame photometer method	Jackson (1970)

3.5 Dry matter production (DMP)

Stem, leaves and flowering cymes of uprooted plant were dried to constant weight at 70-80°C in a hot air oven. The dry weight gave the dry matter and was expressed in g $plant^{-1}$.

3.6 Uptake of nutrients

The nitrogen content of plant was determined by modified micro kjeldal method (Jackson, 1970), phosphorus content by vanadomolybdate yellow colour method (Jackson, 1970) and potassium content by extraction with neutral ammonium acetate extract and then reading in an EEL flame photometer. The total uptake of nitrogen, phosphorus and potassium was computed from their contents in the plant parts and dry weight. The values were expressed in kg ha^{-1}.

3.7 Essential oil content

Essential oil content was analysed using soxhlet apparatus and expressed as percentage weight basis.

3.8 Carbohydrate content of flowering shoot

This was estimated by copper reduction method (AOAC, 1975).

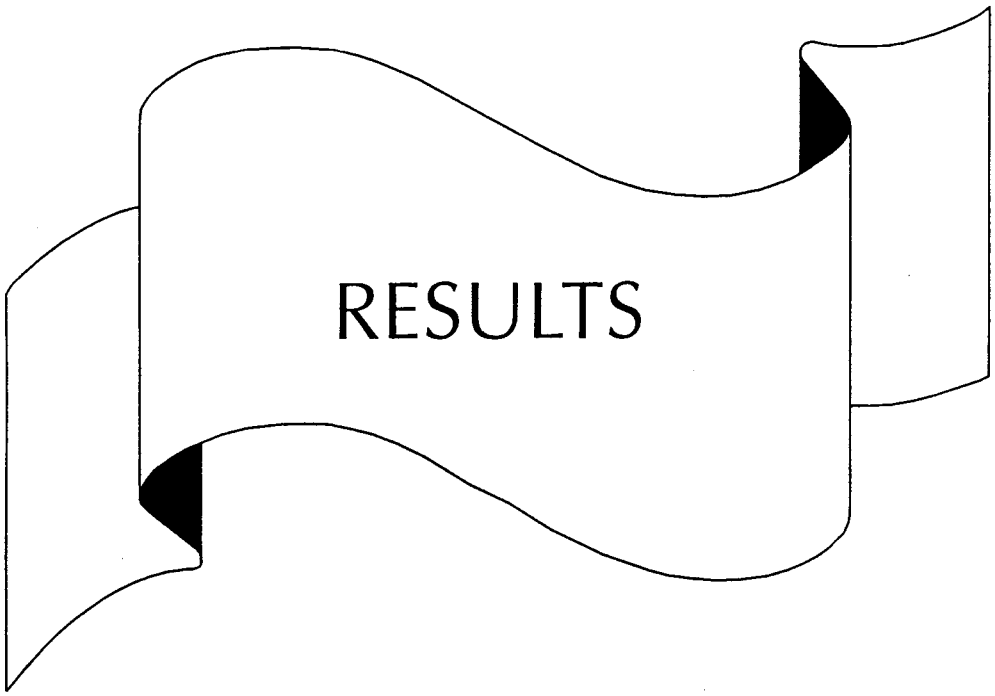
3.9 Other observations

3.9.1 Incidence of pest and diseases

Occurrence of pest and disease were studied.

Statistical analysis

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


RESULTS

RESULTS

The present investigation was carried out to study the nutrient requirement of bush jasmine (*Jasminum sambac*). This field trial was conducted at Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 1996-1998. The results of the study are presented below.

4.1. Vegetative characters

Vegetative characters were measured in terms of main shoot length, number and length of lateral branches and spread of bush. The data was recorded at monthly intervals for a period of one year from the date of planting.

4.1.1. Effect of nutrients on length of main shoot

The effect of major nutrients on length of mainshoot of bush jasmine is presented in Tables 1 and 2.

The effect of nitrogen application was found to be highly significant in influencing the length of main shoot throughout the growth period. The level n_3 recorded the highest length at all stages. The

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	17.78	22.78	27.11	29.56	32.37	34.67	40.07	39.07	41.07	43.67	45.52	47.52
n_2	19.07	23.74	28.19	31.44	35.37	38.78	42.59	44.63	47.37	50.59	53.00	56.33
n_3	24.74	31.81	37.74	42.52	48.81	54.70	55.85	62.07	66.04	70.15	73.89	79.11
F	24.04**	45.88**	56.54**	80.66**	98.18**	108.12**	17.24**	117.52**	123.18**	114.69**	120.89**	117.72**
CD	2.14	2.076	2.205	2.21	2.558	2.886	5.786	3.137	3.315	3.634	3.790	4.258
p_1	19.48	25.00	29.89	33.00	36.85	40.04	43.74	45.48	48.30	51.11	53.15	56.48
p_2	21.07	26.59	31.37	34.56	38.26	41.89	44.33	47.78	50.30	53.78	56.37	59.15
p_3	21.04	26.74	31.78	35.96	41.44	46.19	48.44	52.52	55.89	59.52	62.89	67.33
F	NS	NS	NS	NS	6.80**	9.59**	NS	10.51**	11.32**	11.22**	13.77**	14.16**
CD	--	--	--	--	2.558	2.886	--	3.137	3.315	3.634	3.790	4.258
k_1	20.78	25.89	30.30	33.63	37.63	41.41	45.56	47.22	50.04	53.37	55.85	58.93
k_2	20.33	25.96	30.81	34.33	38.41	42.04	46.89	47.78	50.44	53.59	56.04	59.37
k_3	20.48	26.48	31.93	35.56	40.52	44.67	46.07	50.78	54.00	57.44	60.52	64.67
F	NS	NS	NS	NS	NS	NS	NS	NS	3.47*	3.19*	3.90*	4.52*
CD	--	--	--	--	--	--	--	--	3.315	3.634	3.790	4.258

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	17.78	22.89	26.56	28.89	31.33	32.89	40.33	36.33	38.22	40.56	42.11	44.33
n_1p_2	19.00	24.44	29.22	30.89	33.00	35.11	43.11	40.00	41.56	43.78	45.78	46.78
n_1p_3	16.56	21.00	25.56	28.89	32.78	36.00	36.78	40.89	43.44	46.67	48.67	51.44
n_2p_1	18.22	22.89	27.56	30.56	34.33	37.33	42.89	44.22	47.11	50.00	51.78	55.11
n_2p_2	19.00	23.78	27.89	31.22	34.56	37.33	38.56	42.44	48.78	48.33	50.44	52.89
n_2p_3	20.00	24.56	29.11	32.56	37.22	41.56	43.33	47.22	50.22	53.44	56.78	61.00
n_3p_1	22.44	29.22	35.56	39.56	44.89	49.89	54.00	55.89	59.56	62.78	56.56	70.00
n_3p_2	25.22	31.56	37.00	41.56	47.22	53.22	51.33	60.89	64.56	69.22	72.89	77.78
n_3p_3	26.56	34.67	40.67	46.44	54.33	61.00	62.22	69.44	74.00	78.44	83.22	89.56
F	NS	2.59*	NS	NS	NS	NS	NS	2.72*	2.65*	NS	NS	NS
CD	--	3.597	--	--	--	--	--	5.434	5.742	--	--	--
n_1k_1	18.44	22.44	26.11	28.33	30.78	33.00	36.00	36.89	38.89	41.56	43.11	45.11
n_1k_2	17.56	22.89	27.44	30.00	32.89	35.00	41.11	40.11	42.22	44.78	46.33	48.11
n_1k_3	17.33	23.00	27.78	30.33	33.44	36.00	43.11	40.22	42.11	44.67	47.11	49.33
n_2k_1	20.11	25.11	29.44	32.44	36.67	40.11	45.00	46.33	49.00	52.33	54.78	57.89
n_2k_2	18.00	22.44	26.56	29.89	32.89	36.22	41.33	42.22	44.56	47.89	50.11	53.67
n_2k_3	19.11	23.67	28.56	32.00	36.56	39.89	41.44	45.33	48.56	51.56	54.11	57.44

Table 2. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	23.78	30.11	35.33	40.11	45.44	51.11	66.22	58.44	62.22	66.22	69.67	73.78
n_3k_2	25.44	32.56	38.44	43.11	49.44	54.89	68.11	61.00	64.56	48.11	71.67	46.33
n_3k_3	25.00	32.78	39.44	44.33	51.56	58.11	76.11	66.78	71.33	76.11	80.33	89.22
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--	--	--	--	--	--	--
p_1k_1	17.33	22.00	26.11	29.11	32.11	34.78	44.89	39.56	42.11	44.89	46.56	49.11
p_1k_2	19.67	25.22	30.22	33.44	37.33	40.78	52.11	46.67	49.33	52.11	54.33	58.11
p_1k_3	21.44	27.78	33.33	36.44	41.44	44.56	56.33	50.22	53.44	56.33	58.56	62.22
p_2k_1	22.78	28.00	32.44	35.33	38.67	42.22	54.44	48.11	50.78	54.44	56.67	59.00
p_2k_2	20.44	25.89	30.33	33.56	37.00	40.33	51.89	46.33	48.44	51.89	54.22	56.56
p_2k_3	20.00	25.89	31.33	34.78	39.11	43.11	55.00	48.89	51.67	55.00	58.22	61.89
p_3k_1	22.22	27.67	32.33	36.44	42.11	47.22	60.78	54.00	57.22	60.78	64.33	68.67
p_3k_2	20.89	26.78	31.89	36.00	40.89	45.00	56.78	50.33	53.56	56.78	59.56	63.44
p_3k_3	20.00	25.78	31.11	35.44	41.33	46.33	61.00	53.22	56.89	61.00	64.78	69.89
F	NS	3.24*	3.45*	3.24*	3.14*	2.99*	NS	3.26*	3.11*	2.65*	2.66	NS
CD	--	3.597	3.820	3.828	4.43	4.99	--	5.434	5.742	6.295	5.565	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

significant influence of applied phosphorus was noticed from fifth month onwards, except during seventh month. The level p_3 was found highly significant over other levels while p_2 and p_1 produced main stems which were on par in length. Effect of K applications was found significant in last quarter of growth period viz., ninth month onwards. k_3 level was found to be highly significant while length with k_2 and k_1 were on par.

NP interactions were found to be significant in producing maximum length of main shoot. It was obvious during second, eighth and ninth months of planting. In second month of planting, the interaction n_3p_3 was highly significant (34.67 cm) and was found to be statistically on par with n_3p_2 (31.56 cm). During eighth and ninth month of planting also n_3p_3 produced maximum length of main shoot (69.44 and 74.00 cm respectively). The PK interaction was pronounced from second month of planting till the eleventh month in producing maximum length of main shoot, with the exception of first, seventh and twelfth months of planting. During second month p_2k_1 was found to be highly significant (28.00 cm), while during the third month p_1k_3 (33.33 cm) was found to be significant. From the fourth month till the ninth month, p_3k_1 was found to be superior to other interactions producing the maximum length for main shoot (36.44, 42.11, 47.22, 54.00 and 52.22 cm respectively). Superiority of p_3k_3 was evident in the last quarter of growth period in tenth and eleventh month of planting (61.00 cm and 64.78 cm).

4.1.2. Effect of nutrients on number of primary branches

The data on the number of primary branches recorded periodically are presented in Tables 3 and 4.

From the first month onwards, the effect of N was highly pronounced which was evident throughout the growth period. The impact of N at n_3 level was found to be greater than the other two levels viz., n_1 and n_2. The effect of P became significant from the fourth month onwards. The levels p_2 and p_3 were statistically on par till the eighth month and were superior to p_1 while at the later stages p_3 was highly significant. Effect of K was manifested from fifth month onwards with the level k_3 proving superior to other two levels viz., k_1 and k_2. All the treatment effects were superior to the controls.

NP interaction was found to be significant in producing maximum number of primary branches. A high significance was found for n_3p_3 through out the growth period except for the first month of planting (Table 4). NK interaction was found significant at n_3k_3. A high significance for n_3k_3 was experienced during the last quarter of growth period viz., ninth (16.67), tenth (18.56), eleventh (19.33) and twelfth (20.67) month respectively. PK interaction was significant only during the second month of planting with p_2k_3, significantly superior to other interactions in producing more primary branches (3.22).

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	1.59	2.3	3.52	4.63	5.41	6.19	6.85	7.37	7.70	8.37	8.59	8.89
n_2	1.44	2.41	3.74	5.85	6.63	7.78	8.81	9.70	10.48	11.33	12.07	13.37
n_3	2.52	3.48	5.30	7.93	9.30	10.89	11.96	13.85	14.56	15.96	16.93	18.26
F	21.26**	35.76**	33.41**	52.51**	86.79**	93.69**	95.32**	75.97**	95.01**	104.15**	110.21**	107.00**
CD	0.358	0.310	0.475	0.652	0.605	0.700	0.748	1.067	1.002	1.063	1.130	1.284
p_1	1.89	2.63	4.04	5.67	6.63	7.48	8.52	9.63	9.89	10.78	11.44	12.19
p_2	1.89	2.78	4.11	6.11	7.15	8.33	9.19	10.15	10.67	11.52	12.07	12.96
p_3	1.78	2.78	4.41	6.63	7.56	9.04	9.93	11.15	12.19	13.37	14.07	15.37
F	NS	NS	NS	4.39*	4.73*	9.93**	7.11**	4.20*	10.91**	12.68**	11.86**	13.43**
CD	--	--	--	0.652	0.605	0.700	0.748	1.067	1.002	1.063	1.130	1.284
k_1	1.78	2.56	4.04	5.70	6.78	7.93	8.85	10.07	10.63	11.37	12.11	12.93
k_2	1.74	2.70	4.11	6.30	7.04	8.07	8.89	9.74	10.26	11.30	12.00	12.96
k_3	2.04	2.93	4.41	6.41	7.56	8.85	9.89	11.11	11.85	13.00	13.48	14.63
F	NS	NS	NS	NS	3.73*	4.05*	4.96*	3.60*	5.56**	6.60**	4.28*	4.65*
CD	--	--	--	--	0.605	0.700	0.748	1.067	1.002	1.063	1.130	1.284

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	1.67	2.22	3.11	3.78	4.67	5.11	5.78	6.44	6.54	7.22	7.44	7.56
n_1p_2	1.67	2.56	3.78	4.56	5.33	6.11	6.78	6.89	7.00	7.33	7.67	7.89
n_1p_3	1.44	2.11	3.67	5.56	6.22	7.33	8.00	8.78	9.67	10.56	10.67	11.22
n_2p_1	1.67	2.56	4.11	6.11	6.89	8.00	9.44	10.22	10.89	11.67	12.44	13.56
n_2p_2	1.33	2.44	3.67	6.00	6.78	7.89	8.67	9.56	10.33	11.00	11.44	12.78
n_2p_3	1.33	2.22	3.44	5.44	6.22	7.44	8.33	9.33	10.22	11.33	12.33	13.78
n_3p_1	2.33	3.11	4.89	7.11	8.33	9.33	10.33	12.22	12.33	13.44	14.44	15.44
n_3p_2	2.67	3.33	4.89	7.78	9.33	11.00	12.11	14.00	14.67	16.22	17.11	18.22
n_3p_3	2.56	4.00	6.11	8.89	10.22	12.33	13.44	15.33	16.67	18.22	19.22	21.11
F	NS	3.82^{**}	3.71^{**}	3.25^{*}	3.60^{*}	4.81^{**}	6.01^{**}	2.82^{*}	4.94^{**}	4.86^{**}	3.79^{**}	3.36^{*}
CD	--	0.537	0.823	1.129	1.048	1.213	1.296	1.849	1.736	1.841	1.957	2.224
n_1k_1	1.56	2.00	3.33	4.11	5.00	5.78	6.44	6.67	7.11	7.67	7.89	8.00
n_1k_2	1.56	2.44	3.56	5.11	5.67	6.44	7.11	7.56	8.00	8.67	9.22	9.44
n_1k_3	1.67	2.44	3.67	4.67	5.56	6.33	7.00	7.89	8.00	8.78	8.67	9.22
n_2k_1	1.44	2.33	3.56	5.78	6.44	7.78	8.78	9.56	10.33	11.11	11.89	12.89
n_2k_2	1.22	2.33	3.78	5.78	6.56	7.56	8.44	9.44	10.22	11.22	11.89	13.22
n_2k_3	1.67	2.56	3.89	6.00	6.89	8.00	9.22	10.11	10.89	11.67	12.44	14.00

Table 4. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	2.33	3.33	5.22	7.22	8.78	10.22	11.33	14.00	14.44	15.33	16.56	17.89
n_3k_2	2.44	3.33	5.00	8.00	8.89	10.22	11.11	12.22	12.56	14.00	14.89	16.22
n_3k_3	2.78	3.78	5.67	8.56	10.22	12.22	13.44	15.33	16.67	18.56	19.33	20.67
F	NS	NS	NS	NS	NS	NS	NS	NS	3.39*	3.75**	3.72**	2.54*
CD	--	--	--	--	--	--	--	--	1.736	1.841	1.957	2.224
p_1k_1	1.56	2.11	3.44	5.00	6.11	7.00	8.11	9.56	9.22	9.89	10.56	11.22
p_1k_2	1.89	2.67	4.11	5.89	6.78	7.33	8.22	9.00	9.67	10.44	11.22	12.11
p_1k_3	2.22	3.11	4.56	6.11	7.00	8.11	9.22	10.33	10.78	12.00	12.56	13.22
p_2k_1	1.78	2.67	4.11	5.44	6.67	7.89	8.89	10.00	10.78	14.44	12.22	12.89
p_2k_2	1.67	2.44	3.78	6.22	6.78	7.78	8.44	9.11	9.22	10.22	10.78	11.56
p_2k_3	2.22	3.22	4.44	6.67	8.00	9.33	10.22	11.33	12.00	12.89	13.22	14.44
p_3k_1	2.00	2.89	4.56	6.67	7.44	8.89	9.56	10.67	11.89	12.78	13.56	14.67
p_3k_2	1.67	3.00	4.44	6.78	7.56	9.11	10.00	11.11	11.89	13.22	14.00	15.22
p_3k_3	1.67	2.44	4.22	6.44	7.67	9.11	10.22	11.67	12.78	14.11	14.67	16.22
F	NS	5.84**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	0.537	--	--	--	--	--	--	--	--	--	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

4.1.3. Effect of nutrients on number of secondary branches

The data on the effect of N, P and K on number of secondary branches of *Jasminum sambac* is shown in Tables 5 and 6.

The main effect of N influenced the number of secondary branches significantly throughout the growth period. The level n_3 fared well over other levels. The levels of P were found to significantly influence the number of secondary laterals. From the fifth month onwards significantly higher values were recorded for p_3 compared to other two levels of p_1 and p_2. Significance of application of K at various levels proved k_3 to be superior though the effect was not steady. Controls were found not significant compared to treatments.

During the first, second, sixth, seventh, eighth, ninth, tenth and twelfth month, the effect of n_3p_3 combination was significant (Table 6). For NK interaction n_3k_3 showed maximum significance for the last four months. viz., ninth (18.44), tenth (19.00), eleventh (21.00) and twelfth month (22.11). During second and ninth months of planting, PK interaction was found to be highly significant in producing maximum number of secondary laterals. During second month, p_1k_3 (2.00) and p_3k_3 (14.56) during ninth month showed a greater significance.

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	0.07	1.11	2.37	3.89	5.37	6.48	7.22	7.59	8.00	8.85	9.22	9.59
n_2	0.04	1.07	2.78	4.89	6.07	8.07	8.81	9.63	11.07	11.85	12.48	13.56
n_3	0.41	2.41	3.85	6.44	8.70	11.26	12.74	14.15	15.59	16.85	18.30	19.48
F	19.41**	41.54**	11.52**	21.88**	36.24**	43.38**	57.55**	69.98**	80.76**	106.84**	117.81**	115.10**
CD	0.131	0.334	0.639	0.780	0.827	1.047	1.061	1.137	1.204	1.108	1.200	1.315
p_1	0.11	1.44	2.93	4.96	6.15	7.81	8.70	9.52	10.67	11.37	12.00	12.78
p_2	0.07	1.52	2.85	4.81	6.59	8.56	9.44	10.30	10.93	12.11	13.00	13.81
p_3	0.33	1.63	3.22	5.44	7.41	9.44	10.63	11.56	13.07	14.07	15.00	16.04
F	9.17**	NS	NS	NS	4.79*	4.88*	6.73**	6.57**	9.67**	12.77**	13.01**	12.89**
CD	0.131	--	--	--	0.827	1.047	1.061	1.137	1.204	1.108	1.200	1.315
k_1	0.15	1.41	2.85	4.56	6.33	8.26	9.15	9.96	11.11	12.30	12.89	13.74
k_2	0.19	1.37	2.78	4.81	6.56	8.26	9.26	10.22	11.15	11.96	12.81	13.67
k_3	0.19	1.81	3.37	5.85	7.26	9.30	10.37	11.19	12.41	13.30	14.30	15.22
F	NS	4.38*	NS	6.21**	NS	NS	3.26*	NS	NS	NS	3.89*	3.58*
CD	--	0.334	--	0.780	--	--	1.061	--	--	--	1.200	1.315

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	0.11	1.11	2.22	3.44	4.11	4.78	5.56	6.00	6.11	7.00	7.22	7.56
n_1p_2	0.11	1.22	2.56	4.11	5.67	6.56	7.22	7.33	7.33	8.00	8.44	8.56
n_1p_3	0.00	1.00	2.33	4.11	6.33	8.11	8.89	9.44	10.56	11.56	12.00	12.67
n_2p_1	0.11	1.22	3.00	5.66	6.33	8.33	9.00	9.89	12.00	11.78	12.22	13.33
n_2p_2	0.00	1.11	2.56	4.44	5.89	8.22	8.89	9.67	10.89	12.00	12.33	13.44
n_2p_3	0.00	0.89	2.78	4.67	6.00	7.67	8.56	9.33	10.33	11.78	12.89	13.89
n_3p_1	0.11	2.00	3.56	5.89	8.00	10.33	11.56	12.67	13.89	15.33	16.56	17.44
n_3p_2	0.11	2.22	3.44	5.89	8.22	10.89	12.22	13.89	14.56	16.33	18.22	19.44
n_3p_3	1.00	3.00	4.56	7.56	9.89	12.56	14.44	15.89	18.33	18.89	20.11	21.56
F	16.53**	3.49*	NS	NS	NS	2.75*	2.72*	2.66*	6.00**	3.55*	NS	2.58*
CD	0.227	0.578	--	--	--	1.813	1.838	1.969	2.086	1.919	--	2.277
n_1k_1	0.00	0.89	2.11	3.22	4.67	6.00	6.56	6.89	7.56	8.22	8.78	8.89
n_1k_2	0.11	1.00	2.33	3.89	5.67	6.78	7.67	8.11	8.33	9.22	9.56	10.00
n_1k_3	0.11	1.44	2.67	4.56	5.78	6.67	7.44	7.78	8.11	9.11	9.33	9.89
n_2k_1	0.00	1.11	2.78	4.56	6.22	8.22	8.89	9.56	10.89	12.00	12.33	13.33
n_2k_2	0.11	0.89	2.56	4.56	5.89	7.67	8.33	9.33	11.67	11.78	12.56	13.67
n_2k_3	0.00	1.22	3.00	5.56	6.11	9.33	9.22	10.00	10.67	11.78	12.56	13.67

Table 6. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	0.44	2.22	3.67	5.89	8.11	10.56	12.00	13.44	14.89	16.67	17.56	19.00
n_3k_2	0.33	2.22	3.44	6.00	8.11	10.33	11.78	13.22	13.44	14.89	16.33	17.33
n_3k_3	0.44	2.78	4.44	7.44	9.89	12.89	14.44	15.78	18.44	19.00	21.00	22.11
F	NS	NS	NS	NS	NS	NS	NS	NS	5.01**	3.41*	3.66*	3.08*
CD	--	--	--	--	--	--	--	--	2.086	1.919	2.079	2.277
p_1k_1	0.00	0.89	2.22	3.67	5.11	6.89	7.56	8.33	9.22	10.11	10.33	11.00
p_1k_2	0.11	1.44	2.89	4.78	6.33	8.11	8.89	9.89	12.00	11.78	12.33	13.22
p_1k_3	0.22	2.00	3.67	6.44	7.00	8.44	9.67	10.33	10.78	12.22	13.33	14.11
p_2k_1	0.11	1.56	2.89	4.56	6.89	8.89	9.89	10.89	11.56	13.00	13.78	14.67
p_2k_2	0.11	1.22	2.44	4.56	5.78	7.44	8.44	9.11	9.33	10.78	11.56	12.22
p_2k_3	0.00	1.78	3.22	5.33	7.11	9.33	10.00	10.89	11.89	12.56	13.67	14.56
p_3k_1	0.33	1.78	3.44	5.44	7.00	9.00	10.00	10.67	12.56	13.78	14.56	15.56
p_3k_2	0.33	1.44	3.00	5.11	7.56	9.22	10.44	11.67	12.11	13.33	14.56	15.56
p_3k_3	0.33	1.67	3.22	5.78	7.67	10.11	11.44	12.33	14.56	15.11	15.89	17.00
F	NS	2.80*	NS	NS	NS	NS	NS	NS	3.63*	NS	NS	NS
CD	--	0.578	--	--	--	--	--	--	2.086	--	--	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

4.1.4. Effect of nutrients on length of primary branches

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

Throughout the growth period the main effect of N at n_3 level confirmed its superiority to other levels. Effects of P was found to be significant from third month onwards with maximum length of primary branches noticed at p_3 level. Also p_3 was found to be statistically on par with p_2. The significance of K application was noticed from ninth month onwards with k_3 level superior but on par with k_1.

NP interaction proved its significance in producing lengthy primary branches. During the nineth and eleventh months of planting, n_3p_3 interaction was found to be superior in producing maximum length for primary branches of 56.44 and 64.89 cm respectively.

4.1.5. Effect of nutrients on length of secondary branches

The data on the effect of nutrients in length of secondary branches is presented in Tables 9 and 10.

The effect of N was significant on length of secondary branches throughout the period under study with n_3 level being superior to the other

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	8.85	12.41	16.44	19.67	21.48	24.11	26.52	28.56	30.41	32.56	34.15	35.96
n_2	9.30	13.33	17.96	20.89	24.48	28.00	31.41	34.15	36.93	39.67	41.41	45.41
n_3	12.33	17.33	23.81	30.67	34.78	38.70	42.56	46.33	49.67	53.00	57.11	59.19
F	15.48**	22.08**	46.15**	65.68**	91.90**	52.70**	60.23**	74.31**	78.57**	84.31**	96.37**	60.58**
CD	1.365	1.579	1.623	1.782	2.062	2.950	3.002	2.989	3.132	3.204	3.389	4.252
p_1	9.26	13.30	18.07	21.48	25.07	26.41	29.96	32.67	35.19	37.67	39.89	43.26
p_2	10.44	14.81	19.93	23.41	27.26	31.59	34.59	37.22	39.37	42.56	44.70	46.37
p_3	10.78	14.96	20.22	23.74	28.41	32.81	35.93	39.15	42.44	45.00	48.07	50.93
F	NS	NS	4.13*	3.76*	5.42**	10.68**	8.73**	9.96**	10.87**	10.91**	11.84**	6.60**
CD	1.365	1.579	1.623	1.782	2.062	2.950	3.002	2.989	3.132	3.204	3.389	4.252
k_1	10.07	13.85	18.85	22.30	26.19	29.07	32.89	35.67	38.37	40.93	43.44	45.56
k_2	9.85	14.15	19.11	22.48	26.22	29.81	32.56	35.00	36.96	39.74	42.26	45.15
k_3	10.56	15.07	20.26	23.85	28.33	31.93	35.04	38.37	41.67	44.56	46.96	49.85
F	NS	NS	NS	NS	NS	NS	NS	NS	4.77*	4.93*	4.19*	NS
CD	--	--	--	--	--	--	--	--	3.132	3.204	3.389	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	8.22	11.44	14.67	17.00	19.00	21.11	23.89	26.22	27.56	29.11	30.56	32.44
n_1p_2	8.89	13.22	17.56	20.33	22.56	24.89	26.78	28.33	29.67	32.00	33.67	34.78
n_1p_3	9.44	12.56	17.11	19.89	22.89	26.33	28.89	31.11	34.00	36.56	38.22	40.67
n_2p_1	8.67	12.78	17.33	20.44	24.00	24.78	29.44	32.11	35.22	37.78	39.78	44.44
n_2p_2	9.67	13.67	18.56	21.22	24.67	30.44	33.33	36.11	38.67	41.67	43.33	46.89
n_2p_3	9.56	13.56	18.00	21.00	24.78	28.78	31.44	34.22	36.89	39.56	41.11	44.89
n_3p_1	10.89	15.67	22.22	27.00	32.22	33.33	36.56	39.67	42.78	46.11	49.33	52.89
n_3p_2	12.78	17.56	23.67	28.67	34.56	39.44	43.67	47.22	49.78	54.00	57.11	57.44
n_3p_3	13.33	18.78	25.56	30.33	37.56	43.33	47.44	52.11	56.44	58.89	64.89	67.22
F	NS	NS	NS	NS	NS	NS	NS	NS	2.82*	NS	3.24*	NS
CD	--	--	--	--	--	--	--	--	5.425	--	5.869	--
n_1k_1	9.11	12.44	16.22	18.78	21.00	23.56	26.33	28.22	29.89	31.89	33.22	34.44
n_1k_2	8.56	12.44	16.44	19.22	21.67	24.33	26.67	28.33	29.89	32.44	38.11	39.44
n_1k_3	8.89	12.33	16.67	19.22	21.78	24.44	26.56	29.11	31.44	33.33	35.11	37.00
n_2k_1	9.56	12.44	17.11	20.00	23.78	25.33	30.22	33.00	35.67	38.33	40.00	44.67
n_2k_2	8.78	13.33	17.67	20.22	23.44	26.78	29.33	32.00	34.67	37.78	39.67	42.89
n_2k_3	9.56	14.22	19.11	22.44	26.22	31.89	34.67	37.44	40.44	42.89	44.56	48.67

Table 8. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	11.56	15.44	23.22	28.11	33.78	38.33	42.11	45.78	43.78	52.56	57.11	57.56
n_3k_2	12.22	14.78	23.22	28.00	33.56	38.33	41.67	44.67	40.33	49.00	53.00	56.11
n_3k_3	13.22	14.67	25.00	29.89	37.00	39.44	43.89	48.56	43.22	57.44	61.22	63.89
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--	--	--	--	--	--	--
p_1k_1	9.00	12.78	16.44	19.33	22.44	23.11	28.11	30.22	32.44	34.67	36.44	40.00
p_1k_2	8.89	12.44	17.89	21.33	24.78	27.89	30.67	33.11	35.33	38.22	40.33	44.11
p_1k_3	9.89	14.67	19.89	23.78	28.00	28.22	31.11	34.67	37.78	40.11	42.89	45.67
p_2k_1	10.00	13.33	19.11	22.78	26.78	30.33	35.56	36.56	38.89	42.33	44.11	43.89
p_2k_2	9.89	15.22	19.56	22.56	26.00	29.56	32.11	34.22	35.22	38.44	40.89	42.89
p_2k_3	11.44	15.89	21.11	24.89	29.00	34.89	38.11	40.89	44.00	46.89	49.11	52.33
p_3k_1	11.22	15.44	21.00	24.78	29.33	33.78	37.00	40.22	43.78	45.78	49.78	52.78
p_3k_2	10.78	14.78	19.89	23.56	27.89	32.00	34.89	37.67	40.33	42.56	45.56	48.44
p_3k_3	10.33	14.67	19.78	22.89	28.00	32.67	35.89	39.56	43.22	46.67	48.89	51.56
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--	--	--	--	--	--	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	0.15	2.59	6.22	10.04	11.89	14.07	15.81	18.15	20.22	22.37	24.15	26.22
n_2	0.07	2.41	6.33	10.11	13.30	16.96	20.26	22.26	24.70	27.63	29.78	33.63
n_3	0.96	3.67	8.30	14.44	19.78	24.56	27.89	31.67	35.78	39.93	43.00	45.81
F	20.78**	7.51**	12.74**	10.07**	22.78**	42.11**	38.17**	56.70**	63.85**	68.25**	76.43**	52.30**
CD	0.307	0.703	0.934	2.253	2.499	2.364	2.801	2.608	2.840	3.091	3.137	3.877
p_1	0.26	2.63	6.67	11.00	14.15	16.78	19.81	21.59	24.19	26.81	28.67	30.00
p_2	0.15	2.81	7.04	12.37	15.44	18.81	21.26	24.22	27.00	29.93	32.30	35.41
p_3	0.78	3.22	7.11	11.22	15.37	20.00	22.89	26.26	29.52	33.19	35.96	40.26
F	9.65**	NS	NS	NS	NS	3.82*	NS	6.46**	7.09**	8.53**	10.86**	14.07**
CD	0.307	--	--	--	--	2.364	--	2.608	2.840	3.091	3.137	3.877
k_1	0.30	2.52	6.63	11.22	14.56	18.11	20.78	23.19	25.81	29.04	31.04	33.26
k_2	0.41	2.85	6.70	10.70	13.56	17.44	20.11	22.67	25.44	28.26	30.59	34.19
k_3	0.48	3.30	7.48	12.67	16.85	20.04	23.07	26.22	29.44	32.63	35.30	38.22
F	NS	NS	NS	NS	NS	NS	NS	4.36*	4.86*	4.57*	5.50**	3.72*
CD	--	--	--	--	--	--	--	2.608	2.840	3.091	3.137	3.877

* Significant at 5% level ** Significant at 1% level

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	0.22	2.33	5.78	8.33	9.67	11.78	14.00	15.78	17.33	19.11	20.78	22.67
n_1p_2	0.22	2.56	6.78	11.89	13.33	14.89	15.67	18.22	20.22	22.56	24.00	25.11
n_1p_3	0.00	2.89	6.11	9.89	12.67	15.56	17.78	20.44	23.11	25.44	27.67	30.89
n_2p_1	0.22	2.22	6.11	9.44	12.78	16.11	21.00	21.56	24.00	26.89	28.00	32.11
n_2p_2	0.00	2.67	6.67	11.78	14.56	17.89	20.56	23.22	25.44	28.11	30.44	34.67
n_2p_3	0.00	2.33	6.11	9.11	12.56	16.89	19.22	22.00	24.67	27.89	30.89	34.11
n_3p_1	0.33	3.33	8.11	15.22	20.00	22.44	24.44	27.44	31.22	34.44	37.22	35.22
n_3p_2	0.22	3.22	7.67	13.44	18.44	23.67	27.56	31.22	35.33	39.11	42.44	46.44
n_3p_3	0.33	4.44	9.11	14.67	20.89	27.56	31.67	36.33	40.78	46.22	49.33	55.78
F	15.74**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.15**
CD	0.531	--	--	--	--	--	--	--	--	--	--	6.715
n_1k_1	0.00	2.00	5.67	9.00	10.56	12.11	13.11	16.22	18.00	19.89	21.33	23.11
n_1k_2	0.22	2.22	5.78	9.22	11.00	13.67	16.00	17.78	19.89	22.22	23.78	25.56
n_1k_3	0.22	3.56	7.22	11.89	14.11	16.44	18.33	20.44	22.78	25.00	27.33	30.00
n_2k_1	0.00	2.22	6.00	9.11	12.78	16.56	21.22	21.67	24.33	27.89	29.78	33.56
n_2k_2	0.22	2.44	6.11	9.56	12.44	15.67	18.00	20.67	22.67	25.22	27.67	31.67
n_2k_3	0.00	2.56	6.78	11.67	14.67	18.67	21.56	24.44	27.11	29.78	31.89	35.67

Table 10. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	0.89	3.33	8.22	15.56	20.33	25.67	28.00	31.67	35.11	36.33	39.89	43.11
n_3k_2	0.78	3.89	8.22	13.33	17.22	23.00	26.33	29.56	33.78	33.83	38.89	45.33
n_3k_3	1.22	3.78	8.44	14.44	21.78	25.00	29.33	33.78	38.44	39.11	43.11	49.00
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--	--	--	--	--	--	--
p_1k_1	0.00	1.56	5.00	8.56	11.56	15.11	18.56	18.22	20.78	23.22	24.67	25.67
p_1k_2	0.22	3.11	7.11	10.89	13.67	17.22	19.89	22.11	24.78	27.11	28.67	29.67
p_1k_3	0.56	3.22	7.89	13.56	17.22	18.00	21.00	24.44	27.00	30.11	32.67	33.67
p_2k_1	0.22	2.78	7.33	13.78	16.44	19.44	21.22	25.11	27.56	30.67	32.56	33.56
p_2k_2	0.22	2.44	6.11	10.56	13.22	16.33	18.78	21.22	23.78	26.78	29.22	30.22
p_2k_3	0.00	3.22	7.67	12.78	16.67	20.67	23.78	26.33	29.67	32.33	35.11	36.11
p_3k_1	0.67	3.22	7.56	11.33	15.67	19.78	22.56	26.22	29.11	33.22	35.89	36.89
p_3k_2	0.78	3.00	6.89	10.67	13.78	18.78	21.67	24.67	27.78	30.89	33.89	34.89
p_3k_3	0.89	3.44	6.89	11.67	16.67	21.44	24.44	27.89	31.67	35.44	38.11	39.11
F	NS	NS	3.66**	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	1.618	--	--	--	--	--	--	--	--	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

two levels of n_1 and n_2. The levels p_2 and p_3 were on par till ninth month. During the last four months, level p_3 alone proved to be significant. Significant difference was observed in the length of the secondary branch since eighth month of planting proving the k_3 level to be superior over other levels.

The superiority of NP interaction was felt in the first and the last month of planting with n_3p_3 interaction superior to the other interactions in producing maximum length of secondary branches (0.33 and 55.78 cm respectively).

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

The data on the effect of nutrients in North-South spread of plants is shown in Tables 11 and 12.

The effect of N at n_3 level was highly significant over the other levels throughout the growing period. The effect of P was highly significant at p_3 level in producing maximum North South spread, manifested from sixth month onwards. But during the last month, the effect of p_2 and p_3 were comparable. All the treatment effects were seem to be significantly superior to the controls.

NP interaction was highly significant in effecting maximum North-South spread of jasmine bush. The interaction n_3p_3 was significant during

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	15.5	20.04	24.74	25.89	28.67	31.63	33.93	35.96	37.63	39.96	41.48	42.93
n_2	15.04	19.19	23.96	25.56	29.30	33.48	36.48	39.30	41.63	44.78	46.85	50.11
n_3	20.74	26.93	32.37	34.56	39.96	44.19	49.07	52.33	55.93	60.22	64.00	67.81
F	33.89**	47.00**	48.65**	44.83**	54.38**	51.80**	69.04**	69.59**	76.34**	75.22**	80.05**	62.28**
CD	1.588	1.755	1.888	2.151	2.440	2.669	2.766	2.960	3.120	3.459	3.726	4.60
p_1	16.81	21.56	26.30	27.48	31.30	35.26	38.07	40.74	42.74	45.56	47.59	50.59
p_2	17.07	22.15	27.07	28.78	32.93	35.63	39.30	41.93	44.44	47.96	50.59	53.04
p_3	17.04	22.44	27.70	29.70	33.70	38.41	42.11	44.93	48.00	51.44	54.15	57.22
F	NS	NS	NS	NS	NS	3.34*	4.50*	4.26*	5.94**	5.89**	6.23**	4.27*
CD	--	--	--	--	--	2.669	2.766	2.96	3.120	3.459	3.726	4.60
k_1	16.59	21.37	26.15	27.70	31.63	35.56	38.78	41.30	43.63	46.89	48.41	51.22
k_2	17.67	22.74	27.85	28.93	33.26	36.33	40.00	42.48	44.96	48.26	50.78	53.33
k_3	16.67	22.04	27.07	29.33	33.04	37.41	40.70	43.81	46.59	49.81	53.15	56.30
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.25*	NS
CD	--	--	--	--	--	--	--	--	--	--	3.726	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	16.56	21.33	25.22	26.11	28.33	30.89	33.11	35.11	35.89	37.56	39.67	41.78
n_1p_2	15.44	20.11	25.33	26.44	29.11	31.67	33.22	35.00	36.89	39.56	41.44	41.51
n_1p_3	13.44	18.67	23.67	25.11	28.56	32.33	35.44	37.78	40.11	42.78	43.33	45.89
n_2p_1	15.67	19.67	25.00	26.22	30.22	34.33	36.89	39.89	42.00	45.11	46.44	49.44
n_2p_2	13.78	18.00	22.33	24.11	27.89	31.67	34.67	37.44	39.67	43.33	45.00	47.89
n_2p_3	15.67	19.89	24.56	26.33	29.78	34.44	37.89	40.56	43.22	45.89	49.11	53.00
n_3p_1	18.22	23.67	28.67	30.11	35.33	40.56	44.22	47.22	50.33	54.00	56.67	60.56
n_3p_2	22.00	28.33	33.56	35.78	41.78	43.56	50.00	53.33	56.78	61.00	65.33	70.11
n_3p_3	22.00	28.78	34.89	37.67	42.78	48.44	53.00	56.44	60.67	65.67	70.00	72.78
F	4.45**	4.46**	4.56**	3.99**	3.03*	NS	NS	NS	NS	NS	NS	4.27*
CD	2.750	3.039	3.270	3.725	4.225	--	--	--	--	--	--	4.600
n_1k_1	16.00	20.11	24.33	25.56	28.00	30.89	33.44	35.33	36.89	38.89	40.11	41.44
n_1k_2	15.56	20.67	25.67	26.67	29.56	32.56	34.33	36.22	38.00	40.33	41.56	41.78
n_1k_3	13.89	19.33	24.22	25.44	28.44	31.44	34.00	36.33	38.30	40.67	42.78	45.56
n_2k_1	15.67	20.11	25.00	26.44	29.89	34.00	37.11	40.00	42.00	45.33	46.89	50.44
n_2k_2	15.56	19.78	24.44	25.56	29.44	33.22	36.11	38.44	41.00	44.44	46.00	49.33
n_2k_3	13.89	17.67	22.44	24.67	28.56	33.22	36.22	39.44	41.89	44.56	47.67	50.56

Table 12. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	18.11	23.89	29.11	31.11	37.00	41.78	45.78	48.56	52.00	56.44	58.22	61.78
n_3k_2	21.89	27.78	33.44	34.56	40.78	43.22	49.56	52.78	55.89	60.00	64.78	68.89
n_3k_3	22.22	29.11	34.56	37.89	42.11	47.56	51.89	55.67	59.89	64.22	69.00	72.78
F	3.38**	3.55*	3.21*	3.06*	NS	NS	NS	NS	NS	NS	NS	NS
CD	2.750	3.039	3.270	3.725	--	--	--	--	--	--	--	--
p_1k_1	14.89	19.11	23.56	24.44	27.78	31.00	33.56	35.67	37.22	39.89	41.00	44.00
p_1k_2	18.33	23.44	28.44	29.11	33.00	37.33	40.44	42.89	45.11	48.33	50.33	53.00
p_1k_3	17.22	22.11	26.89	28.89	33.11	37.44	40.22	43.67	45.89	48.44	51.44	54.78
p_2k_1	17.56	22.67	27.56	29.00	32.78	36.56	39.67	42.33	44.67	48.44	50.56	51.89
p_2k_2	16.89	51.78	26.33	27.33	31.67	32.22	37.00	39.33	41.56	44.89	47.56	50.44
p_2k_3	16.78	22.00	27.33	30.00	34.33	38.11	41.22	44.11	47.11	50.56	53.67	56.78
p_3k_1	17.33	22.33	27.33	29.67	34.33	39.11	43.11	45.89	49.00	52.33	53.67	57.78
p_3k_2	17.78	23.00	28.78	30.33	35.11	39.44	42.56	45.22	48.22	51.56	54.44	56.56
p_3k_3	16.00	22.00	27.00	29.11	31.67	36.67	40.67	43.67	46.78	50.44	54.33	57.33
F	NS	NS	NS	NS	2.70*	4.25**	3.27*	3.33*	3.49*	2.99*	NS	NS
CD	--	--	--	--	4.225	4.623	4.791	5.128	5.404	5.997	--	--

* Significant at 5% level ** Significant at 1% level NS - Not significant

first, second, third, fourth, fifth and twelfth months of planting (22.00, 28.78, 34.89, 37.67, 42.78 and 72.78 cm respectively). Interaction of N and K proved its significant influence in effecting maximum North South spread of bush. For the first four months of planting, the interaction of N and K at n_3k_3 was dominant in effecting maximum spread (22.22, 29.11, 34.56 and 37.89 cm respectively). From the fifth month to tenth month of planting PK interaction was found significant in North-South spread. During fifth and sixth month, maximum spread was noticed in p_3k_2 combination (35.11 and 39.44 cm) whereas during the later months p_3k_1 was found highly significant (43.11, 45.89, 49.00 and 52.33 cm respectively).

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

The results of the study on effect of major nutrients on East-West spread of bush jasmine is presented in Tables 13 and 14.

The influence of N at n_3 level was highly significant over the other levels throughout the growth period. The effect of P on east west spread of bush was found to be significant. During the third month of planting, effect of p_2 and p_3 were comparable and later on p_3 was superior over the other levels viz. p_1 and p_2. Effect of k_2 and k_3 were comparable in all the months except fifth, ninth, tenth and eleventh months of planting, where effect of k_3 was found significant.

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1	10.00	14.78	19.44	20.33	23.00	26.22	28.70	30.85	32.85	35.00	36.37	38.70
n_2	9:56	14.41	19.48	20.89	24.89	29.11	31.78	34.04	36.70	39.81	41.89	45.78
n_3	12.85	21.70	27.74	30.48	36.33	41.22	45.04	48.96	53.37	58.15	61.78	66.48
F	53.56**	57.64**	93.54**	103.23**	124.09**	108.84**	116.90**	126.67**	150.63**	143.75**	156.91**	109.06**
CD	0.850	1.534	1.404	1.591	1.836	2.162	2.275	2.435	2.518	2.887	3.024	3.918
p_1	10.56	16.19	20.70	22.26	25.85	29.67	32.67	35.33	37.89	40.41	42.59	46.52
p_2	10.70	17.22	22.41	23.78	28.04	31.59	34.67	37.33	40.22	43.52	45.70	49.22
p_3	11.15	17.48	23.52	25.67	30.33	35.30	38.19	41.19	44.81	49.04	51.74	55.22
F	NS	NS	8.19**	9.24**	11.97**	14.07**	12.11**	11.99**	15.73**	18.40**	19.01**	10.39**
CD	--	--	1.404	1.591	1.836	2.162	2.275	2.435	2.518	2.887	3.024	3.918
k_1	10.44	15.78	20.93	22.48	26.67	30.78	33.59	36.33	39.07	42.07	44.41	47.44
k_2	10.67	17.44	22.19	23.93	27.74	31.81	35.07	37.74	40.33	43.74	46.00	50.22
k_3	11.30	17.70	23.52	25.30	29.81	33.96	36.85	29.78	43.52	47.15	49.63	53.30
F	3.67*	3.67*	6.85**	6.28**	6.11**	4.54*	4.13*	4.06*	6.65*	6.45**	6.29**	4.48*
CD	1.534	1.534	1.404	1.591	1.836	2.162	2.275	2.435	2.518	2.887	3.024	3.918

* Significant at 5% level ** Significant at 1% level NS - Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_1p_1	9.89	13.78	17.44	19.11	21.00	24.33	27.00	29.00	30.56	32.00	33.11	36.00
n_1p_2	9.78	15.00	20.22	20.44	22.89	25.56	28.22	30.00	31.89	34.44	34.67	36.11
n_1p_3	10.33	15.56	20.56	21.44	25.11	28.78	30.89	33.56	36.11	39.56	41.33	44.00
n_2p_1	9.44	14.00	18.78	20.11	23.89	27.67	30.56	33.00	35.22	37.89	39.89	44.00
n_2p_2	9.22	14.22	18.78	19.89	23.67	27.11	29.89	32.33	34.44	38.22	39.89	43.33
n_2p_3	10.0	15.00	20.89	22.67	27.11	32.56	34.89	36.78	40.44	43.33	45.89	50.00
n_3p_1	12.33	20.78	25.89.	27.56	32.67	37.11	39.89	39.90	39.91	39.96	39.99	43.33
n_3p_2	13.11	22.44	28.22	31.00	37.56	42.11	45.89	49.67	54.33	58.89	62.56	68.22
n_3p_3	13.11	21.89	29.11	32.89	38.78	44.56	48.78	53.22	57.89	64.22	68.00	71.67
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--	--	--	--	--	--	--
n_1k_1	9.89	14.44	19.00	19.67	22.22	24.56	26.78	28.89	30.67	32.33	33.78	35.44
n_1k_2	9.33	14.11	18.44	20.11	22.33	26.89	30.00	32.33	34.44	36.67	37.89	39.78
n_1k_3	10.78	15.78	20.78	21.22	24.44	27.22	29.33	31.33	34.44	36.00	37.44	40.89
n_2k_1	8.89	13.33	18.00	19.56	23.89	29.33	32.00	34.56	36.89	39.78	42.56	46.00
n_2k_2	9.67	15.44	19.78	21.11	24.89	28.00	30.67	32.67	35.00	38.44	40.44	44.44
n_2k_3	10.11	14.44	20.67	22.00	25.89	30.00	32.67	34.89	38.22	41.22	42.67	46.89

Table 14. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
n_3k_1	12.56	19.56	25.78	28.22	33.89	38.44	42.00	45.56	49.67	54.11	56.89	60.89
n_3k_2	13.00	22.67	28.33	30.56	36.00	40.56	44.56	48.22	51.56	56.11	59.67	66.44
n_3k_3	13.00	22.89	29.11	32.67	39.11	44.67	48.56	53.11	58.89	64.22	68.78	72.11
F	NS	NS	NS	NS	NS	NS	NS	NS	3.05*	2.57*	3.48*	NS
CD	--	--	--	--	--	--	--	--	4.362	5.001	5.237	--
p_1k_1	9.56	13.67	18.00	19.56	22.78	25.78	28.11	30.44	32.67	34.78	36.33	39.22
p_1k_2	11.11	17.44	21.67	23.33	26.33	31.22	34.89	37.67	40.11	42.78	45.22	49.89
p_1k_3	11.00	17.44	22.44	23.89	28.44	32.00	35.00	37.89	40.89	43.67	46.22	50.44
p_2k_1	10.44	17.22	23.33	23.33	27.11	30.33	33.67	36.33	39.11	42.56	45.11	47.11
p_2k_2	10.33	16.56	21.22	22.44	26.67	30.11	33.11	35.67	37.89	40.78	42.78	46.78
p_2k_3	11.33	17.89	23.67	25.56	30.33	34.33	37.22	40.00	43.67	47.22	49.22	53.78
p_3k_1	11.33	16.44	22.44	24.56	30.11	36.22	39.00	42.22	45.44	48.89	51.78	56.00
p_3k_2	10.56	18.22	23.67	26.00	30.22	34.11	37.22	39.89	43.00	47.67	50.00	54.00
p_3k_3	11.56	17.78	24.44	26.44	30.67	35.56	38.33	41.44	46.00	50.56	53.44	55.67
F	NS	NS	NS	NS	NS	2.97*	3.46*	3.57*	3.52*	2.74*	3.19*	2.71*
CD	--	--	--	--	--	3.745	3.941	4.217	4.362	5.001	5.237	6.785

* Significant at 5% level ** Significant at 1% level NS - Not significant

NK interaction was highly significant in influencing maximum East-West spread. The interaction n_3k_3 was significant during ninth (58.89 cm), tenth (64.22 cm) and eleventh (68.78 cm) months of planting. From the sixth month of planting and throughout the later growth stages PK interactions was found to be significant. p_3k_1 was found to be significant in sixth (36.22 cm), seventh (39.00 cm), eighth (42.22 cm) and twelfth (56.00 cm). Whereas in ninth, tenth and eleventh month, p_3k_3 found highly significant (46.00, 50.66 and 53.44 cm respectively).

4.2. Flowering and Floral characters

Floral characters were measured in terms in number of days for first flower picking, flower yield, monthly yield pattern, hundred bud weight and time taken for opening of flowers after harvest. As the plants were very young at the time of planting, observations on flower yield was recorded only after sixth month of planting when the flower production stabilised.

4.2.1. Effect of nutrients on number of days taken for first flower picking

The results of the study on the effect of major nutrients on number of days for first flower picking is presented in Tables 15 and 16.

Table 15. Main effect of N, P and K on flowering and floral characters

Treatment	Number of days taken for first flower picking	Weight of 100 flower buds (grams)	Time taken for opening of flowers after harvest (hours)
n_1	70.48	23.28	4.39
n_2	70.70	23.52	4.35
n_3	70.37	23.97	4.32
F	NS	NS	NS
CD	—	—	—
p_1	70.52	23.39	4.20
p_2	70.41	23.07	4.38
p_3	70.63	24.31	4.47
F	NS	NS	5.14**
CD	—	—	0.171
k_1	70.26	24.17	4.34
k_2	70.56	23.83	4.36
k_3	70.74	22.78	4.35
F	NS	NS	NS
CD	—	—	—

** Significant at 1% level NS - Not significant

Table 16. Interaction effect of NP, NK and PK on flowering and floral characters

Treatment	Number of days taken for first flower picking	Weight of 100 flower buds (grams)	Time taken for opening of flowers after harvest (hours)
n_1p_1	70.11	22.02	4.20
n_1p_2	70.56	23.88	4.32
n_1p_3	70.78	23.96	4.64
n_2p_1	70.78	23.47	4.18
n_2p_2	70.33	22.56	4.45
n_2p_3	71.00	24.53	4.41
n_3p_1	70.67	24.69	4.23
n_3p_2	70.33	22.78	4.36
n_3p_3	70.11	24.44	4.38
F	NS	NS	NS
CD	—	—	—
n_1k_1	70.22	23.02	4.36
n_1k_2	70.00	23.21	4.38
n_1k_3	71.22	23.63	4.42
n_2k_1	70.56	24.93	4.37
n_2k_2	70.78	24.09	4.36
n_2k_3	70.78	21.54	4.31
n_3k_1	70.00	24.55	4.29
n_3k_2	70.89	24.19	4.35
n_3k_3	70.22	23.19	4.33
F	NS	NS	NS
CD	—	—	—
p_1k_1	70.44	24.42	4.25
p_1k_2	70.78	24.53	4.25
p_1k_3	70.33	21.23	4.11
p_2k_1	70.11	23.06	4.44
p_2k_2	70.00	22.47	4.24
p_2k_3	71.11	23.70	4.46
p_3k_1	70.22	25.03	4.34
p_3k_2	70.89	24.48	4.60
p_3k_3	70.78	23.42	4.48
F	NS	NS	NS
CD	—	—	—

NS - Not significant

It was observed that the nutrients did not influence the number of days taken for first flower picking.

4.2.2. Weight of hundred flower buds

The data on the effect of nutrients on weight of hundred flower buds is presented in Tables 15 and 16.

It was observed that weight of hundred flower buds was not influenced by the major nutrients. The controls also did not significantly differ from treatments.

4.2.3. Time taken for opening of flowers after harvest

The data on time taken for opening of flowers after harvest is presented in Tables 15 and 16.

This character was found to be influenced significantly by the application of P. Maximum time was taken with level p_3 followed by p_2 and p_1 respectively. The controls also did not differ significantly from treatments.

4.2.4. Effect of nutrients on flower yield

The data on effect of nutrients on yield of flowers are presented in Tables 17 and 18.

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

Treatment	Flower yield (kg ha^{-1})
n_1	4830.81
n_2	6231.27
n_3	7935.32
F	1921.62**
CD	100.382
p_1	6095.67
p_2	6088.15
p_3	6903.69
F	175.10**
CD	100.382
k_1	5807.91
k_2	6063.66
k_3	7215.93
F	448.45**
CD	100.382

** - Significant at 1% level

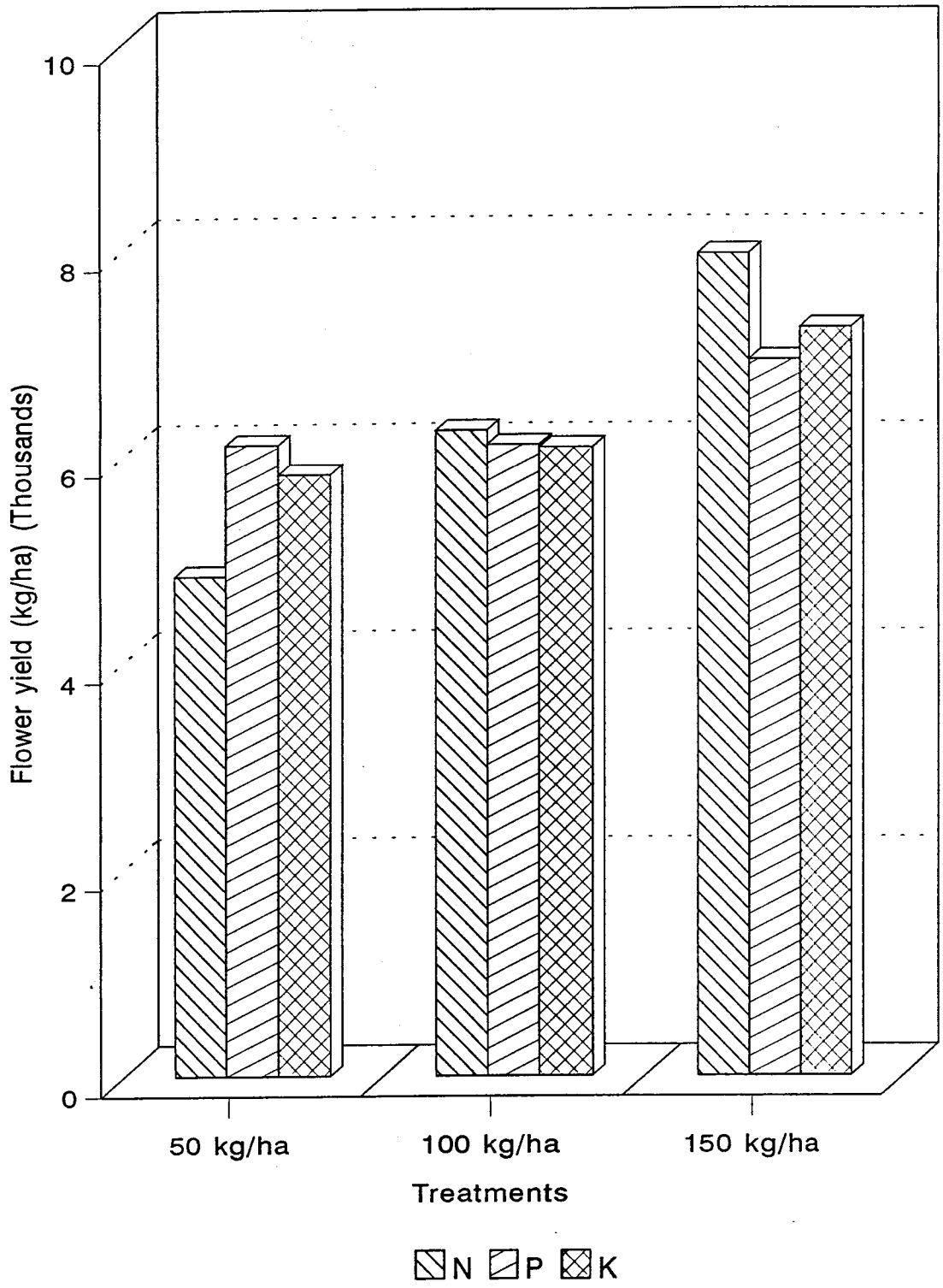


Fig. 2. Effect of N, P and K on flower yield of bush jasmine

Plate 2. T_{22} ($n_3P_2k_1$)

Plate 3. T_{23} ($n_3P_2k_2$)


T-22


T-23


T-25


T-27

Plate 4. T_{25} ($n_3P_3k_1$)

Plate 5. T_{27} ($n_3P_3k_3$)

Table 18. Interaction effect of NP, NK and PK on flower yield (kg ha^{-1})

Treatment	Flower yield (kg ha^{-1})
n_1p_1	5866.55
n_1p_2	3964.57
n_1p_3	4661.32
n_2p_1	6073.23
n_2p_2	6185.23
n_2p_3	6705.65
n_3p_1	6347.22
n_3p_2	8114.65
n_3p_3	9344.09
F	352.09**
CD	173.867
n_1k_1	3938.42
n_1k_2	4298.19
n_1k_3	6255.83
n_2k_1	6009.94
n_2k_2	6795.10
n_2k_3	6159.07
n_3k_1	7475.36
n_3k_2	7097.70
n_3k_3	9232.90
F	178.00**
CD	173.867
p_1k_1	4929.98
p_1k_2	6177.11
p_1k_3	7179.91
p_2k_1	6335.33
p_2k_2	5232.86
p_2k_3	6696.26
p_3k_1	6158.42
p_3k_2	6781.02
p_3k_3	7771.63
F	109.71**
CD	173.867

** Significant at 1% level

On flower yield, the highest yield being recorded at n_3 level. Yield of flowers was significantly influenced by application of P, where p_3 level fared over the others viz. p_2 and p_1. Significant difference in flower yield was noticed at various levels of K. Here the level k_3 effected significantly higher yields compared to k_2 and k_1.

Among the NP interactions, n_3p_3 proved to be highly significant in producing maximum flower yield (9344.09 kg ha^{-1}). NK interaction was found to significantly influence flower yield at n_3k_3 (9232.90 kg ha^{-1}). The interaction of P and K was found significant recording the yield of 7771.63 kg ha^{-1} in p_3k_3.

4.2.5. Effect of nutrients on monthly yield pattern

The data on the effect of nutrients on monthly yield pattern is presented in Tables 19 and 20.

It was found that the monthly yield pattern in jasmine was not significantly influenced by the major nutrients. Also controls did not differ significantly from the treatments.

4.3. Content of nutrients in leaves

4.3.1. Effect of nutrients on leaf nitrogen content

The data on effect of nutrients on leaf nitrogen is presented in Tables 21 and 22.

Table 19. Main effect of N, P and K on monthy yield pattern (kg ha^{-1})

Treatment	Months after planting					
	7	8	9	10	11	12
n_1	263.81	404.42	531.97	971.56	645.48	370.81
n_2	245.98	367.99	458.94	808.53	499.26	316.30
n_3	267.45	297.99	570.39	960.39	624.44	345.48
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--
p_1	251.37	381.15	485.58	858.59	550.37	328.00
p_2	255.28	383.60	498.59	875.89	561.78	329.63
p_3	270.59	405.67	577.13	1006.00	657.04	374.96
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--
k_1	252.34	378.25	485.73	872.98	552.00	334.81
k_2	261.46	393.40	526.30	916.76	594.52	337.78
k_3	263.44	398.76	549.26	950.74	622.67	360.00
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--

NS - Not significant

Table 20. Interaction effect of NP, NK and PK on monthy yield pattern (kg ha^{-1})

Treatment	Months after planting					
	7	8	9	10	11	12
n_1p_1	242.24	369.67	430.78	794.94	533.33	331.56
n_1p_2	257.59	387.12	492.32	853.23	588.89	314.67
n_1p_3	291.61	456.47	672.80	1266.53	814.22	466.22
n_2p_1	247.22	371.97	456.9	835.32	529.78	323.56
n_2p_2	250.54	372.89	481.29	856.45	581.67	328.44
n_2p_3	240.17	259.11	438.58	733.83	449.33	296.89
n_3p_1	264.64	401.82	569.01	945.54	588.00	328.89
n_3p_2	257.70	390.80	522.17	917.98	577.78	345.78
n_3p_3	279.99	401.36	619.99	1017.64	707.56	361.78
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--
n_1k_1	249.30	383.91	465.68	847.26	556.89	320.89
n_1k_2	271.28	409.17	561.67	1010.29	560.00	362.67
n_1k_3	270.87	420.19	568.55	1057.13	629.33	428.89
n_2k_1	236.02	356.36	400.92	696.63	436.00	300.44
n_2k_2	243.08	359.11	434.91	792.16	477.33	308.89
n_2k_3	258.84	388.50	541.00	936.81	584.44	339.56
n_3k_1	271.70	394.47	590.60	1075.04	663.11	383.11
n_3k_2	270.04	411.92	582.33	947.83	637.33	341.78
n_3k_3	260.61	387.56	538.24	858.28	572.89	311.56
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--
p_1k_1	240.17	363.70	440.88	755.42	461.78	304.44
p_1k_2	258.01	386.21	494.15	912.47	560.00	337.33
p_1k_3	255.93	393.55	521.71	907.88	629.33	342.22
p_2k_1	258.84	394.01	501.04	936.81	606.67	360.44
p_2k_2	247.22	366.92	463.84	828.43	541.33	309.33
p_2k_3	259.78	389.88	530.89	862.42	537.33	319.11
p_3k_1	258.01	377.02	515.28	926.70	587.56	339.56
p_3k_2	279.16	427.08	620.91	1009.37	682.22	366.67
p_3k_3	274.66	412.84	595.19	1081.93	701.33	418.67
F	NS	NS	NS	NS	NS	NS
CD	--	--	--	--	--	--

NS - Not significant

The leaf nitrogen content was found to be significantly influenced by the application of N. The level n_3 fared over other levels, while the content was found to increase from n_1 to n_2. The applied K significantly influenced leaf nitrogen content. However, a reducing trend in leaf K content was noted in k_1 to k_3.

The two factor interactions of N, P and K significantly influence the nitrogen content of leaves. In N x P interaction, n_3p_1 was found significant (1.77 per cent). NK interaction also showed significance in n_3k_1 (1.87 per cent). Interaction between P and K was significant with p_3k_1 (1.73 per cent) recording the highest content of N.

4.3.2. Effect of nutrients on leaf phosphorus content

The data on effect of nutrients on leaf phosphorus is presented in Tables 21 and 22.

Leaf P content was not found significantly influenced by any nutritive treatments. Eventhough the main effect was not significant, interaction effect was found to influence foliar P content.

NK interaction found highly significant with n_3k_3 giving maximum leaf P content (0.36 per cent). n_3k_3 was found statistically on par with n_1k_2, n_3k_1 and n_2k_1 (0.36 per cent each). PK interaction confirmed its superiority with p_1k_1 (0.37 per cent) recording maximum leaf P conent and was found statistically on par with p_1k_3 (0.36 per cent).

Table 21. Main effect of N, P and K on content of nutrients in leaves

Treatment	Leaves (per cent)		
	N	P	K
n_1	1.40	0.35	3.84
n_2	1.62	0.35	3.52
n_3	1.67	0.35	3.65
F	655.18**	NS	183.51**
CD	0.016	—	0.034
p_1	1.56	0.36	3.60
p_2	1.57	0.35	3.87
p_3	1.57	0.35	3.54
F	NS	NS	207.02**
CD	—	—	0.034
k_1	1.70	0.36	3.48
k_2	1.55	0.35	3.71
k_3	1.45	0.35	3.83
F	484.84**	NS	224.42**
CD	0.016	—	0.034

** Significant at 1% level

NS - Not significant

Table 22. Interaction effect of NP, NK and PK on content of nutrients in leaves

Treatment	Leaves (per cent)		
	N	P	K
n_1p_1	1.32	0.35	3.85
n_1p_2	1.47	0.35	4.16
n_1p_3	1.42	0.36	3.52
n_2p_1	1.59	0.35	3.19
n_2p_2	1.59	0.35	3.84
n_2p_3	1.69	0.34	3.53
n_3p_1	1.77	0.36	3.76
n_3p_2	1.65	0.34	3.60
n_3p_3	1.60	0.36	3.58
F	91.99**	NS	149.99**
CD	0.028	—	0.059
n_1k_1	1.52	0.35	3.50
n_1k_2	1.38	0.36	3.90
n_1k_3	1.30	0.35	4.13
n_2k_1	1.70	0.36	3.42
n_2k_2	1.60	0.35	3.48
n_2k_3	1.57	0.34	3.67
n_3k_1	1.87	0.36	3.51
n_3k_2	1.67	0.34	3.74
n_3k_3	1.47	0.36	3.70
F	53.14**	2.75*	40.40**
CD	0.028	0.018	0.059
p_1k_1	1.70	0.37	3.45
p_1k_2	1.55	0.34	3.68
p_1k_3	1.44	0.36	3.68
p_2k_1	1.66	0.35	3.75
p_2k_2	1.59	0.35	3.77
p_2k_3	1.46	0.34	4.08
p_3k_1	1.73	0.34	3.22
p_3k_2	1.52	0.35	3.68
p_3k_3	1.45	0.35	3.73
F	12.53**	3.48*	38.03**
CD	0.028	0.018	0.059

* Significant at 5% level ** Significant at 1% level NS - Not significant

4.3.3. Effect of nutrients on leaf potassium

The data on effect of nutrients on leaf potassium content is presented in Tables 21 and 22.

The leaf K content was found to be influenced by N application. Highest leaf K content was seen in n_1 followed by n_3 and n_2. Leaf K content was shown to be influenced by P application with level p_2 highly significant over the other levels. Applied K was found to significantly influence leaf K, with level k_3 highly significant over k_2 and k_1. The treatments were found to be statistically superior compared to the controls.

Highest percentage of leaf K was shown in n_1p_2 (4.16 per cent). NK interaction was maximum being in n_1k_3 (4.13 per cent). PK interaction was found significant with p_2k_3 (4.08 per cent) producing highest leaf potassium content.

4.4. Content of available soil nutrients

After the completion of the period under study, soil samples were collected from all treatment combinations for the analysis of available nutrients.

4.4.1 Effect of nutrients on available nitrogen content in soil

The data on available soil nitrogen for various treatment combination is shown in Tables 23 and 24.

Table 23. Main effect of N, P and K on available soil nutrients

Treatment	Soil (kg ha^{-1})		
	N	P	K
n_1	128.77	331.85	438.09
n_2	131.77	322.94	358.79
n_3	134.47	334.26	383.61
F	2083.68**	94.91**	539.86**
CD	0.456	1.734	4.498
p_1	133.03	229.00	352.69
p_2	122.94	327.04	397.51
p_3	136.05	433.02	430.30
F	1824.07**	27820.32**	497.92**
CD	0.456	1.734	4.948
k_1	139.26	326.43	390.69
k_2	120.69	336.24	389.78
k_3	132.06	326.39	400.02
F	3391.31**	86.10**	10.55**
CD	0.456	1.734	4.948

** Significant at 1% level

Table 24. Interaction effect of NP, NK and PK on available soil nutrients

Treatment	Soil (kg ha^{-1})		
	N	P	K
n_1p_1	110.18	224.67	353.66
n_1p_2	138.47	348.61	443.88
n_1p_3	137.66	422.28	516.75
n_2p_1	146.56	244.06	360.84
n_2p_2	125.84	285.44	359.22
n_2p_3	143.91	442.33	356.31
n_3p_1	142.34	218.28	343.58
n_3p_2	104.50	350.06	389.44
n_3p_3	126.56	434.44	417.83
F	3911.02**	742.69**	193.06**
CD	0.789	3.003	8.570
n_1k_1	123.84	341.22	543.36
n_1k_2	127.86	340.28	357.93
n_1k_3	134.62	314.06	412.99
n_2k_1	172.32	305.78	318.07
n_2k_2	114.50	347.50	382.51
n_2k_3	129.50	315.56	375.80
n_3k_1	121.63	332.28	310.66
n_3k_2	119.72	320.94	428.90
n_3k_3	132.06	349.56	411.29
F	4585.39**	367.35**	781.75**
CD	0.789	3.003	8.570
p_1k_1	130.42	243.78	368.86
p_1k_2	133.35	206.11	364.54
p_1k_3	135.32	237.11	324.67
p_2k_1	134.18	302.83	378.31
p_2k_2	118.17	371.78	394.30
p_2k_3	116.47	306.50	419.93
p_3k_1	153.19	432.67	424.91
p_3k_2	110.57	430.83	410.51
p_3k_3	144.39	435.56	455.48
F	2224.99**	809.54**	80.11**
CD	0.789	3.003	8.570

** Significant at 1% level

Available soil nitrogen was found to be influenced by applied nitrogen. Highest available N was noticed at n_3 level followed by n_2 and n_1 respectively. Applied P was found to influence available soil N. Highest available N content being recorded with p_3. Influence of applied K was also significant with level k_1 highly significant over other levels. The treatments were found to be statistically superior over the controls.

NP interaction was found significant in producing highest available soil N with n_2p_1 recording maximum soil N content (146.56 kg ha^{-1}). NK interaction was highly significant at n_2k_1 (172.32 kg ha^{-1}). Interaction of P and K was also found to be significantly higher at p_3k_1 (153.19 kg ha^{-1}).

4.4.2 Effect of nutrients on available phosphorus content of soil

The data on available P content in soil is presented in tables 23 and 24.

Available P was found to be significantly influenced by N application. Nitrogen at 150 kg ha^{-1} found highly significant over other levels viz., 100 and 50 kg ha^{-1} respectively. Applied P was also found significant in p_3 (150 kg ha^{-1}) producing maximum available P in soil. Influence of applied K was also significant highly at k_1 (50 kg ha^{-1}) followed by k_3 and k_2 respectively. The treatments were found statistically superior to the controls.

Soil P was found to be significantly influenced by NP interaction n_2p_3 was highly significant in producing maximum soil P content (442.33 kg ha^{-1}). NK interaction was significant with n_3k_3 (349.56 kg ha^{-1}) and was found statistically on par with n_2k_2 (347.5 kg ha^{-1}). A significantly higher soil P was noted in p_3k_3 (435.56 kg ha^{-1}) and was found to be statistically on par with p_3k_1 (432.67 kg ha^{-1}).

4.4.3 Effect of nutrients on available potassium content of soil

The data on the effect of nutrients on available soil K content is presented in Tables 23 and 24.

Influence of applied N was found significant in producing a high soil K content. The level n_1 was highly significant followed by n_3 and n_2 respectively. Applied P was also proved to have a significant effect on available K. p_3 level proved to be highly significant over other levels viz., p_2 and p_1 respectively. Influence of K at k_3 level was highly significant in producing maximum available K in soil. Treatments were found statistically superior to the controls.

Interaction of N and P was found significant in producing maximum content of available soil K. NP interaction was found highly significant in n_1p_3 (516.75 kg ha^{-1}). NK interaction was found significant at n_1k_1 (543.36 kg ha^{-1}). Interaction of P and K was also significant with p_3k_3 (455.48 kg ha^{-1}) producing maximum content of available soil K.

4.5 Effect of nutrients on Dry Matter Production (DMP)

Data on DMP are presented in tables 25 and 26.

DMP was found to be influenced signficantly by N application. Maximum DMP was seen with n_3 level followed by still lower levels viz. n_2 and n_1 respectively. Applied P was shown to influence DMP, highly at P_3 level compared to p_2 and p_1. Application of K was also found to influence DMP significantly. Level k_3 was found highly superior over k_2 and k_1. Treatments were found statistically superior compared to controls.

N x P interaction was significant with maximum DMP at n_3p_3 (109.13 g plant^{-1}). Among NK interaction n_3k_3 proved best in effecting highest DMP (90.71 g plant^{-1}). PK interaction was also seen highly significant with p_3k_3 producing maximum dry matter (75.34 g plant^{-1}).

4.6 Effect of nutrients on the uptake of N, P and K

The data on uptake of N, P and K are presented in tables 27 and 28.

It was observed that the uptake of N, P and K was not significantly influenced by major nutrients. The controls also did not significantly differ from the treatments.

Table 25. Main effect of N, P and K on DMP (twelve months after planting)

Treatments	DMP (g plant^{-1})
n_1	32.63
n_2	54.90
n_3	83.86
F	410.36**
CD	1.14
p_1	48.96
p_2	53.29
p_3	69.14
F	701.86**
CD	1.14
k_1	52.17
k_2	58.18
k_3	61.03
F	127.13**
CD	1.14

** Significant at 1% level

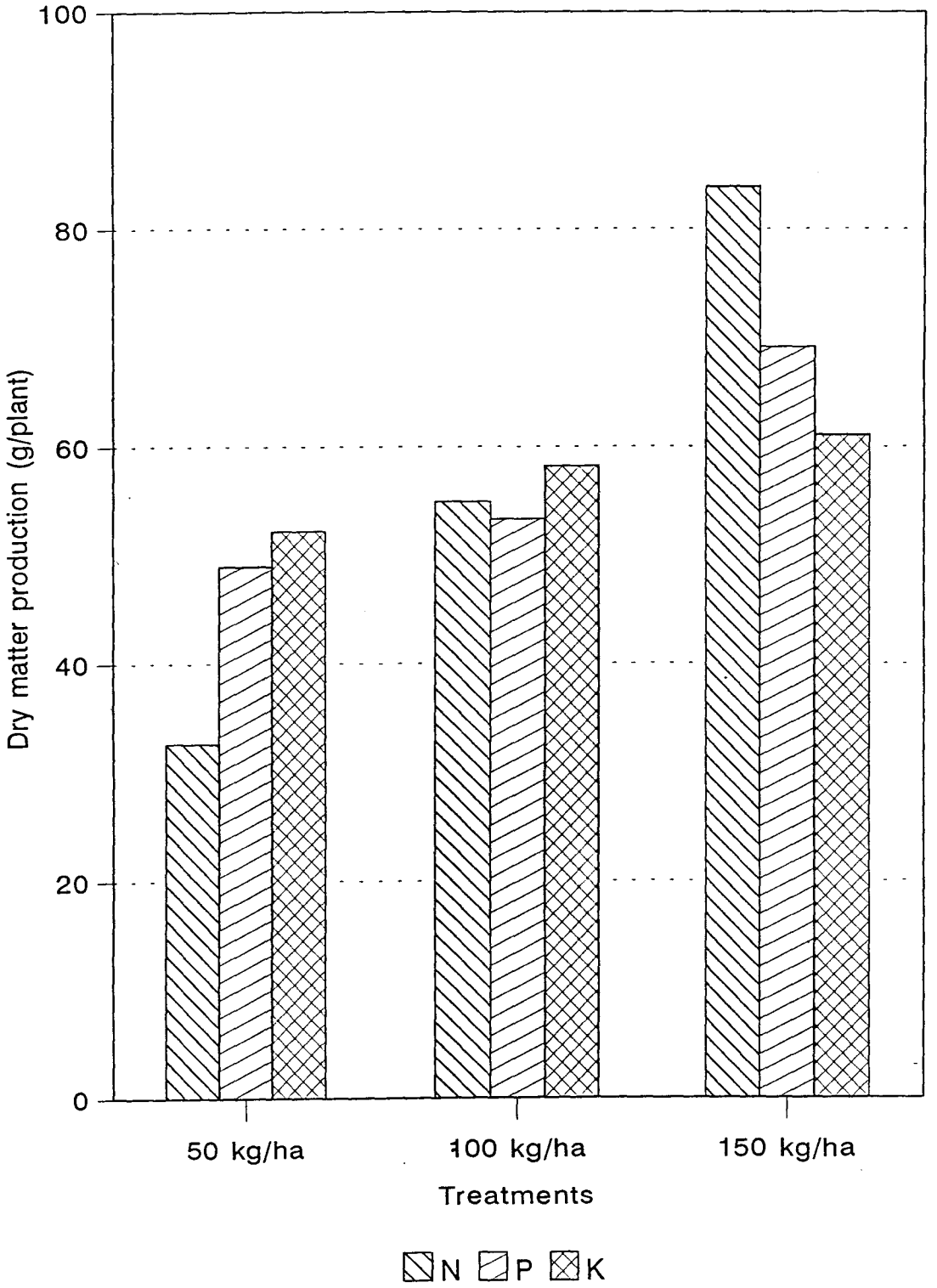


Fig. 3. Effect of N, P and K on DMP of bush jasmine

Table 26. Interaction effect of NP, NK and PK on DMP (twelve months after planting)

Treatments	DMP (g plant^{-1})
n_1p_1	24.58
n_1p_2	29.69
n_1p_3	43.62
n_2p_1	52.82
n_2p_2	57.20
n_2p_3	54.67
n_3p_1	69.47
n_3p_2	72.97
n_3p_3	109.13
F	254.28**
CD	1.97
n_1k_1	29.36
n_1k_2	32.59
n_1k_3	35.94
n_2k_1	54.14
n_2k_2	54.11
n_2k_3	56.43
n_3k_1	73.10
n_3k_2	87.84
n_3k_3	90.71
F	43.00**
CD	1.97
p_1k_1	47.44
p_1k_2	49.44
p_1k_3	49.98
p_2k_1	50.60
p_2k_2	51.49
p_2k_3	57.77
p_3k_1	58.47
p_3k_2	73.61
p_3k_3	75.34
F	43.38**
CD	1.97

** Significant at 1% level

Table 27. Main effect of N, P and K on uptake of nutrients

Treatments	Uptake of N ($kg\ ha^{-1}$)	Uptake of P ($kg\ ha^{-1}$)	Uptake of K ($kg\ ha^{-1}$)
n_1	5.23	0.66	7.51
n_2	6.50	1.22	8.62
n_3	7.06	1.30	9.12
F	NS	NS	NS
CD	—	—	—
p_1	3.0	0.91	8.30
p_2	4.62	1.03	9.94
p_3	6.21	1.29	12.79
F	NS	NS	NS
CD	—	—	—
k_1	5.13	1.21	8.54
k_2	4.00	1.11	8.40
k_3	5.24	1.37	9.70
F	NS	NS	NS
CD	—	—	—

NS - Not significant

Table 28. Interaction effect of NP, NK and PK on uptake of nutrients

Treatments	Uptake of N ($kg\ ha^{-1}$)	Uptake of P ($kg\ ha^{-1}$)	Uptake of K ($kg\ ha^{-1}$)
n_1p_1	3.51	0.35	6.23
n_1p_2	3.09	0.60	6.98
n_1p_3	3.09	1.02	7.49
n_2p_1	4.30	1.10	7.75
n_2p_2	4.88	1.28	9.06
n_2p_3	5.49	1.29	9.05
n_3p_1	7.25	1.27	9.30
n_3p_2	6.87	1.23	9.08
n_3p_3	6.06	1.25	9.03
F	NS	NS	NS
CD	—	—	—
n_1k_1	2.10	0.58	5.14
n_1k_2	2.30	0.68	5.37
n_1k_3	2.29	0.73	7.02
n_2k_1	5.25	1.40	8.00
n_2k_2	4.30	1.04	8.72
n_2k_3	4.73	1.23	8.72
n_3k_1	5.05	1.52	8.70
n_3k_2	5.42	1.65	8.91
n_3k_3	5.71	2.14	8.93
F	NS	NS	NS
CD	—	—	—
p_1k_1	4.51	0.94	9.30
p_1k_2	4.30	0.71	10.30
p_1k_3	4.04	1.07	9.14
p_2k_1	4.83	0.91	9.73
p_2k_2	4.52	0.87	9.43
p_2k_3	4.50	1.32	10.67
p_3k_1	6.05	1.52	10.21
p_3k_2	5.41	1.75	11.97
p_3k_3	5.18	1.71	12.00
F	NS	NS	NS
CD	—	—	—

NS - Not significant

4.7 Effect of nutrients of essential oil content of flowers

The data on effect of nutrients on essential oil contents is presented in Tables 29 and 30.

Application of N was found to have a significant influence in n_2 level followed by levels n_3 and n_1. Influence of applied P was also found significant with the level p_2 producing highest oil content followed by p_3 and p_1 respectively. Influence of K on essential oil content was found significant with level k_3 superior over other levels. The treatments were not found statistically superior over controls.

Essential oil content was found to be significantly influenced by NP interaction with n_3p_3 (0.292 per cent) recording maximum content. NK interaction was found to be highly significant at n_3k_3 (0.290 per cent). A high significance of PK interaction was also seen with p_3k_2 recording 0.29 per cent of essential oil.

4.8. Effect of nutrients on carbohydrate contents of flowering shoot

The results of the study on effect of major nutrients of carbohydrate content of flowering shoot are presented in Tables 31 and 32.

Applied N was found to significantly influence carbohydrate content of flowering shoot. The level n_1 was found highly significant

Table 29. Main effect of N, P and K on essential oil content of flowers

Treatment	Essential oil content of flowers (per cent)
n_1	0.270
n_2	0.281
n_3	0.280
F	71.31**
CD	0.002
p_1	0.270
p_2	0.281
p_3	0.280
F	91.42**
CD	0.002
k_1	0.274
k_2	0.282
k_3	0.283
F	21.19**
CD	0.002

** Significant at 1% level

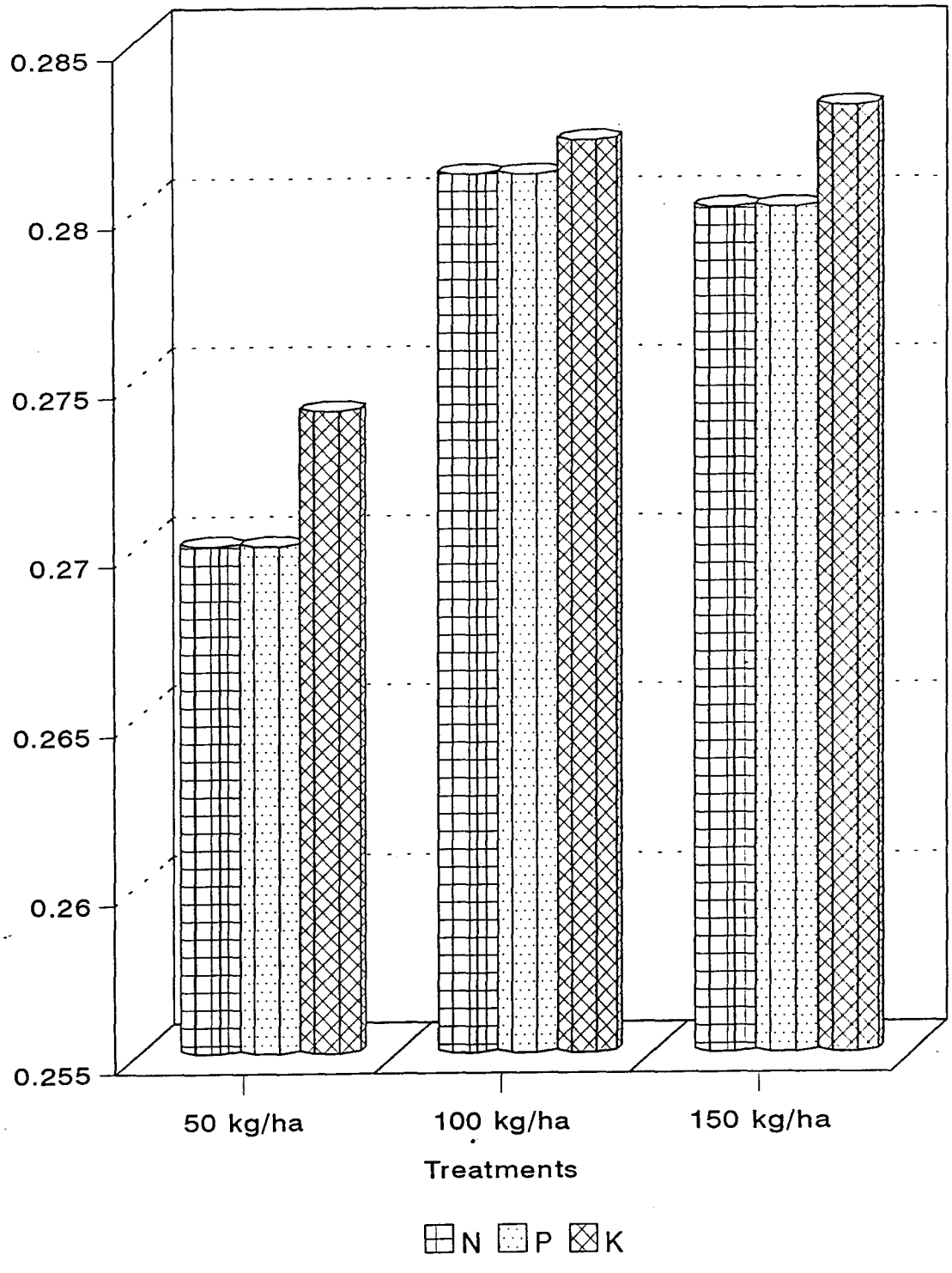


Fig. 4. Effect of N, P and K on essential oil content in flowers of bush jasmine

Table 30. Interaction effect of NP, NK and PK on essential oil content of flowers

Treatment	Essential oil content of flowers (per cent)
n_1p_1	0.267
n_1p_2	0.278
n_1p_3	0.280
n_2p_1	0.273
n_2p_2	0.281
n_2p_3	0.282
n_3p_1	0.284
n_3p_2	0.283
n_3p_3	0.292
F	14.68**
CD	0.004
n_1k_1	0.264
n_1k_2	0.285
n_1k_3	0.272
n_2k_1	0.273
n_2k_2	0.286
n_2k_3	0.287
n_3k_1	0.281
n_3k_2	0.280
n_3k_3	0.290
F	12.97**
CD	0.004
p_1k_1	0.267
p_1k_2	0.276
p_1k_3	0.273
p_2k_1	0.284
p_2k_2	0.272
p_2k_3	0.281
p_3k_1	0.280
p_3k_2	0.290
p_3k_3	0.281
F	11.83**
CD	0.004

** Significant at 1% level

Table 31. Main effect of N, P and K on carbohydrate content of flowering shoot

Treatment	Carbohydrate content of flowering shoot (per cent)
n_1	19.77
n_2	18.77
n_3	17.28
F	221.69**
CD	0.256
p_1	18.25
p_2	18.41
p_3	19.29
F	38.60**
CD	0.256
k_1	18.04
k_2	18.46
k_3	19.46
F	65.52**
CD	0.256

** Significant at 1% level

Table 32. Interaction effect of NP, NK and PK on carbohydrate content of flowering shoot

Treatment	Carbohydrate content of flowering shoot (per cent)
n_1p_1	18.34
n_1p_2	16.63
n_1p_3	16.87
n_2p_1	18.92
n_2p_2	18.52
n_2p_3	18.68
n_3p_1	17.49
n_3p_2	20.08
n_3p_3	22.33
F	119.48**
CD	0.443
n_1k_1	16.66
n_1k_2	16.54
n_1k_3	18.64
n_2k_1	17.40
n_2k_2	19.87
n_2k_3	18.86
n_3k_1	20.06
n_3k_2	18.97
n_3k_3	20.88
F	46.13**
CD	0.443
p_1k_1	16.87
p_1k_2	18.61
p_1k_3	19.28
p_2k_1	19.13
p_2k_2	17.31
p_2k_3	18.79
p_3k_1	18.11
p_3k_2	19.46
p_3k_3	20.31
F	43.34**
CD	0.443

** Significant at 1% level

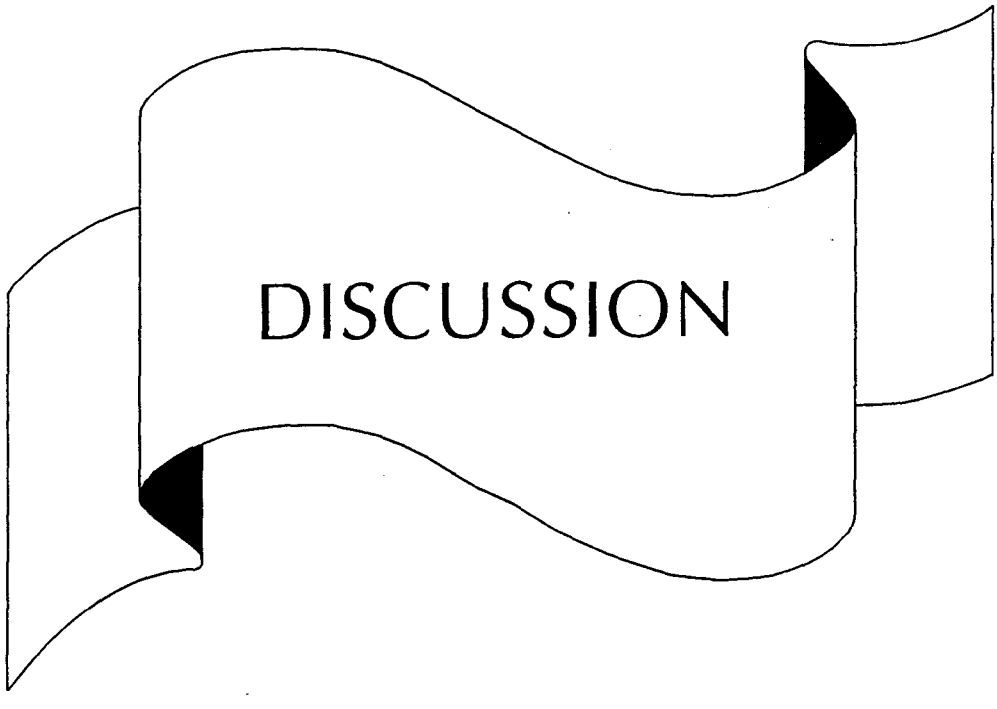
over other levels viz., n_2 and n_3 respectively. With regard to applied P, p_3 level was found highly significant while content with p_1 and p_2 were comparable. Influence of K on carbohydrate content was found superior and level k_3 found highly significant over other levels. The treatments were found statistically superior compared to controls.

The carbohydrate content was found to be significantly influenced by NP interaction with n_3p_3 (22.33 per cent) recording maximum content. NK interaction was found significant highly at n_3k_3 (20.88 per cent). A high significance of PK interaction was also seen with p_3k_3 (20.31 per cent).

4.9 Other observations

4.9.1 Incidence of pest and diseases

Though not serious, occasional incidence of jasmine bud worm attack was observed during peak flowering months. Incidence was kept checked by spraying Monocrotophos (0.04 per cent). Occurrence of any disease infestation was not noticed.


DISCUSSION

DISCUSSION

Cultivation of bush jasmine is becoming more and more popular among the farmers of Kerala especially, as a small scale enterprise by marginal farmers and housewives. Practically no studies have so far been conducted regarding the nutrient requirements for bush jasmine in Kerala.

In order to find out the optimum nutritional requirement for bush jasmine, an experiment was conducted at Department of Horticulture, College of Agriculture, Vellayani.

The experiment consisted of three levels of nitrogen (50, 100, 150 N kg ha^{-1}), three levels of phosphorus (50, 100, 150 P_2O_5 kg ha^{-1}) and three levels of potassium (50, 100, 150 kg K_2O ha^{-1}) in Randomised Block Design. Along with total of 27 treatments, two controls - one as absolute control and other with FYM of 10 kg ha^{-1} - was also included in the trail.

The different characters were critically observed and the results obtained are discussed below.

Growth characters

Growth is a multi dimensional web of many parameters. In the

present study, the growth of bush jasmine as influenced by various treatments has been elucidated through length of mainshoot, number and length of lateral branches and spread of the bush.

Length of main stem

Nitrogen application significantly influenced length of main stem. Throughout the growth period, highest dose of 150 kg N ha^{-1} produced maximum shoot length. This increase in plant height may be due to increased cell division and cell elongation brought about by nitrogen application. Nitrogen being the most potential nutrient element for the vegetative growth and development of plants, its supply and availability would have helped to increase the height of the plant. The effect of nitrogen application in increasing length of main shoot was reported by various workers in *Jasminum sambac* (Bhattarcharjee, 1985), in *Jasminum grandiflorum* (Natarajan, 1977) and in *Jasminum auriculatum* (Hugar and Nalawadi, 1994).

The application of phosphorus produced significant difference from fifth month of planting. Significant difference in plant height was shown at the highest dose of P at 150 kg P_2O_5 ha^{-1}. Phosphorus application might have resulted in better root formation during initial stages of growth and this inturn later resulted in increased plant height. Beneficial effect of P application in increasing plant height was reported by Srinivasan *et al.* (1989) in *Jasminum sambac*, Bose and Jana (1978) in bougainvilleas, Young *et al.* (1973) in rose.

The application of K at the highest level (150 kg K_2O ha^{-1}) produced significant difference in plant height during the last quarter of the growth period. The increased plant height at later stages may be due to the complementary effect of K with other nutrients on the growth of plants, better utilization of carbohydrates, promotion of enzyme activity and water transport. Beneficial effect of K application in increasing plant height was reported by Deswal *et al.* (1982) in gladiolus.

N x P interaction was significant with 150 kg N and 150 kg P_2O_5 ha^{-1} producing taller plants. Among P x K interaction, 150 kg P_2O_5 with 150 kg K_2O ha^{-1} resulted in maximum height of plants. The results revealed that combined application of NPK was necessary for increasing plant height in bush jasmine.

Number of primary and secondary branches

Application of nitrogen at the highest dose of 150 kg N ha^{-1} produced maximum number of branches throughout the growth period. This might be because of the activation of lateral buds, due to better N nutrition. Similar effects were reported in *Jasminum grandiflorum* by Natarajan and Madhava Rao (1980).

Application of 150 kg P_2O_5 ha^{-1} was found to produce maximum number of primary and secondary branches. Since phosphorus is a constituent of cell nucleus, it is closely associated with cell division and

meristematic activity (Ferman, 1965). Its application at higher levels might have resulted in higher rates of availability of this nutrient leading to an increase in number of branches per plant. Similar results were reported by Srinivasan *et al.* (1989) in *Jasminum sambac.*

With potassium nutrition, maximum number of branches were produced at highest level of 150 kg K_2O ha^{-1}. Potassium plays an important role in conversion of amino acids to proteins and soluble sugars to starch and other polysaccharides (Ferman, 1965). This might have led to higher vegetative growth at highest level of K application.

NP and NK interaction were significant at 150 kg N with 150 kg P_2O_5 ha^{-1} and 150 kg N with 150 kg K_2O ha^{-1} giving maximum number of primary and secondary branches.

PK interaction did not significantly influence the number of primary and secondary branches except during the second and nineth month after planting.

The controls registered significantly lower number of primary and secondary branches compared to treatments. This indicates that the supply of nutrients in adequate quantity was essential for good branch production.

Length of primary and secondary branches

Application of N at the highest level of 150 kg N ha^{-1} produced maximum length of primary and secondary branches. This can be attributed to the role of N in enhancing vegetative growth and conforms to the observations in *Jasminum sambac* by Srinivasan *et al.* (1989), Bhattacharjee (1985) and Pal *et al.* (1985).

Significantly higher length for primary and secondary branches were produced when P was applied at 150 kg P_2O_5 ha^{-1}. Phosphorus is closely associated with increased meristematic activity (Ferman, 1965), which inturn leads to increased length for primary and secondary branches. This finding was in conformity with reports of Srinivasan *et al.* (1989) in *Jasminum sambac* and Bose and Jana (1978) in bougainvilleas.

Maximum length of branches was found at 150 kg K_2O ha^{-1}. Increased length of branches may be due to complementary effect of K with other nutrients on growth of plant, better utilization of carbohydrates and water transport. Similar effect of K was also reported by Deswal *et al.* (1982) in gladiolus.

Spread of the plant

Application of N at highest dose of 150 kg N ha^{-1} produced maximum spread for the bushes throughout the growth period. The increased plant spread may be due to increase in length and number of branches as a consequence of N application.

150 kg ha^{-1} of P_2O_5 was found to produce maximum spread for plants. Both length and number of branches increased as a consequence of P application. This inturn increased spread of bush at highest levels of P.

Application of K was found to produce maximum East-West spread at 150 kg K_2O ha^{-1}. The effect of K on increasing length of branches may be attributed to maximum spread of bush.

NP interaction was significant at 150 kg N with 150 kg P_2O_5 ha^{-1} giving maximum North-South spread of bush. NK interaction was significant at 150 kg N and 150 kg K_2O ha^{-1} effecting maximum spread. PK interaction was also significant with 150 kg P_2O_5 + 50 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. So the availability of all the nutrients in adequate amounts is essential for proper spread of the plant. The controls registered spread inferior to those obtained from various treatments indicating that inadequate amounts of nutrients cannot produce satisfactory spread of bush.

Flowering and floral characters

Number of days for first flower picking

Application of N, P and K did not affect significantly the number of days for first flower picking. This shows that nutrients have

no definite role in determining the days required for first flower picking in jasmine.

Weight of 100 flower buds

N, P and K treatments did not affect significantly weight of hundred flower buds. This indicates that nutrients have no specific role in determining weight of flower buds.

Time taken for opening of flowers after harvest

Application of N and K were not significant with regard to the number of hours taken for opening of flower bud. But as the level of P increased, there was a significant delay in the opening of flower buds. This shows that among major nutrients, only P has a role in opening of flower buds. Ushakumari (1986) and Nirmala George (1989) also reported that higher levels of P delayed flower opening in rose.

Flower yield

Application of N at highest level of 150 kg ha^{-1} produces maximum yield. This may be due to production of large number of primary and secondary laterals with N application. These laterals ends in clustered cymes which increases total productive area of the plant. A highly significant positive correlation obtained between number of secondary laterals and yield of flowers was obtained by Nandakumar

(1976) in *Jasminum auriculatum* and Srinivasan *et al.* (1989) in *Jasminum sambac.*

Application of 150 kg P_2O_5 ha^{-1} produced maximum yield of flower buds. This may be due to maximum root activity associated with P nutrition. This equip the plant with wider circle of root system with better absorption of available nutrients, consequently more vegetative growth and higher yield resulted. Similar results were observed by Natarajan and Rao (1980) and Bhattacharjee (1985) in *Jasminum grandiflorum.*

K at its highest level of 150 kg K_2O ha^{-1} produced maximum flower yield. This may be due to favourable influence of K on the translocation of carbohydrates to the economic part which is an established fact. This result agrees with the work of Natarajan *et al.* (1981) in *Jasminum sambac* and Deswal *et al.* (1982) in gladiolus.

NP interaction was significant with 150 kg N + 150 kg P_2O_5 ha^{-1} giving maximum yield. This result agrees with the findings of Pal *et al.* (1985) in *Jasminum sambac* and Muthuswamy and Pappiah (1976) in *Jasminum auriculatum.* N x K and P x K interaction were also significant with 150 kg N + 150 kg K_2O ha^{-1} and 150 kg P_2O_5 + 150 kg K_2O ha^{-1} giving maximum yield of buds. Significant effect of N x K interaction and P x K interaction on flower yield were noticed by Muthuswamy and Pappiah (1976) in *Jasminum auriculatum.*

Monthly yield pattern

Various levels of N, P and K did not cause any significant response in monthly yield pattern. This shows that the nutrient levels have no specific role in altering monthly yield pattern in bush jasmine.

Chemical composition

Nutrient content of leaves

Maximum content of leaf nitrogen was observed at 150 kg N ha^{-1}. Application of 50 kg ha^{-1} of K_2O effected maximum leaf N content, indicating the possibility of an antagonism between N and K which is further stressed by the fact that highest content of K in leaves was observed in treatments receiving lowest N. The P nutrition did not affect leaf N content.

Phosphorus content of leaves was not influenced by application of nutrients. At the lowest level of K (50 kg K_2O ha^{-1}) maximum P content in leaves was observed.

Maximum content of leaf K was observed with nitrogen at 50 kg ha^{-1}. At 100 kg P_2O_5 ha^{-1} highest content of plant K was noticed. A regular increase in plant K content with increase in levels of K was observed.

N x P, N x K and P x K interactions were significant with 150 kg ha^{-1} N + 50 kg ha^{-1} P_2O_5, 150 kg N + 50 kg K_2O ha^{-1} and 150 kg P_2O_5 + 50 kg K_2O ha^{-1} producing maximum leaf N contents. N x K and P x K interactions were significant with 150 kg N + 150 kg K_2O ha^{-1} and 50 kg P_2O_5 + 50 kg K_2O ha^{-1} producing maximum leaf P contents. N x P, N x K and P x K interactions were significant with 50 kg N + 100 kg P_2O_5 ha^{-1} and 100 kg P_2O_5 + 150 kg K_2O ha^{-1} producing maximum leaf K contents.

Dry matter production (DMP)

Nitrogen application significantly influenced DMP. Nitrogen encourages the vegetative development of plants and controls to some extent, the efficient utilization of phosphorus and potassium. According to Russel (1973), as the nitrogen supply increases, the extra protein produced allows the plant leaves to grow larger and hence have surface area available for photosynthesis, which inturn results in better nitrogen use efficiency of plant and enhanced growth. This might have led to increased assimilation, higher productivity and increased DMP. The increased DMP with higher dose of N may be due to production of more primary and secondary laterals and increased leaf number.

The effect of phosphorus on DMP was also significant. At highest dose of P (150 kg P_2O_5 ha^{-1}) maximum DMP was attained. This may be due to the cumulative effect of phosphorus on plant height, leaf number and production of more laterals.

Application of 150 kg K_2O ha^{-1} resulted in higher DMP. Potasium complemented the effect of nitrogen in promoting vegetative growth. 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 + 150 kg K_2O ha^{-1} producing maximum DMP.

A significantly lower DMP was shown by the controls compared to all other treatments. This shows that the nutrient had a great influence on growth of plants. Supply of nutrients through application of chemical fertilizers might have activated many metabolic processes leading to production of complex substances which inturn influenced the growth and yield of jasmine.

Uptake studies

The results presented in the table revealed that there was an increase in the uptake of N, P and K by bush jasmine with application of graded doses of major nutrients to soil.

Uptake of nitrogen

The applicationof N upto 150 kg ha^{-1} increased the uptake of N (8.06 kg ha^{-1}) which resulted in a corresponding increase in vegetative growth and yield.

A positive increase in N uptake with higher P levels was observed.

Application of potassium upto 150 kg ha^{-1} resulted in maximum N uptake. The role of K in increasing nitrogen uptake is an established fact (Tisdale *et al.*, 1995).

Uptake of phosphorus

Phosphorus uptake was found to increase with application of higher doses of N.

Uptake of potassium

Increased K uptake with increased N, P and K application was observed though the effect was not significant.

Eventhough a regular increasing trend in the uptake of nutrients was noticed with higher levels of applied nutrients, the effect was not significant. This may probably due to young stage of growth of the plants.

Soil analysis

Available N, P and K content of soil (after the experiment) was influenced by graded levels of various nutrients. In general, all the treatment plots registered higher available nutrient status compared to control. Controls registered lower nutrient status after the experiment, but there was an increase in available nutrient status of soil in all the treated plots.

Available soil N progressively increased with higher doses of its application. Phosphorus levels enhanced N status of soil and with 150 kg ha^{-1} of P_2O_5 maximum N was left in the soil. The K application at 50 kg ha^{-1} produced highest residual soil nitrogen.

General increase in available P content was observed upto 150 kg N ha^{-1}. Among P levels, 150 kg P_2O_5 ha^{-1} produced maximum soil P status, after the experiment. Maximum content of available P was noted with K at 100 kg K_2O ha^{-1}.

The K status of soil differed with graded doses of N, P and K. N at 50 kg ha^{-1} left maximum available K. Significant increase in K status of soil was observed with increase in levels of P from 50 kg P_2O_5 ha^{-1} to 150 kg P_2O_5 ha^{-1}. Maximum content of available K was noticed when K was applied at 150 kg K_2O ha^{-1}.

All the two factor interactions influenced N, P and K status of soil, after the experiment. With regard to available N status, 100 kg N + 50 kg P_2O_5 ha^{-1} produced maximum soil N. Combined application of 100 kg N + 50 kg K_2O ha^{-1} and 150 kg P_2O_5 + 50 kg K_2O ha^{-1} resulted in maximum N status.

Regarding available P status 100 kg N + 150 kg P_2O_5 ha^{-1} produced higher soil P. Combined application of 150 kg N + 150 kg K_2O ha^{-1} and 150 kg P_2O_5 + 150 kg K_2O ha^{-1} resulted in maximum P status of soil.

With available K status of soil N x P, N x K and P x K interaction were significant with 50 kg N + 150 kg P_2O_5 ha^{-1}, 50 kg N + 50 kg K_2O ha^{-1} and 150 kg P_2O_5 + 150 kg K_2O ha^{-1} resulted in maximum K content of soil.

In general, as the fertilizer rates increased, the residual value also increased. This was in line with the finding of Tisdale *et al.* (1995).

Carbohydrate content of flowering shoot

Effect of N, P and K had significant influence on carbohydrate content of jasmine. At the lowest dose of N (50 kg ha^{-1}) highest content of carbohydrate was noted. This inverse relationship was possibly because nitrogen promoted the growth of additional tissues at the cost of photosynthates thus having little balance of carbohydrates for accumulation in the form of starch.

Influence of P at 150 kg ha^{-1} was significant in effecting maximum carbohydrate content of flowering shoot.

A regular increasing trend in carbohydrate content with increasing potassium level was noticed. Potassium is involved in starch formation and translocation of sugars (Brady, 1996).

N x P, N x K and P x K interactions 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 + 150 kg K_2O ha^{-1} produced maximum carbohydrate per cent in flowering shoots.

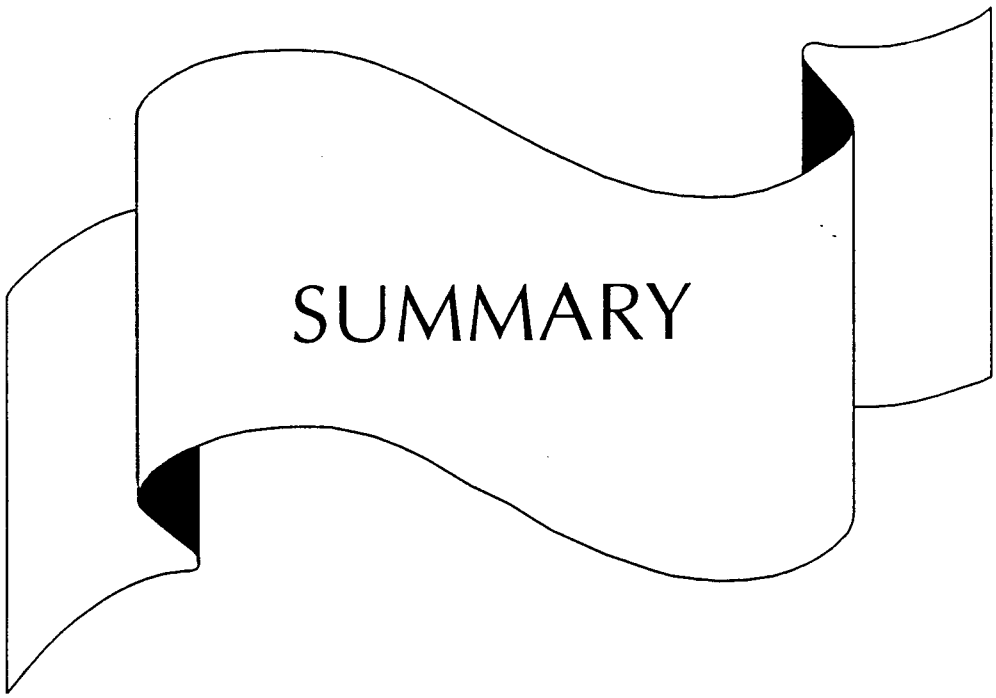
Essential oil content of flowers

Highest essential oil content of flowers were obtained in plots treated with 100 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1}. A regular increasing trend in essential oil was noted with increase in levels of K from 50 kg ha^{-1} to 150 kg K_2O ha^{-1}.

N x P, N x K and P x K interactions 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.

Future line of work

A linear response was observed in the characters studied with increasing levels of nutrients. Maximum response was observed with highest dose of applied nutrients. Hence the trial may be continued with higher levels of major nutrients.


SUMMARY

SUMMARY

The present investigation "Nutrient requirement of bush jasmine, *Jasminum sambac* Ait." was conducted at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 1996-98 to find out a suitable recommendation of major nutrients (N, P and K) for the optimum growth and flowering of bush jasmine. The effect of major nutrients on growth, yield, essential oil content of flowers and chemical composition were studied in detail and important findings are summarised below.

Application of N, P and K significantly influenced length of main shoot. Effect of N was significant throughout the growth period, while that of P was evident from fifth month onwards and that of K during the last quarter of growth period. In all the cases, highest values were obtained with the highest level of the nutrient.

The number of primary and secondary branches were significantly affected by the level of N, P and K. Levels n_3, p_3 and k_3 was found superior over the other levels.

Length of primary and secondary branches increased with increase in the level of nutrients. N influenced the length of primary and

secondary branches throughout the growth period. Effect of P was evident from third month onwards for length of primary branches and from eight month onwards for length of secondary branches. K exerted influence from eight month of planting.

The effect of N at n_3 level was highly significant in producing maximum North-South spread of plants. Applied P has shown maximum significance at p_3 level from sixth month onwards. But applied K was not found to have any influence in the North-South spread of bush.

Influence of N at n_3 level was highly significant in producing maximum East-West spread of bush. The effect of P was found significant with level p_3 superior over p_2 and p_1. Effect of k_2 and k_3 were comparable in all the months except fifth, nineth, tenth and eleventh month of planting, where effect of k_3 was found significant.

Applied N, P and K was not found to influence the number of days taken for first flower picking and weight of hundred flower buds. But the time taken for opening of flowers after harvest was found to be influenced by applied P only. Here, maximum time was taken with level p_3 followed by p_2 and p_1 respectively.

Yield of flowerbuds was significantly influenced by applied N, P and K. Maximum flower yield was noticed with highest level of respective major nutrients viz., n_3, p_3 and k_3.

Monthly yield pattern in jasmine was seen not to be influenced significantly by major nutrients. The leaf N content was found significantly influenced by applied N and applied K. Increasing levels of K reduced content of N. Leaf P content was not found to be significantly influenced by any nutrient treatments.

The leaf K content was significantly influenced by N application. High content of leaf K was noticed at n_1 followed by n_3 and n_2 respectively. Applied P was found to influence highly at p_2 level while applied K was found to influence highly at k_3 level.

DMP was found to be influenced significantly by applied N. Maximum DMP was noticed with n_3 level followed by still lower levels viz., n_2 and n_1 respectively. Applied P and K was shown to influence DMP highly at their respective higher levels ie., p_3 and k_3.

Influence of applied N was found significant in the content of available soil nitrogen. Maximum available N in soil was noticed at n_3 level. Influence of applied P was found significant at level p_3. Applied K was also significant with level k_1 highly superior to other levels.

Available P was found significantly influenced by N application. N at level n_3 was found highly significant over other levels. Applied P

was found significant highly in p_3 producing maximum content of available P in soil. With respect to applied K, available phosphorus content was found maximum with k_1 followed by k_3 and k_2 respectively.

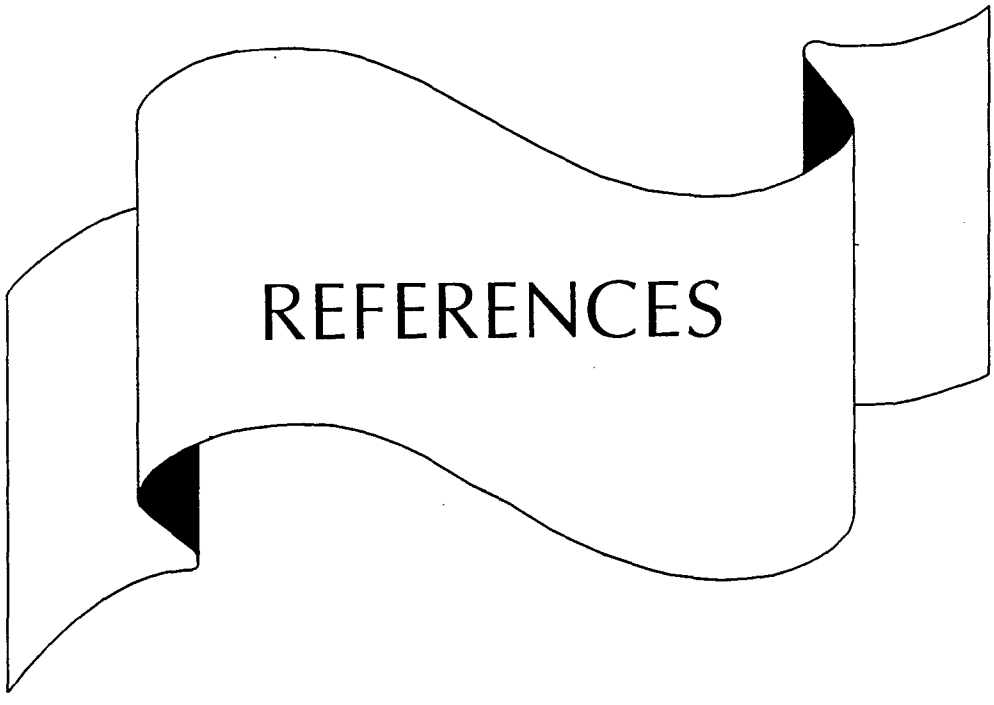
Influence of applied N was found significant in producing maximum content of available soil K with level n_1 highly significant followed by n_3 and n_2 respectively. With respect to applied P, p_3 proved to be highly superior to other levels. Influence of K at k_3 level was highly significant in producing maximum available K in soil.

Carbohydrate content of flowering shoot was found significantly influenced by applied N. Level n_1 was found highly significant over other levels. Influence of applied P was significant highly at p_3. Influence of K on carbohydrate content was found superior with level k_3 superior over other levels.

Application of N is found to have a significant influence on essential oil content highly at n_2 level followed by n_3 and n_1. In the case of applied P, significant influence was observed at level p_2. Influence of K on essential oil content was found significant with level k_3 superior to other levels.

The results of the present investigation thus indicated that the characters ie., growth, yield, time taken for opening of flowers, content

of nutrients in leaves, DMP, carbohydrate content, essential oil content and available soil nutrients, were significantly influenced by levels of nutrients. A linear response to applied nutrients was observed in the said characters.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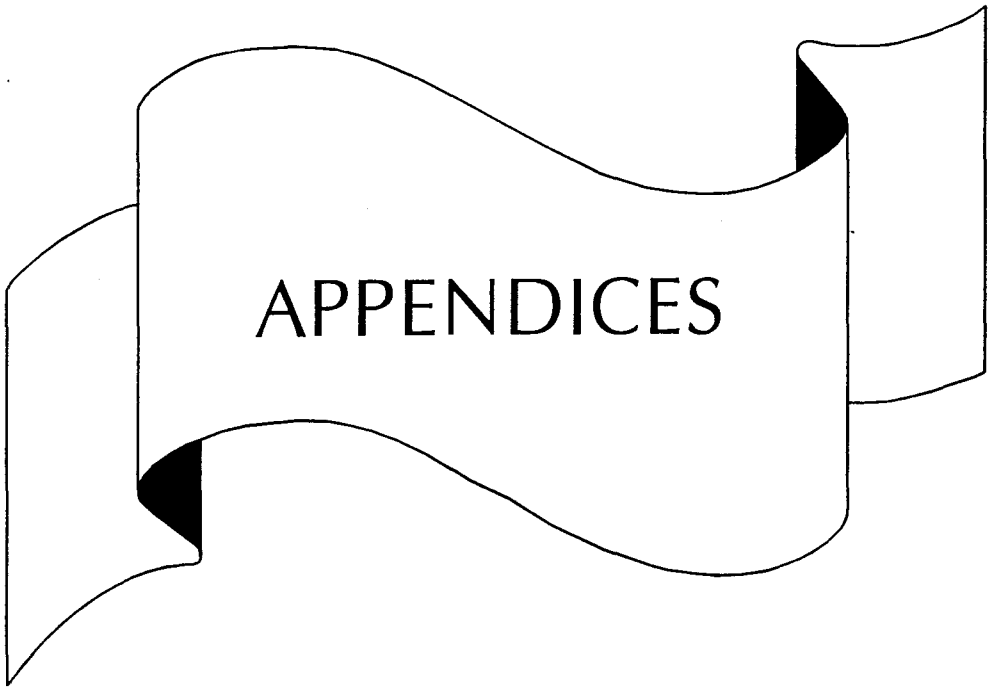
APPENDICES

Appendix 1. Meteorological parameters recorded during the period of study

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Sunshine (hours/day)
	Max	Min	FN	AN		
Aug.	32.80	23.80	91	75	100.5 (14 days)	8.35
Sep.	31.21	23.71	91	74	390.6 (18 days)	9.20
Oct.	30.28	23.70	90	72	200.2 (16 days)	9.05
Nov.	30.9	23.70	94	74	230.0 (19 days)	8.85
Dec.	31.0	23.10	93	73	75.0 (11 days)	9.05
Jan.	31.80	23.10	95	64	2.0 (1 day)	8.25
Feb.	32.12	23.71	93	64	18.8 (2 days)	9.00
Mar.	33.3	24.21	89	61	Nil	9.40
Apr.	34.14	25.38	89	67	49.3 (3 days)	8.40
May	32.90	25.90	93	74	213.0 (14 days)	8.55
Jun.	30.67	24.60	93	78	270.1 (25 days)	6.25
Jul.	31.60	22.10	98	71	110.0 (17 days)	6.15

Mean maximum temperature = 31.81°C
Mean minimum temperature = 23.91°C
Total rain fall = 1659.5 mm
Maximum Rain fall recorded - second month of planting (September)

Appendix 2. Soil nutrient status

Nutrient	Available nutrients (kg/ha)	Rating
N	92.4	Low
P_2O_5	33.00	High
K_2O	74.50	Low
Soil pH	5.5	Acidic

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	17.00	21.00	23.33	25.67	28.00	29.67	37.33	32.67	34.67	37.33	38.33	40.67
$n_1p_1k_2$	18.33	23.33	27.00	29.67	32.00	33.33	42.33	37.67	39.67	42.33	44.33	47.33
$n_1p_1k_3$	18.00	24.33	29.33	31.33	34.00	35.67	42.00	38.67	40.33	42.00	43.67	45.00
$n_1p_2k_1$	20.33	25.33	29.67	30.33	31.67	33.33	41.33	37.33	39.00	41.33	43.33	43.67
$n_1p_2k_2$	17.67	23.00	28.00	30.33	32.67	34.33	44.67	41.00	42.67	44.67	45.67	46.00
$n_1p_2k_3$	19.00	25.00	30.00	32.00	34.67	37.37	45.33	41.67	43.00	45.33	48.33	50.67
$n_1p_3k_1$	18.00	21.00	25.33	29.00	32.67	36.00	46.00	40.67	43.00	46.00	47.67	51.00
$n_1p_3k_2$	16.67	22.33	27.33	30.00	34.00	37.33	47.33	41.67	44.33	47.33	49.00	51.00
$n_1p_3k_3$	15.00	19.67	24.00	27.67	31.67	34.67	46.67	40.33	43.00	46.67	49.33	52.33
$n_2p_1k_1$	17.33	22.33	27.33	30.00	34.00	37.00	49.33	43.67	46.67	49.33	51.00	54.33
$n_2p_1k_2$	17.33	21.67	26.00	29.33	32.33	35.67	50.00	44.00	46.67	50.00	52.00	55.33
$n_2p_1k_3$	20.00	24.67	29.33	32.33	36.67	39.33	50.67	45.00	48.00	50.67	52.33	55.67
$n_2p_2k_1$	21.33	26.33	30.33	33.67	36.67	39.33	50.33	44.33	46.67	50.33	52.33	54.67
$n_2p_2k_2$	18.33	23.00	27.00	30.33	33.33	36.67	47.33	42.00	43.67	47.33	49.33	52.33
$n_2p_2k_3$	17.33	22.00	26.33	29.67	33.67	36.00	47.33	41.00	44.00	47.33	49.67	51.67
$n_2p_3k_1$	21.67	26.67	30.67	33.67	39.33	44.00	57.33	51.00	53.67	57.33	61.00	64.67

Appendix 3. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	18.33	22.67	26.67	30.00	33.00	36.33	46.33	40.67	43.33	46.33	49.00	53.33
$n_2p_3k_3$	20.00	24.33	30.00	34.00	39.33	44.33	56.67	50.00	53.67	56.67	60.33	65.00
$n_3p_1k_1$	17.67	22.67	27.67	31.67	34.33	37.67	48.00	42.33	45.00	48.00	50.33	52.33
$n_3p_1k_2$	23.33	30.67	37.67	41.33	47.67	53.33	64.00	58.33	61.67	64.00	66.67	71.67
$n_3p_1k_3$	26.33	34.33	41.33	45.67	52.67	58.67	76.33	67.00	72.00	76.33	79.67	86.00
$n_3p_2k_1$	26.67	32.33	37.33	42.00	47.67	54.00	71.67	62.67	66.67	71.67	74.33	78.67
$n_3p_2k_2$	25.33	31.67	36.00	40.00	45.00	50.00	63.67	56.00	59.00	63.67	67.67	71.33
$n_3p_2k_3$	23.67	30.67	37.67	42.67	49.90	55.67	72.33	64.00	68.00	72.33	76.67	83.33
$n_3p_3k_1$	27.00	35.33	41.00	46.67	54.33	61.67	79.00	70.33	75.00	79.00	84.33	90.33
$n_3p_3k_2$	27.67	35.33	41.67	48.00	55.67	61.33	76.67	68.67	73.00	76.67	80.67	86.00
$n_3p_3k_3$	25.00	33.33	39.33	44.67	53.00	60.00	79.67	69.33	74.00	79.67	84.67	92.33
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—	—	—	—	—	—	—
C_1	15.00	18.33	20.66	23.00	26.66	29.33	39.66	34.33	36.33	39.66	41.66	46.00
C_2	16.66	20.66	23.33	23.30	25.66	27.66	36.00	32.00	33.66	36.00	37.66	38.33

NS Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	1.33	1.67	2.33	2.67	4.33	5.00	5.67	5.67	6.33	7.00	7.00	7.00
$n_1p_1k_2$	2.00	2.67	3.33	4.33	5.00	5.33	6.00	6.67	7.00	7.67	8.33	8.67
$n_1p_1k_3$	1.67	2.33	3.67	4.33	4.67	5.00	5.67	7.00	6.00	7.00	8.00	9.00
$n_1p_2k_1$	1.33	2.00	3.67	4.00	4.67	5.33	6.33	6.33	6.33	6.67	7.33	7.33
$n_1p_2k_2$	1.33	2.33	3.67	5.33	5.67	6.33	6.67	6.67	6.67	7.00	7.00	7.00
$n_1p_2k_3$	2.33	3.33	4.00	4.33	5.67	6.67	7.33	7.67	8.00	8.33	8.67	9.33
$n_1p_3k_1$	2.00	2.33	4.00	5.67	6.00	7.00	7.33	8.00	8.67	9.33	9.33	9.67
$n_1p_3k_2$	1.33	2.33	3.67	5.67	6.33	7.67	8.67	9.33	10.33	11.33	12.33	12.67
$n_1p_3k_3$	1.00	1.67	3.33	5.33	6.33	7.33	8.00	9.00	10.00	11.00	10.33	11.33
$n_2p_1k_1$	2.00	2.67	4.33	6.67	7.33	8.33	10.00	10.33	11.00	11.67	12.33	13.33
$n_2p_1k_2$	1.33	2.33	4.00	5.67	6.67	7.67	8.67	9.67	10.33	11.33	12.33	13.67
$n_2p_1k_3$	1.67	2.67	4.00	6.00	6.67	8.00	9.67	10.67	11.33	12.00	12.67	13.67
$n_2p_2k_1$	1.33	2.33	3.33	5.00	5.67	7.00	8.00	8.67	9.67	10.33	10.67	11.67
$n_2p_2k_2$	1.00	2.33	3.67	6.33	7.00	8.00	8.67	9.67	10.33	11.00	11.67	13.33
$n_2p_2k_3$	1.67	2.67	4.00	6.67	7.67	8.67	9.33	10.33	11.00	11.67	12.02	13.33
$n_2p_3k_1$	1.33	2.00	3.00	5.67	6.33	8.00	8.33	9.67	10.33	11.33	12.67	13.67

Appendix 4. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	1.67	2.33	3.67	5.33	6.00	7.00	8.00	9.00	10.00	11.33	11.67	12.67
$n_2p_3k_3$	1.67	2.33	3.67	5.33	6.33	7.33	8.67	9.33	10.33	11.33	12.67	15.00
$n_3p_1k_1$	1.33	2.00	3.67	5.67	6.67	7.67	8.67	12.67	10.33	11.00	12.33	13.33
$n_3p_1k_2$	2.33	3.00	5.00	7.67	8.67	9.00	10.00	10.67	11.67	12.33	13.00	14.00
$n_3p_1k_3$	3.33	4.33	6.00	8.00	9.67	11.33	12.33	13.33	15.00	17.00	18.00	19.00
$n_3p_2k_1$	2.67	3.67	5.33	7.33	9.67	11.33	12.33	15.00	16.33	17.33	18.67	19.67
$n_3p_2k_2$	2.67	2.67	4.00	7.00	7.67	9.00	10.00	11.00	10.67	12.67	13.67	14.33
$n_3p_2k_3$	2.67	3.67	5.33	9.00	10.67	12.67	14.00	16.00	17.00	18.67	19.00	20.67
$n_3p_3k_1$	3.00	4.33	6.67	8.67	10.00	11.67	13.00	14.33	16.67	17.67	18.67	20.67
$n_3p_3k_2$	2.33	4.33	6.00	9.33	10.33	12.67	13.33	15.00	15.33	17.00	18.00	20.33
$n_3p_3k_3$	2.33	3.33	5.67	8.67	10.33	12.67	14.00	16.67	18.00	20.00	21.00	22.33
F	2.43*	3.27**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	1.073	0.931	—	—	—	—	—	—	—	—	—	—
c_1	1.00	1.66	2.00	3.00	4.00	5.33	6.33	7.33	7.66	8.33	9.00	10.33
c_2	1.00	1.66	2.66	3.60	4.33	5.33	6.00	6.33	7.00	7.33	7.66	8.00

** Significant at 1% level * Significant at 5% level NS Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	0.00	0.00	1.33	2.00	2.67	4.00	4.33	5.00	5.33	5.67	6.33	6.33
$n_1p_1k_2$	0.00	1.33	2.33	3.67	4.33	5.67	6.00	6.67	7.33	8.00	8.00	8.67
$n_1p_1k_3$	0.33	2.00	3.00	4.67	5.33	4.67	6.33	6.33	5.67	7.33	7.33	7.67
$n_1p_2k_1$	0.00	1.33	2.33	3.67	6.33	6.67	7.33	7.33	7.67	8.67	9.00	9.00
$n_1p_2k_2$	0.33	1.00	2.67	4.33	5.00	6.00	7.00	7.00	6.33	7.33	7.67	7.67
$n_1p_2k_3$	0.00	1.33	2.67	4.33	5.67	7.00	7.33	7.67	8.00	8.00	8.67	9.00
$n_1p_3k_1$	0.00	1.33	2.67	4.00	5.00	7.33	8.00	8.33	9.67	10.33	11.00	11.33
$n_1p_3k_2$	0.00	0.67	2.00	3.67	7.67	8.67	10.00	10.67	11.33	12.33	13.00	13.67
$n_1p_3k_3$	0.00	1.00	2.33	4.67	6.33	8.33	8.67	9.33	10.67	12.00	12.0	13.00
$n_2p_1k_1$	0.00	1.67	3.00	4.67	6.33	8.33	9.00	9.67	11.00	11.67	11.67	12.67
$n_2p_1k_2$	0.33	1.00	3.33	5.00	6.67	8.67	9.33	10.33	15.00	12.67	13.67	14.67
$n_2p_1k_3$	0.00	1.00	2.67	7.00	6.00	8.00	8.67	9.67	10.00	11.00	11.33	12.67
$n_2p_2k_1$	0.00	0.67	2.67	4.33	6.00	8.33	9.00	9.67	10.67	11.67	12.00	13.00
$n_2p_2k_2$	0.00	1.00	2.00	4.67	6.00	8.00	8.67	9.67	11.33	12.67	12.33	13.67
$n_2p_2k_3$	0.00	1.67	3.00	4.33	5.67	8.33	9.00	9.67	10.67	11.67	12.67	13.67
$n_2p_3k_1$	0.00	1.00	2.67	4.67	6.33	8.00	8.67	9.33	11.00	12.67	13.33	14.33

Appendix 5. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	0.00	0.67	2.33	4.00	5.00	6.33	7.00	8.00	8.67	10.00	11.67	12.67
$n_2p_3k_3$	0.00	1.00	3.33	5.33	6.67	8.67	10.00	10.67	11.33	12.67	13.67	14.67
$n_3p_1k_1$	0.00	1.00	2.33	4.33	6.33	8.33	9.33	10.33	11.33	13.00	13.00	14.00
$n_3p_1k_2$	0.00	2.00	3.00	5.67	8.00	10.00	11.33	12.67	13.67	14.67	15.33	16.33
$n_3p_1k_3$	0.33	3.00	5.33	7.67	9.67	12.67	14.00	15.00	16.67	18.33	21.33	22.00
$n_3p_2k_1$	0.33	2.67	3.67	5.67	8.33	11.67	13.33	15.67	16.33	18.67	20.33	22.00
$n_3p_2k_2$	0.00	1.67	2.67	4.67	6.33	8.33	9.67	10.67	10.33	12.33	14.67	15.33
$n_3p_2k_3$	0.00	2.33	4.00	7.33	10.00	12.67	13.67	15.33	17.00	18.00	19.67	21.00
$n_3p_3k_1$	1.00	3.00	5.00	7.67	9.67	11.67	13.33	14.33	17.00	18.33	19.33	21.00
$n_3p_3k_2$	1.00	3.00	4.67	7.67	10.00	12.67	14.33	16.33	16.33	17.67	19.00	20.33
$n_3p_3k_3$	1.00	3.00	4.00	7.33	10.00	13.33	15.67	17.00	21.67	20.67	22.00	23.33
F	NS	3.07**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	—	1.002	—	—	—	—	—	—	—	—	—	—
c_1	0.00	0.33	2.33	3.66	5.33	7.33	8.00	8.33	9.00	9.66	10.33	11.00
c_2	0.00	0.33	2.00	2.33	3.00	4.33	5.00	5.66	6.33	7.00	7.33	7.33

** Significant at 1% level NS Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	8.67	11.67	14.00	16.00	18.00	20.33	23.33	25.33	26.33	27.67	28.33	30.00
$n_1p_1k_2$	9.33	11.67	14.67	17.33	19.33	21.33	24.33	26.33	27.67	30.00	31.67	35.00
$n_1p_1k_3$	6.67	11.00	15.33	17.67	19.67	21.67	24.00	27.00	28.67	29.67	31.67	32.33
$n_1p_2k_1$	7.67	12.00	16.33	19.00	21.00	23.00	25.33	26.67	28.00	30.33	32.00	32.33
$n_1p_2k_2$	7.67	14.33	18.67	21.33	23.67	26.00	27.33	28.67	29.67	32.33	34.67	35.00
$n_1p_2k_3$	11.33	13.33	17.67	20.67	23.00	25.67	27.67	29.67	31.33	33.33	34.33	37.00
$n_1p_3k_1$	11.00	13.67	18.33	21.33	24.00	27.33	30.33	32.67	35.33	37.67	39.33	41.00
$n_1p_3k_2$	8.67	11.33	16.00	19.00	22.00	25.67	28.33	30.00	32.33	35.00	36.00	39.33
$n_1p_3k_3$	8.67	12.67	17.00	19.33	22.67	26.00	28.00	30.67	34.33	37.00	39.33	41.67
$n_2p_1k_1$	9.67	13.00	17.33	20.00	24.00	20.67	30.00	32.33	35.00	37.33	39.67	45.33
$n_2p_1k_2$	7.67	12.67	17.33	20.67	24.00	27.00	29.33	32.00	35.00	38.33	40.67	44.33
$n_2p_1k_3$	8.67	12.67	17.33	20.67	24.00	26.67	29.00	32.00	35.67	37.67	39.00	43.67
$n_2p_2k_1$	9.33	11.00	16.00	19.33	23.00	26.00	28.67	31.67	34.00	37.00	38.00	43.00
$n_2p_2k_2$	8.67	13.67	18.0	19.67	23.00	27.00	30.00	32.67	35.33	38.33	40.00	42.33
$n_2p_2k_3$	11.00	16.33	21.67	24.67	28.00	38.33	41.33	44.00	46.67	49.67	52.00	55.33
$n_2p_3k_1$	9.67	13.33	20.67	22.67	24.33	29.33	32.00	35.00	38.00	40.67	42.33	45.67

Appendix 6. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	10.00	13.67	21.33	20.33	23.33	26.33	28.67	31.33	33.67	36.67	38.33	42.00
$n_2p_3k_3$	9.00	13.67	23.00	22.00	26.67	30.67	33.67	36.33	39.00	41.33	42.67	47.00
$n_3p_1k_1$	8.67	13.67	23.00	22.00	25.33	28.33	31.00	33.00	36.00	39.00	41.33	44.67
$n_3p_1k_2$	9.67	13.00	26.00	26.00	31.00	35.33	38.33	41.00	43.33	46.33	48.67	53.00
$n_3p_1k_3$	14.33	20.33	33.00	33.00	40.33	36.33	40.33	45.00	49.00	53.00	58.00	61.00
$n_3p_2k_1$	13.00	17.00	30.00	30.00	36.33	42.00	46.67	51.33	54.67	59.67	62.33	66.33
$n_3p_2k_2$	13.33	17.67	22.00	26.67	31.33	35.67	39.00	41.33	40.67	44.67	48.00	51.33
$n_3p_2k_3$	12.00	18.00	24.00	29.33	36.00	40.67	45.33	49.00	54.00	57.67	61.00	64.67
$n_3p_3k_1$	13.00	19.33	26.67	32.33	39.67	44.67	48.67	53.00	58.00	59.00	67.67	71.67
$n_3p_3k_2$	13.67	19.33	26.00	31.33	38.33	44.00	47.67	51.67	55.00	56.00	62.33	64.00
$n_3p_3k_3$	13.33	17.67	24.00	27.33	34.67	41.33	46.00	51.67	56.33	61.67	64.67	66.00
F	NS	NS	NS	NS	2.59*	NS	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	6.185	—	—	—	—	—	—	—
c_1	7.33	10.66	13.00	15.00	18.33	21.00	24.33	26.33	28.66	31.30	33.33	36.33
c_2	6.00	9.66	12.00	13.66	16.00	18.66	21.00	23.00	23.33	27.00	27.66	28.66

* Significant at 5% level NS Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	0.00	0.00	2.67	5.00	6.67	8.67	10.33	12.00	13.33	15.00	16.00	17.00
$n_1p_1k_2$	0.00	2.67	6.00	8.67	9.67	12.00	14.67	16.33	18.00	20.00	21.00	22.00
$n_1p_1k_3$	0.67	4.33	8.67	11.33	12.67	14.67	17.00	19.00	20.67	22.33	25.33	26.33
$n_1p_2k_1$	0.00	3.33	7.67	12.33	13.00	13.33	11.67	16.67	18.33	20.00	21.67	21.87
$n_1p_2k_2$	0.67	1.67	5.33	10.33	12.00	14.33	16.33	17.67	19.67	22.33	24.00	25.37
$n_1p_2k_3$	0.00	2.67	7.33	13.00	15.00	17.00	19.00	20.33	22.67	25.33	26.33	27.22
$n_1p_3k_1$	0.00	2.67	6.67	9.67	12.00	14.33	17.33	20.00	22.33	24.67	26.33	29.33
$n_1p_3k_2$	0.00	2.33	6.00	8.67	11.33	14.67	17.00	19.33	22.00	24.33	26.33	27.23
$n_1p_3k_3$	0.00	3.67	5.67	11.33	14.67	17.67	19.00	22.00	25.00	27.33	30.33	31.32
$n_2p_1k_1$	0.00	2.33	6.00	8.33	12.67	15.33	24.67	20.00	23.00	26.07	27.67	29.67
$n_2p_1k_2$	0.67	2.67	6.33	10.00	13.00	16.67	19.00	21.67	24.00	26.67	27.33	28.51
$n_2p_1k_3$	0.00	1.67	6.00	10.00	12.67	16.33	19.33	23.00	25.00	27.33	29.00	30.12
$n_2p_2k_1$	0.00	1.67	6.00	10.00	12.67	16.67	19.67	22.00	24.33	27.00	29.33	31.21
$n_2p_2k_2$	0.00	3.00	6.67	10.33	13.33	16.00	18.67	21.67	23.33	26.33	28.00	30.21
$n_2p_2k_3$	0.00	3.33	7.33	15.00	17.67	21.00	23.33	26.00	28.67	31.00	34.00	36.21
$n_2p_3k_1$	0.00	2.67	6.00	9.00	13.00	17.67	19.33	23.00	25.67	30.00	32.33	33.31

Appendix 7. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	0.00	1.67	5.33	8.33	11.00	14.33	16.33	18.67	20.67	22.67	27.67	28.30
$n_2p_3k_3$	0.00	2.67	7.00	10.00	13.67	18.67	22.00	24.33	27.67	31.00	32.67	34.31
$n_3p_1k_1$	0.00	2.33	6.33	12.33	15.33	21.33	20.67	22.67	26.00	28.00	30.33	32.32
$n_3p_1k_2$	0.00	4.00	9.00	14.00	18.33	23.00	26.00	28.33	32.33	34.67	37.67	39.34
$n_3p_1k_3$	1.00	3.67	9.00	19.33	26.33	23.00	26.67	31.33	35.33	40.67	43.67	49.20
$n_3p_2k_1$	0.67	3.33	8.33	19.00	23.67	28.33	32.33	36.67	40.00	45.00	46.67	46.27
$n_3p_2k_2$	0.00	2.67	6.33	11.00	14.33	18.67	21.33	24.33	28.33	31.67	35.67	37.29
$n_3p_2k_3$	0.00	3.67	8.33	10.33	17.33	24.00	29.00	32.67	37.67	40.67	45.00	46.23
$n_3p_3k_1$	2.00	4.33	10.00	15.33	22.00	27.33	31.00	35.67	39.33	45.00	49.00	52.31
$n_3p_3k_2$	2.33	5.00	9.33	15.00	19.00	27.33	31.67	36.00	40.67	45.67	47.67	51.20
$n_3p_3k_3$	2.67	4.00	8.00	13.67	21.67	28.00	32.33	37.33	42.33	48.00	51.33	54.23
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—	—	—	—	—	—	—
c_1	0.00	0.66	3.66	6.33	9.00	11.66	15.00	16.66	19.33	22.00	23.33	23.81
c_2	0.00	0.66	3.66	13.00	14.00	17.33	19.00	20.66	22.00	24.00	24.66	24.81

NS Not significant

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

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	17.00	21.00	24.00	25.00	27.00	29.00	31.33	33.00	34.00	35.67	35.67	38.00
$n_1p_1k_2$	18.00	23.00	27.00	27.67	30.00	33.00	35.33	37.33	38.00	39.67	42.00	43.00
$n_1p_1k_3$	14.67	20.00	24.67	25.67	28.00	30.67	32.67	35.00	35.67	37.33	41.33	44.33
$n_1p_2k_1$	16.33	21.00	26.00	27.00	29.00	32.00	34.67	36.33	37.67	39.33	42.67	43.67
$n_1p_2k_2$	14.33	19.00	24.33	25.67	28.67	30.67	31.00	32.33	34.67	37.67	38.33	39.67
$n_1p_2k_3$	15.67	20.33	25.67	26.67	29.67	32.33	34.00	36.33	38.33	41.67	43.33	45.00
$n_1p_3k_1$	14.67	18.33	23.00	24.67	28.00	31.67	34.33	36.67	39.00	41.67	42.00	43.67
$n_1p_3k_2$	14.33	20.00	25.67	26.67	30.00	34.00	36.67	39.00	41.33	43.67	44.33	46.67
$n_1p_3k_3$	11.33	17.67	22.33	24.00	27.67	31.33	35.33	37.67	40.00	43.00	43.67	47.33
$n_2p_1k_1$	17.00	21.33	27.00	27.33	31.33	35.33	38.33	41.00	42.00	45.00	46.33	49.61
$n_2p_1k_2$	15.33	20.33	26.00	27.33	31.67	35.00	37.67	40.33	43.67	47.67	48.67	51.00
$n_2p_1k_3$	14.67	17.33	22.00	24.00	27.67	32.67	34.67	38.33	40.33	42.67	44.33	47.67
$n_2p_2k_1$	13.67	18.00	22.67	24.33	27.67	31.33	34.00	36.67	39.33	43.67	45.00	47.33
$n_2p_2k_2$	14.67	19.00	22.67	22.67	26.67	30.33	33.33	36.00	37.67	41.33	42.67	45.67
$n_2p_2k_3$	13.00	17.00	21.67	25.33	29.33	33.33	36.67	39.67	42.00	45.00	47.33	50.67
$n_2p_3k_1$	16.33	21.00	25.33	27.67	30.67	35.33	39.00	42.33	44.67	47.33	49.33	54.33

Appendix 8. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_2p_3k_2$	16.67	20.00	24.67	26.67	30.00	34.33	37.33	39.00	41.67	44.33	46.67	51.33
$n_2p_3k_3$	14.00	18.67	23.67	24.67	28.67	33.67	37.33	40.33	43.33	46.00	51.33	53.33
$n_3p_1k_1$	10.67	15.00	19.67	21.00	25.00	28.67	31.00	33.00	35.67	39.00	41.00	44.33
$n_3p_1k_2$	21.67	27.00	32.33	32.33	37.33	44.00	48.33	51.00	53.67	57.67	60.33	65.00
$n_3p_1k_3$	22.33	29.00	34.00	37.00	43.67	49.00	53.33	57.67	61.67	65.33	68.67	72.33
$n_3p_2k_1$	22.67	29.00	34.00	35.67	41.67	46.33	50.33	54.00	57.00	62.33	64.00	65.67
$n_3p_2k_2$	21.67	27.33	32.00	33.67	39.67	35.67	46.67	49.67	52.33	55.67	61.67	70.00
$n_3p_2k_3$	21.67	28.67	34.67	38.00	44.00	48.67	53.00	56.33	61.00	65.00	70.33	74.67
$n_3p_3k_1$	21.00	27.67	33.67	36.67	44.33	50.33	56.00	58.67	63.33	68.00	69.67	75.33
$n_3p_3k_2$	22.33	29.00	36.00	37.67	45.33	50.00	53.67	57.67	61.67	66.67	72.33	71.67
$n_2p_3k_3$	22.67	29.67	35.00	38.67	35.67	45.00	49.33	53.00	57.00	62.33	68.00	71.33
F	2.14*	2.17*	NS	NS	2.22*	2.62*	2.63*	2.46*	2.31*	NS	NS	NS
CD	4.763	5.264	—	—	7.319	8.007	8.298	8.881	9.36	—	—	—
c_1	16.66	21.00	25.66	27.00	30.00	33.33	36.66	39.00	41.66	42.66	44.33	49.00
c_2	13.33	17.00	20.00	21.33	28.66	26.33	28.33	29.66	31.33	33.66	33.66	34.33

* Significant at 5% level NS Not significant

Appendix 9. Interaction effect of NPK on East West spread (cm)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_1p_1k_1$	10.33	13.33	16.67	18.33	21.33	22.33	24.00	25.67	27.33	28.67	30.00	32.33
$n_1p_1k_2$	9.67	14.00	17.00	20.00	20.33	27.00	31.33	34.00	35.67	37.33	38.33	40.67
$n_1p_1k_3$	9.67	14.00	18.67	19.00	21.33	23.67	25.67	27.33	28.67	30.00	31.00	35.00
$n_1p_2k_1$	8.33	14.00	19.33	18.67	20.33	22.67	25.33	27.33	29.00	30.33	31.67	32.00
$n_1p_2k_2$	9.67	14.33	19.33	20.00	22.67	25.67	28.00	29.33	31.33	32.67	33.33	34.33
$n_1p_2k_3$	11.33	16.67	22.00	22.67	25.67	28.33	31.33	33.33	35.33	37.33	39.00	42.00
$n_1p_3k_1$	11.00	16.00	21.00	22.00	25.00	28.67	31.00	33.67	35.67	38.00	39.67	42.00
$n_1p_3k_2$	8.67	14.00	19.00	20.33	24.00	28.00	30.67	33.67	36.33	40.00	42.00	44.33
$n_1p_3k_3$	11.33	11.67	21.67	22.00	26.33	29.67	31.00	33.33	36.33	40.67	42.33	45.67
$n_2p_1k_1$	7.67	12.00	17.33	18.67	22.33	26.67	29.33	32.00	34.00	37.00	39.00	42.33
$n_2p_1k_2$	10.67	15.67	20.00	21.00	25.00	28.00	30.67	33.33	35.67	38.67	41.00	44.67
$n_2p_1k_3$	10.00	14.33	19.00	20.67	24.33	28.33	31.67	33.67	36.00	38.00	39.67	45.00
$n_2p_2k_1$	9.33	14.33	18.67	20.33	23.67	27.00	30.33	32.67	35.33	38.67	41.67	45.00
$n_2p_2k_2$	8.33	13.33	17.67	18.33	22.33	26.00	29.00	31.67	33.33	37.33	39.00	42.33
$n_2p_2k_3$	10.00	15.00	20.00	21.00	25.00	28.33	30.33	30.33	34.67	38.67	39.00	42.67
$n_2p_3k_1$	9.67	13.67	18.00	19.67	25.67	24.33	36.33	36.33	41.33	43.67	47.00	50.67

Appendix 9. (Contd...)

Treatments	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	12
$n_3p_3k_2$	10.00	17.33	21.67	24.00	27.33	30.00	32.33	32.33	36.00	39.33	41.33	46.33
$n_3p_3k_3$	10.33	14.00	23.00	24.33	28.33	33.33	36.00	36.00	44.00	47.00	49.33	53.00
$n_3p_1k_1$	10.67	15.67	20.00	21.67	24.67	28.33	31.00	31.00	36.67	28.67	40.00	43.00
$n_3p_1k_2$	13.00	22.67	28.00	29.00	33.67	38.67	42.67	42.67	49.00	52.33	56.33	64.33
$n_3p_1k_3$	13.33	24.00	29.67	32.00	39.67	44.00	47.67	47.67	28.00	63.00	68.00	71.33
$n_3p_2k_1$	13.67	23.33	29.00	31.00	37.33	41.33	45.33	45.33	53.00	58.67	62.00	64.33
$n_3p_2k_2$	13.00	22.00	26.67	29.00	35.00	38.67	42.33	42.33	49.00	52.33	56.33	63.67
$n_3p_2k_3$	12.67	22.00	29.00	33.00	40.33	46.33	50.00	50.00	61.00	65.67	69.67	76.67
$n_3p_3k_1$	13.33	19.67	28.33	32.00	39.67	45.67	49.67	49.67	59.33	65.00	68.67	75.33
$n_3p_3k_2$	13.00	23.33	30.30	33.67	39.33	44.33	48.67	48.67	56.67	63.67	66.67	71.33
$n_3p_3k_3$	13.00	22.67	28.67	33.00	37.33	43.67	48.00	48.00	57.67	64.00	68.67	68.33
F	NS	NS	NS	NS	2.51*	NS	NS	2.20*	2.32*	2.51*	NS	NS
CD	—	—	—	—	5.507	—	—	6.33	7.555	8.662	—	—
c_1	9.00	12.66	14.66	16.33	20.00	23.66	26.66	29.00	32.00	35.66	37.00	38.00
c_2	8.00	12.00	16.00	16.33	19.30	22.00	24.00	25.11	27.33	28.33	30.33	31.00

* Significant at 5% level NS Not significant

Appendix 10. Interaction effect of NPK on flowering and floral characters

Treatment	Number of days taken for first flower picking	Weight of 100 flower buds (grams)	Time taken for opening of flowers after harvest (hours)
$n_1p_1k_1$	70.00	20.86	4.17
$n_1p_1k_2$	69.67	23.81	4.25
$n_1p_1k_3$	70.67	21.40	4.18
$n_1p_2k_1$	70.33	23.75	4.32
$n_1p_2k_2$	70.33	22.73	4.12
$n_1p_2k_3$	71.33	25.15	4.53
$n_1p_3k_1$	70.33	24.45	4.60
$n_1p_3k_2$	70.33	23.08	4.77
$n_1p_3k_3$	71.67	24.33	4.55
$n_2p_1k_1$	71.33	25.76	4.33
$n_2p_1k_2$	70.67	25.07	4.20
$n_2p_1k_3$	70.33	19.57	4.02
$n_2p_2k_1$	70.00	23.10	4.58
$n_2p_2k_2$	69.67	21.97	4.35
$n_2p_2k_3$	71.33	22.63	4.42
$n_2p_3k_1$	70.33	25.94	4.20
$n_2p_3k_2$	72.00	25.54	4.53
$n_2p_3k_3$	70.67	22.41	4.48
$n_3p_1k_1$	70.00	26.64	4.25
$n_3p_1k_2$	72.00	24.73	4.30
$n_3p_1k_3$	70.00	22.72	4.15
$n_3p_2k_1$	70.33	22.32	4.42
$n_3p_2k_2$	70.33	22.71	4.25
$n_3p_2k_3$	70.67	23.32	4.42
$n_3p_3k_1$	70.00	24.69	4.22
$n_3p_3k_2$	70.33	25.12	4.50
$n_3p_3k_3$	70.00	23.52	4.42
F	NS	NS	NS
CD	—	—	—
c_1	70.00	23.26	4.183
c_2	69.66	23.90	4.183

NS - Not significant

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

Treatment	Flower yield (kg ha^{-1})
$n_1p_1k_1$	3780.94
$n_1p_1k_2$	4059.99
$n_1p_1k_3$	9758.73
$n_1p_2k_1$	3848.99
$n_1p_2k_2$	4092.71
$n_1p_2k_3$	3952.00
$n_1p_3k_1$	4185.33
$n_1p_3k_2$	4741.86
$n_1p_3k_3$	5056.75
$n_2p_1k_1$	4601.76
$n_2p_1k_2$	7907.06
$n_2p_1k_3$	5710.87
$n_2p_2k_1$	7575.26
$n_2p_2k_2$	5512.66
$n_2p_2k_3$	5467.77
$n_2p_3k_1$	5852.81
$n_2p_3k_2$	6965.59
$n_2p_3k_3$	7298.56
$n_3p_1k_1$	6407.24
$n_3p_1k_2$	6564.27
$n_3p_1k_3$	6070.14
$n_3p_2k_1$	7518.74
$n_3p_2k_2$	6093.23
$n_3p_2k_3$	10668.99
$n_3p_3k_1$	8337.10
$n_3p_3k_2$	8635.60
$n_3p_3k_3$	10959.57
F	273.70**
CD	301.147
c_1	3409.67
c_2	3662.43

** Significant at 1% level

Appendix 12. Interaction effect of NPK on monthy yield pattern (kg ha^{-1})

Treatment	Months after planting					
	7	8	9	10	11	12
$n_1p_1k_1$	217.77	329.26	334.79	541.42	356.00	245.33
$n_1p_1k_2$	260.08	389.88	479.46	934.06	620.00	362.67
$n_1p_1k_3$	248.88	389.88	478.08	909.26	624.00	386.67
$n_1p_2k_1$	241.42	371.97	391.28	735.67	502.67	298.67
$n_1p_2k_2$	262.57	380.24	529.06	997.43	653.33	340.00
$n_1p_2k_3$	268.79	409.17	556.61	826.60	610.67	305.33
$n_1p_3k_1$	288.70	450.50	670.97	1264.70	812.00	418.67
$n_1p_3k_2$	291.19	457.39	676.48	1099.38	733.33	385.33
$n_1p_3k_3$	294.93	461.52	670.97	1435.53	897.33	594.67
$n_2p_1k_1$	226.48	340.28	356.83	595.15	376.00	284.00
$n_2p_1k_2$	231.46	343.04	365.10	728.78	397.33	298.67
$n_2p_1k_3$	283.73	432.59	648.92	1182.04	816.00	388.00
$n_2p_2k_1$	253.86	387.12	473.95	834.86	542.67	341.33
$n_2p_2k_2$	237.68	345.79	417.46	772.87	477.33	308.00
$n_2p_2k_3$	260.08	385.75	552.48	961.61	536.00	336.00
$n_2p_3k_1$	227.73	341.66	371.99	659.88	389.33	276.00
$n_2p_3k_2$	260.08	388.50	522.17	874.82	557.33	320.00
$n_2p_3k_3$	232.71	347.17	421.59	666.79	401.33	294.67
$n_3p_1k_1$	276.26	421.57	631.01	1129.69	653.33	384.00
$n_3p_1k_2$	282.48	425.70	637.90	1074.58	662.67	350.67
$n_3p_1k_3$	235.19	358.19	438.12	632.35	448.00	252.00
$n_3p_2k_1$	281.24	422.94	637.90	1239.90	774.67	441.33
$n_3p_2k_2$	241.41	374.73	445.02	715.01	493.33	280.00
$n_3p_2k_3$	250.46	374.73	483.59	799.04	465.33	316.00
$n_3p_3k_1$	257.59	338.91	502.88	855.53	561.33	324.00
$n_3p_3k_2$	286.22	435.38	664.08	1053.91	756.00	394.67
$n_3p_3k_3$	296.17	429.83	693.01	1143.46	805.33	366.67
F	NS	NS	NS	NS	NS	NS
CD	—	—	—	—	—	—
c_1	180.00	280.00	300.00	410.00	320.00	210.00
c_2	187.00	293.0	304.00	420.00	350.00	187.00

NS - Not significant

Appendix 13. Interaction effect of NPK on content of nutrients in leaves

Treatment	Leaves (per cent)		
	N	P	K
$n_1p_1k_1$	1.49	0.35	3.38
$n_1p_1k_2$	1.28	0.34	4.38
$n_1p_1k_3$	1.20	0.35	3.80
$n_1p_2k_1$	1.51	0.35	3.98
$n_1p_2k_2$	1.48	0.37	3.82
$n_1p_2k_3$	1.41	0.33	4.68
$n_1p_3k_1$	1.56	0.36	3.15
$n_1p_3k_2$	1.39	0.36	3.50
$n_1p_3k_3$	1.30	0.35	3.90
$n_2p_1k_1$	1.52	0.37	3.21
$n_2p_1k_2$	1.62	0.35	2.97
$n_2p_1k_3$	1.64	0.34	3.40
$n_2p_2k_1$	1.62	0.37	3.90
$n_2p_2k_2$	1.63	0.35	3.80
$n_2p_2k_3$	1.51	0.34	3.82
$n_2p_3k_1$	1.95	0.34	3.14
$n_2p_3k_2$	1.56	0.34	3.67
$n_2p_3k_3$	1.57	0.38	3.78
$n_3p_1k_1$	2.10	0.37	3.78
$n_3p_1k_2$	1.74	0.34	3.68
$n_3p_1k_3$	1.48	0.33	3.84
$n_3p_2k_1$	1.84	0.34	3.38
$n_3p_2k_2$	1.65	0.34	3.68
$n_3p_2k_3$	1.45	0.35	3.74
$n_3p_3k_1$	1.68	0.34	3.37
$n_3p_3k_2$	1.62	0.36	3.87
$n_3p_3k_3$	1.48	0.38	3.51
c_1	1.023	0.246	2.43
c_2	1.070	0.230	2.76
F	62.81**	NS	74.10**
CD	0.048	—	0.102

** Significant at 1% level NS - Not significant

Appendix 14. Interaction effect of NPK on DMP (twelve months after planting)

Treatments	DMP (g plant^{-1})
$n_1p_1k_1$	24.00
$n_1p_1k_2$	24.00
$n_1p_1k_3$	25.73
$n_1p_2k_1$	26.40
$n_1p_2k_2$	26.67
$n_1p_2k_3$	36.00
$n_1p_3k_1$	37.67
$n_1p_3k_2$	47.10
$n_1p_3k_3$	46.10
$n_2p_1k_1$	52.50
$n_2p_1k_2$	52.93
$n_2p_1k_3$	53.03
$n_2p_2k_1$	53.60
$n_2p_2k_2$	55.33
$n_2p_2k_3$	62.67
$n_2p_3k_1$	56.33
$n_2p_3k_2$	54.07
$n_2p_3k_3$	53.66
$n_3p_1k_1$	65.83
$n_3p_1k_2$	71.40
$n_3p_1k_3$	71.17
$n_3p_2k_1$	71.80
$n_3p_2k_2$	72.47
$n_3p_2k_3$	74.63
$n_3p_3k_1$	84.40
$n_3p_3k_2$	119.67
$n_3p_3k_3$	126.33
F	42.97**
CD	3.42
c_1	10.40
c_2	13.06

** Significant at 1% level

Appendix 15. Interaction effect of NPK on uptake of nutrients

Treatments	Uptake of N ($kg\ ha^{-1}$)	Uptake of P ($kg\ ha^{-1}$)	Uptake of K ($kg\ ha^{-1}$)
$n_1p_1k_1$	1.68	0.35	3.36
$n_1p_1k_2$	1.79	0.34	3.97
$n_1p_1k_3$	1.05	0.37	4.85
$n_1p_2k_1$	2.08	0.56	3.72
$n_1p_2k_2$	1.88	0.57	4.42
$n_1p_2k_3$	2.32	0.66	4.81
$n_1p_3k_1$	2.55	0.84	4.33
$n_1p_3k_2$	3.23	1.06	5.73
$n_1p_3k_3$	3.49	1.16	5.40
$n_2p_1k_1$	3.99	1.40	6.42
$n_2p_1k_2$	3.62	0.80	5.45
$n_2p_1k_3$	4.16	1.10	6.39
$n_2p_2k_1$	4.06	1.23	5.43
$n_2p_2k_2$	4.61	1.05	6.03
$n_2p_2k_3$	4.98	1.55	5.03
$n_2p_3k_1$	4.69	1.56	6.16
$n_2p_3k_2$	4.73	1.26	5.68
$n_2p_3k_3$	5.04	1.04	8.72
$n_3p_1k_1$	4.88	1.06	6.27
$n_3p_1k_2$	4.94	1.01	6.30
$n_3p_1k_3$	4.93	1.75	6.03
$n_3p_2k_1$	5.35	0.95	7.84
$n_3p_2k_2$	5.06	1.00	6.34
$n_3p_2k_3$	5.20	1.73	6.84
$n_3p_3k_1$	5.91	1.70	6.90
$n_3p_3k_2$	7.26	2.93	7.23
$n_3p_3k_3$	8.02	2.93	6.91
F	NS	NS	NS
CD	—	—	—
c_1	0.619	0.1298	2.910
c_2	0.793	0.172	1.378

NS Not significant

Appendix 16. Interaction effect of NPK on carbohydrate content of flowering shoot

Treatment	Carbohydrate content of flowering shoot (%)
$n_1p_1k_1$	16.93
$n_1p_1k_2$	16.03
$n_1p_1k_3$	22.07
$n_1p_2k_1$	17.00
$n_1p_2k_2$	16.60
$n_1p_2k_3$	16.30
$n_1p_3k_1$	16.03
$n_1p_3k_2$	17.00
$n_1p_3k_3$	17.57
$n_2p_1k_1$	16.60
$n_2p_1k_2$	21.83
$n_2p_1k_3$	18.33
$n_2p_2k_1$	19.30
$n_2p_2k_2$	18.33
$n_2p_2k_3$	17.93
$n_2p_3k_1$	16.30
$n_2p_3k_2$	19.43
$n_2p_3k_3$	20.30
$n_3p_1k_1$	17.07
$n_3p_1k_2$	17.97
$n_3p_1k_3$	17.43
$n_3p_2k_1$	21.10
$n_3p_2k_2$	17.00
$n_3p_2k_3$	22.13
$n_3p_3k_1$	22.00
$n_3p_3k_2$	21.93
$n_3p_3k_3$	23.07
F	45.78**
CD	0.767
c_1	15.15
c_2	15.05

** Significant at 1% level

Appendix 17. Interaction effect of NPK on essential oil content of flowers

Treatment	Essential oil content of flowers (per cent)
$n_1p_1k_1$	0.254
$n_1p_1k_2$	0.275
$n_1p_1k_3$	0.266
$n_1p_2k_1$	0.274
$n_1p_2k_2$	0.273
$n_1p_2k_3$	0.281
$n_1p_3k_1$	0.285
$n_1p_3k_2$	0.290
$n_1p_3k_3$	0.287
$n_2p_1k_1$	0.264
$n_2p_1k_2$	0.273
$n_2p_1k_3$	0.282
$n_2p_2k_1$	0.281
$n_2p_2k_2$	0.284
$n_2p_2k_3$	0.283
$n_2p_3k_1$	0.282
$n_2p_3k_2$	0.296
$n_2p_3k_3$	0.290
$n_3p_1k_1$	0.282
$n_3p_1k_2$	0.285
$n_3p_1k_3$	0.283
$n_3p_2k_1$	0.291
$n_3p_2k_2$	0.274
$n_3p_2k_3$	0.292
$n_3p_3k_1$	0.283
$n_3p_3k_2$	0.284
$n_3p_3k_3$	0.291
F	5.44**
CD	0.006
c_1	0.280
c_2	0.278

** Significant at 1% level

Appendix 18. Interaction effect of NPK on available soil nutrients

Treatment	Soil (kg ha^{-1})		
	N	P	K
$n_1p_1k_1$	95.53	232.00	479.94
$n_1p_1k_2$	129.19	220.00	357.73
$n_1p_1k_3$	107.83	222.00	223.31
$n_1p_2k_1$	144.83	388.67	442.70
$n_1p_2k_2$	147.48	367.33	420.10
$n_1p_2k_3$	123.11	289.83	468.83
$n_1p_3k_1$	133.17	403.00	407.43
$n_1p_3k_2$	106.90	433.50	295.97
$n_1p_3k_3$	172.93	430.33	546.83
$n_2p_1k_1$	168.60	268.67	303.17
$n_2p_1k_2$	141.86	227.83	354.80
$n_2p_1k_3$	129.22	235.67	424.56
$n_2p_2k_1$	150.87	206.33	275.18
$n_2p_2k_2$	99.46	373.33	369.29
$n_2p_2k_3$	127.19	267.67	433.19
$n_2p_3k_1$	197.47	442.33	375.85
$n_2p_3k_2$	102.20	441.33	423.45
$n_2p_3k_3$	132.07	443.33	269.63
$n_3p_1k_1$	129.13	230.67	323.47
$n_3p_1k_2$	129.00	170.50	381.10
$n_3p_1k_3$	168.90	253.67	326.15
$n_3p_2k_1$	106.83	313.50	417.06
$n_3p_2k_2$	107.57	374.67	393.50
$n_3p_2k_3$	99.10	362.00	357.76
$n_3p_3k_1$	128.92	452.67	191.43
$n_3p_3k_2$	122.60	417.67	512.09
$n_3p_3k_3$	128.17	433.00	549.96
F	1777.40**	416.46**	633.21**
CD	1.367	5.201	14.844
c_1	90.60	31.33	74.13
c_2	92.36	34.00	75.10

** Significant at 1% level

NUTRIENT REQUIREMENT FOR BUSH JASMINE (*Jasminum sambac* Ait.)

By

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ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1999

ABSTRACT

The investigation "Nutrient requirement of bush jasmine, *Jasminum sambac* Ait." was conducted at Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 1996-'98 inorder to standardise the requirement of major nutrients (N, P and K) for the growth of flowering of bush jasmine.

The treatments consisted of factorial combinations of three levels each of nitrogen (50, 100 and 150 kg N ha^{-1}), phosphorus (50, 100 and 150 kg P_2O_5 ha^{-1}) and potassium (50, 100 and 150 kg K_2O ha^{-1}) with two controls. The experiment was laid out as 3^3 + 2 Factorial Randomised Block Design with three replications.

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 major nutrients viz., 150 kg N, 150 kg P_2O_5 and 150 kg K_2O ha^{-1}.

At the maximum level of major nutrients with 150 kg N : 150 kg P_2O_5 : 150 kg K_2O ha^{-1}, yield of flower buds was found significantly higher.

Other flowering characters like monthly yield pattern and weight of hundred flower buds were not found to be influenced by nutritive

treatments. However, time taken for opening of lower buds after harvest was maximum at 150 kg P_2O_5 ha^{-1}.

Content of N, P and K in leaves revealed that maximum content of foliar nitrogen noticed at 150 kg N : 50 kg K_2O ha^{-1} while foliar potassium content was maximum at 50 kg N : 100 kg P_2O_5 : 150 kg K_2O ha^{-1}. Foliar phosphorus content was not at all influenced by nutrient application.

Uptake of nutrients was not found to be influenced by applied nutrients where as DMP was maximum at the highest dose of major nutrients (150 kg N : 150 kg P_2O_5 : 150 kg K_2O ha^{-1}).

Available soil nutrient status revealed that maximum content of nitrogen and phosphorus in soil was noticed at 150 kg N : 150 kg P_2O_5 and 150 kg K_2O ha^{-1}. But maximum available potassium was noticed with 50 kg N : 150 kg P_2O_5 and 150 kg K_2O ha^{-1}.

Maximum essential oil content was obtained with 100 kg N : 100 kg P_2O_5 and 150 kg K_2O ha^{-1}. Carbohydrate content of flowering shoot was found to be highest with 50 kg N : 150 kg p_2O_5 : 150 kg K_2O ha^{-1}.

In general, highest dose of major nutrients, n_3 (150 kg N ha^{-1}), p_3 (150 kg P_2O_5 ha^{-1} and k_3 (150 kg K_2O ha^{-1}) was found best for cultivation of bush jasmine. However, as maximum response was shown at respective higher levels of major nutrients, higher levels of these nutrients can be tried to find out optimum nutrient combination for commercial cultivation.