

**STUDIES ON NUTRIENT MANAGEMENT
AND VASE LIFE OF GOLDEN ROD
(*Solidago canadensis* L.)**

NAGARAJA C. GANGANAGUDAR

**DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005**

SEPTEMBER, 1997

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ಸ್ತಂಭಾಲಯ
ಗಾ. ಕೃ. ವಿ. ಸೆ. , ಬೆಂಗಳೂರು-65

19 AUG 1998

Th. 4902

ಅನುಷ್ಠಾನ ಸಂ.....

ಪ. ಸಂ.....

STUDIES ON NUTRIENT MANAGEMENT
AND VASE LIFE OF GOLDEN ROD
(*Solidago canadensis* L.)

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements for the
Degree of

Master of Science (Agriculture)

IN
HORTICULTURE

By
NAGARAJA C. GANGANAGOUDAR

DEPARTMENT OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005


SEPTEMBER, 1997.

DEPARTMENT OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD.

Certificate

This is to certify that the thesis entitled "STUDIES ON NUTRIENT MANAGEMENT AND VASE LIFE OF GOLDEN ROD (*Solidago canadensis* L.)" submitted by Mr.NAGARAJA C. GANGANAGOUDAR for the degree of MASTER OF SCIENCE (Agriculture) in HORTICULTURE of the University of Agricultural Sciences, Dharwad, is a record of bonafide research work done by him during the period of his study in this university, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

DHARWAD
September, 1997


15/12/97

(U.G. NALAWADI)
Special Officer (Horticulture)
and Major Advisor

Approved by :
Chairman :


15/12/97

(U.G. NALAWADI)

Members :

1.

(A.K. ROKHADE)

2.



(NALINI PRABHAKAR)

3.



(M.S. PATIL)

*Affectionately
Dedicated To
My Beloved
Parents & Sisters*

ACKNOWLEDGEMENT

With regardful memories.....

Would it be all envisaging to offer salutations at the feet of the lord, who kindly imbued the energy and enthusiam through ramifying paths of my thick and thin of the efforts.

I express my deep sense of gratitude to my esteemed Chairman of the Advisory Committee Dr. U.G. Nalawadi, Special Officer (Horticulture), University of Agricultural Sciences, Dharwad for his excellent guidance, inspiring encouragement and critical comments in the course of investigation. I must confess that, it has been a rare privilege for me to work under his valuable guidance during my M.Sc. (Agri.) degree programme.

I am equally grateful to Dr. A.K. Rokhade, Professor and Head, Department of Post-harvest Technology, K.R.C. College of Horticulture, Arabhavi, University of Agricultural Sciences, Dharwad, Dr. (Mrs.) Nalini Prabhakar, Associate Professor of Crop Physiology and Dr. M.S. Patil, Associate Professor of Plant Pathology and Technical Assistant to Director of Instruction (PGS), University of Agricultural Sciences, Dharwad, the members of Advisory Committee for their patient task of correcting the manuscript, helpful suggestions and valuable comments throughout this study.

My Sincere thanks are also due to Dr. B. Sathyanarayana Reddy, Professor and Head, Department of Floriculture, K.R.C. College of Horticulture, Arabhavi, Shri. V.S. Patil, Shri. Y.H. Ryagi and other staff members of the Division of Horticulture for their help in carrying out this investigation.

The constant source of inspiration and encouragement offered by my beloved father Shri. Chandrashekhharagouda and mother Smt. Siddamma, sisters Sharada, Saroja, Indira and Leela and all other family members

made this study a lot easier for me to complete. I express my heartfelt thanks to them.

I owe sincere thanks to my friends Honnu, Suresh, Karunakar, Vinod, Vijay, Kallesh, Shashi, Prabhat, Shridhar and others who helped me throughout the study in one or the other way.

Finally I thank Mr. S.A. Patil for the skilful typing of this manuscript.

DHARWAD
SEPTEMBER, 1997.


(NAGARAJA C. GANGANAGOUDAR)

C O N T E N T S

CHAPTER	TITLE	PAGE NO.
I	INTRODUCTION	.... 1 - 3
II	REVIEW OF LITERATURE	.... 4 - 18
III	MATERIAL AND METHODS	.... 19 - 30
IV	EXPERIMENTAL RESULTS	.... 31 - 65
V	DISCUSSION	.... 66 - 79
VI	SUMMARY	.... 80 - 84
VII	REFERENCES	.... 85 - 98
	APPENDICES	.... 99 - 102

LIST OF TABLES

TABLE	TITLE	PAGE NO.
1	Plant height (cm) as influenced by NPK levels at different growth stages of golden rod (<i>Solidago canadensis</i> L.)	.... 32
2	Effect of NPK levels on number of leaves per plant in golden rod (<i>Solidago canadensis</i> L.)	.... 34
3	Effect of NPK levels on sucker production in golden rod (<i>Solidago canadensis</i> L.)	.... 37
4	Effect of NPK levels on dry weight of plants (g/plant) and leaf area (dm ² /plant) in golden rod (<i>Solidago canadensis</i> L.)	.... 39
5	Effect of NPK levels on number of days taken for flower initiation and time taken for 50 per cent flowering in golden rod (<i>Solidago canadensis</i> L.)	.... 42
6	Effect of NPK levels on flower stalk characters in golden rod (<i>Solidago canadensis</i> L.)	.... 45
7	Effect of NPK levels on flower yield characters of golden rod (<i>Solidago canadensis</i> L.)	.... 49
8	Effect of NPK levels on flower yield characters of golden red (<i>Solidago canadensis</i> L.)	.... 53
9	Total uptake (kg/ha) of nitrogen, phosphorous and potassium as influenced by NPK levels in golden rod (<i>Solidago canadensis</i> L.)	.... 57

TABLE	TITLE	PAGE NO.
10	Correlation between flower yield and other characters in golden rod (<i>Solidago canadensis</i> L.)	.... 60
11	Effect of chemicals on fresh weight and vase life of flower stalks of golden rod (<i>Solidago canadensis</i> L.)	.... 62
12	Effect of chemicals on water relations of flower stalks of golden rod during 14 days of vase life	.... 64

LIST OF FIGURES

FIGURE	TITLE	BETWEEN PAGES
1	Layout plan of experiment on the effect of NPK levels on plant growth, flowering and flower production in golden rod	.... 21 - 22
2	Effect of nitrogen, phosphorous and potassium on plant height and number of leaves at 90 days after planting	.... 33 - 34
3	Effect of NPK levels on dry weight (g) and leaf area (dm^2/plant) in golden rod at 60 days after planting	.... 40 - 41
4	Effect of nitrogen, phosphorous and potassium on flower stalk yield (t/ha) in golden rod	.... 54 - 55
5	Effect of nitrogen, phosphorous and potassium on total N, P and K uptake at harvest in golden rod	.... 57 - 58
6	Net returns (Rs/ha) as influenced by NPK levels in golden rod	.... 61 - 62
7	Effect of chemicals on vase life of golden rod (Days)	.... 65 - 66

LIST OF PLATES

PLATE	TITLE	BETWEEN PAGES
1	Golden rod in vase -----
2	General view of the experimental plot on effect of NPK on plant growth, flowering and flower production in golden rod	.... 22 - 23
3	Effect of nutrition on flower stalk characters in golden rod	.... 45 - 46
4	Effect of nutrition on flower stalk character in golden rod	.... 45 - 46
5	Effect of nutrition on flower stalk characters in golden rod	.... 45 - 46
6	Vase life as influenced by chemicals	.... 64 - 65
7	Golden rod flower stalks in best vase solutions having sucrose (2%) + Aluminium sulphate (100 ppm) i.e., T ₈ and sucrose (2%) + Benzyl adenine (10 ppm) i.e., T ₄ and distilled water (control) i.e., T ₉	.... 64 - 65

LIST OF APPENDICES

APPENDIX	TITLE	PAGE NO.
I	Monthly meteorological data for the year 1996-97 and average of 10 years (1985-1995) recorded at the meteorological observatory, Agricultural Research Station, Arabhavi	.... 99
II	Physical and chemical properties of soil from experimental site	.... 100
III	Details of cost of cultivation per hectare (Rs.)	.... 101
IV	Details of cost of cultivation per hectare (Rs.)	.... 102



Plate 1. Golden rod in vase

INTRODUCTION

I INTRODUCTION

Solidago, commonly known as golden rod belongs to the family Asteraceae. The genus comprises about 130 species of perennial herbs and a shrub. Most of the species are native to North America, a few species are found in South America, temperate Europe and Asia. Though it extensively finds its presence in every garden and is also cultivated for cut flowers all over the world, however, statistics on its area and production is not available.

Solidago canadensis L. is cultivated for its attractive yellow coloured flowers, arranged in rod shaped inflorescence, hence it is commonly called as golden rod. The common name refers to the appearance of flower. The herb is not mentioned much in ancient writings, but there is evidence that it was particularly promoted by Arabs, Italians and Germans as a wound healing herb.

The genus solidago comprises species like *Solidago canadensis*, *Solidago virgaurea* and *Solidago memorialis* which are grown in beds, borders, rock gardens and also for cut flowers. Golden rod is generally used as cut flower for indoor decoration in vases. It is used either singly or with other flowers in flower bouquets and also as a dry flower. Several interspecific hybrids have been evolved from *Solidago canadensis* and

Solidago virgaurea which are more free flowering and have showy flowers than the parental species.

Some of the popular cultivars are Ballardii, Golden gates, Golden wing and Peter pan.

Solidago canadensis L. is an erect growing perennial plant with simple alternate leaves and produce large panicles of yellow flowers for most parts of a year. Flowers in spikes open in basipetal manner from top towards bottom and has a good shelf-life. They occur as common wild plants and propagated by division of stools, suckers or seeds. The plants are easy to grow, they flower throughout the autumn and thrives in sun or shade in almost any soil.

Essential oils, flavonoides, glycosides, tannins, saponins and various organic acids derived from *Solidago* are used as anti-inflammatory ointment for urinogenital and chronic skin problems apart from being used as adjuvant along with other remedies of benefits in asthma, arthritis and rheumatism.

A popular and an attractive flower like golden rod has a promising untapped export potential besides local demand for the Indian floriculture industry. Though climatic and geographical factors affect the yield and quality to some extent, nutrition plays a major role. Toxic levels of nutrients adversely affect the quality of ornamental plants and flowers. In general, nitrogen, phosphorus and potassium have been found to

influence production and quality of flowers. Besides increasing the production, conservation of flowers for longer duration goes a long way in meeting the ever increasing demand for the flowers. Improvement in quality of flowers and conservation necessitates research into the basic and applied aspect of flower physiology. Therefore, studies were undertaken in golden rod (*Solidago canadensis* L.) with the following objectives.

1. To findout the effect of nitrogen, phosphorus and potassium on plant growth and flower yield.
2. To findout suitable dose of nitrogen, phosphorus and potassium for getting maximum flower yield.
3. To findout suitable chemical to extend longevity of cut flowers of golden rod.

**REVIEW OF
LITERATURE**

II REVIEW OF LITERATURE

Information on nutrition and vase life of golden rod is very meagre. Therefore, such information pertaining to other crops like carnation (*Dianthus caryophyllus* L.) petunia (*Petunia hybrida*), marigold (*Tagetes erecta* L.), china aster (*Callistephus chinensis* Nees.), Zinnia (*Zinnia elegans*), Chrysanthemum (*Chrysanthemum morifolium* Ramat.), Gerbera (*Gerbera jamesonii* Hook.), Cosmos (*Cosmos sulphureus* Wild.), Sunflower (*Helianthus annuus* L.) have been reviewed.

2.1 Importance of nutrition in flowering annuals

Mengel (1969) observed that an interruption in plant nutrition even for a short period had a negative effect on the yield and this could not be corrected later by nutrient supply. He also stressed the need for adjustment of nutrient supply to specific requirements of the plants during the growth stages to attain maximum yield. Tayama *et al.* (1974) reported that regular application of fertilizers would not only maintain the sturdy growth of the plants but also improve the quality also.

Judicious and balanced fertilizer are known to result in overall improvement in quality of flowers and total flower yields in many crops (Elengovan, 1975 and Mantrova *et al.*, 1976).

Nutritional studies carried out by Raman *et al.* (1967) in the field grown chrysanthemum showed that higher number of flowers and flower yield combined with increased flower size

could be obtained by application of N at 370, P_2O_5 at 407.5 and K at 308.75 kg per hectare.

2.2 Nutrient elements and its effects

2.2.1 Nitrogen

Noggle and Fritz (1979) summarised various levels of nitrogen in plants. Nitrogen is a component of amino acids which are essential for protein synthesis. Many co-enzymes also need nitrogen for their synthesis. It is also a component of cytochrome and chlorophyll a and b that are needed for photosynthesis.

Nitrogen was found to greatly influence the growth, flower production and quality of bloom in many ornamental flowering plants. Favourable effects of nitrogen nutrition on crop growth and flower production have been stressed by many workers.

Extensive trials by Penningsfeld (1973) on the nutrient requirements of herbaceous plants revealed that phlox tolerated upto 300 kg N per hectare and chrysanthemum was best with 200 kg N per hectare.

2.2.2 Phosphorous

Phosphorous is also one of the major nutrient elements which influence the yield of many flower crops. It is also multifunctional in plant metabolism and as phosphate ion is of greater importance in trapping, conserving and donating

energy metabolism. The uptake of N is associated with 'P' uptake. The free amino acid content is reduced and amides accumulated when 'P' is in short supply (Sircar and Sen, 1941)

Booth (1957) emphasised the need for heavy dressing of P through superphosphate before planting for commercial production of aster flowers. Kazimivora (1975) stressed the need of 'P' at the start of growth during flowering.

In *Chrysanthemum*, Joiner (1967) evaluated the need for 'P' during flower initiation and development and in his study increased 'P' levels from lower to medium resulted in an increase in stem length and flower diameter.

2.2.3 Potassium

Potash act as a catalyst for various enzymes and co-enzymes, protein and starch synthesis takes place in the presence of potassium. It has a vital role in translocation of metabolites.

2.3 Effect of NPK

2.3.1 On growth and growth components

Increased plant height was noted at higher levels of nutrients in marigold, zinnia and cosmos (El-Gamassy *et al.*, 1965). Bose and Das (1966) reported that deficiency of N and P caused stunted growth, reduction in number of leaves in China aster, Zinnia and Salvia.

Arora and Saini (1976) observed in carnation increased plant height and number of shoots when nitrogen and phosphorous were applied at 40 and 20 g per m² respectively.)

Maheshwar (1977) reported increased number of branches, plant height, number of leaves, leaf area when N and P applied 180 and 120 kg per hectare respectively in china aster.

Ingawale (1979) reported that balanced application of nutrients brought about a significant increase in number of branches, plant spread, stem thickness, leaf area and flower yield in marigold.

Nalawadi (1982) observed that nitrogen was effective in increasing vegetative growth over P₂O₅ and noted that increasing plant height, number of leaves, leaf area and leaf area index due to increased level of nitrogen from 75 to 225 kgs per hectare.

(Ramachandra (1982) reported that plant height, number of leaves, leaf area, leaf area index, total dry matter production in china aster were increased upto the level of N 120 kg and P₂O₅ 60 kg per hectare and they were reduced at higher levels.) In the same crop Narayanagowda (1985) noticed increase in plant height, number of leaves, leaf area and dry weight at 180 kg N, 120 kg P₂O₅ and 100 kg K₂O per hectare.

Dongre (1984) reported in marigold increased plant height, dry matter content in marigold at highest level (40 gm per m²) of nitrogen, further he observed that increased plant height due to highest level of phosphorous at 40 g per m², however he noted that the interaction effects of nitrogen and phosphorous were non-significant.

Mantur (1988) observed in China aster increased plant height, number of branches, leaf area, total dry matter production with increasing levels of N and P but effect of K showed reverse results.

Sharanabasappa (1990) observed that in helichrysum the application of 150 kg N + 100 kg P recorded tallest plants with more number of branches, leaves, leaf area and leaf area index.

Sigedar *et al.*(1991) reported that significant increase in plant height, number of branches and plant spread with the increase in application of nitrogen, phosphorus and potassium levels in calendula. He further reported that application of 100 kg N, 50 kg P₂O₅ and 25 kg K₂O had shown maximum growth. Jana and Pal (1991) noticed increased plant height, number of branches and number of leaves at higher nitrogen levels in cosmos.

Lodhi and Tiwari (1993) noticed that plant height and spread were greatest with 45 g N + 45 g P per square meter, while the higher number of branches recorded with 30 g N + 15 g P per square meter area in the field grown chrysanthemum.

Zile Singh *et al.* (1996) reported that increase in doses of nitrogen, phosphorous and potassium, the plant height, number of leaves and number of branches increased significantly, however application of K did not affect the plant height and number of branches in dahlia.

2.3.2 On flowering, yield components and flower yield

Nutritional studies carried out by Raman *et al.* (1967) in the field grown chrysanthemum over a period of three years showed the possibility of obtaining higher number of flowers and flower yield combined with increased flower size by the application of N at 370, P₂O₅ at 407.55 and K₂O at 308.75 kg per hectare. The need of a heavy basal dressing of P for commercial production of asters has been established by Booth (1957).

In chrysanthemum, Joiner (1967) established the need of P during the periods of flower initiation and flower development. Increase in phosphorous from lower to medium levels resulted in the increase in stem length and flower diameter. Winsor (1962) reported that in carnation P fertilization resulted in an increase in flower production by about 20 per cent.

Rober (1971) observed that with the increased nitrogen concentration, the total flower yield as well as the number of open and closed flowers in chrysanthemum increased. Extensive trials on phlox by Penningsfeld (1973) on the nutrient

requirements, reported it tolerated upto 300 kg N per hectare. The higher nitrogen levels were found to delay the flowering and shortened the vase life.

Delayed flowering was associated with higher rates of nitrogen application above 100 kg per hectare in chrysanthemum (Wordsworth and Butters, 1973). However, earliness was enhanced by higher potash rates of 200 to 600 kg per hectare.

Maheshwar (1977) did not find any influence of nitrogen or P on time taken for 50 per cent flowering in china aster, while more number of flowers, flower size, fresh weight of flowers and flower yield increased with increasing levels of N and P.

Nalawadi (1982) found that application of 225 kg N, 120 kg P_2O_5 with 60 kg K_2O gave significantly higher flower yield in all the eight varieties of marigold studied. He further reported significantly higher number of flowers, flower size, flower length, flower weight and flowering duration under the same fertilizer combination. However, significantly more number of days were taken for commencement of flowering at higher levels of N and P tried.

Mokashi (1988) recorded maximum flower yield per hectare with the application of 150 kg N and 80 kg P per hectare in gaillardia.

Mantur (1988) reported that delayed flowering with nitrogen and phosphorus and maximum flower yield recorded with 180 kg N, 120 kg P₂O₅ and 75 kg K₂O per hectare.

Singh Lodhi *et al.* (1990) reported that the delay in number of days taken to visible bud, days to complete bud formation and days to complete flowering with increasing N rates but application of P improved earliness in chrysanthemum.

Khimani (1991) observed that nitrogen (150 kg/ha) enhanced the flowering and took minimum days to first and 50 per cent flowering.

Gowda *et al.* (1991) observed that an increased phosphorous and potassium rates resulted in greater number of flower spikes and number of flowers per spike. The higher yield of flower, longest spike were obtained with 200 kg N + 75 kg P₂O₅ + 25 kg K₂O per hectare in tuberose. In the same crop Parthiban and Khader (1991) recorded application of 100 kg N + 75 kg P₂O₅ + 62.5 kg K₂O per hectare resulted in higher number of spikes per plant, number of flowers and higher flower yield per hectare.

Nutritional studies carried out by Sigedar *et al.* (1991) in calendula reported that the increased nitrogen, phosphorous and potassium levels produced significantly greater number and weight of flowers per plant obtained when plants were supplied with 100 kg N, 50 kg P₂O₅ and 25 kg K₂O per hectare. Anuradha *et al.* (1990) reported that number of flowers per

plant and the individual weight of single flower increased with increasing N and P rates. Flower vase life decreased with increasing N rates, where as P had no significant effect in marigold.

Lodhi and Tiwari (1993) worked on field grown chrysanthemum and observed beneficial effect on maximum size and number of flowers per plant were obtained with 30 g N + 15 g P₂O₅ per square meter. Higher yield and dry weight of flowers were obtained with 30 g N + 45 g P₂O₅ per square meter.

Amargeet Singh *et al.* (1996) reported that application of high rates of N, P and K delay the spike emergence and considerably prolonged the flowering period and shelf life of flowers. He further reported that length of spike and rachis increased significantly with increasing doses of N and P fertilization, increasing K application increased rachis length at opening of the last floret, but not the first floret in tuberose.

Zile Singh *et al.*, 1996, reported that increase in doses of nitrogen phosphorous and potassium, number of flowers per plant and size of the flower increased significantly, but application of K did not affect the size of the flower in case of pot grown dahlia.

2.4 Nutrient uptake

The plant analysis is one of the techniques adopted for determining nutritional requirement of crops. Optimum

nutritional level in plants for good growth and yield have been worked out in different plants.

The complementary effect of one nutrient element over the other in the uptake process is well established by many workers. Grunes (1959) studied that effect of N on the availability of soil and fertilizer P_2O_5 to plants and stated that addition of N stimulated the uptake of phosphorous.

Joiner and Smith (1962) found four to five per cent of drymatter to be nitrogen and five to six per cent potash in leaves. They further reported that potash application had antagonistic effect on the uptake of phosphorous, calcium and magnesium, while nitrogen had a synergistic effect on the uptake of nutrients.

Wittwer (1969) found an increased uptake of soil and fertilizer P_2O_5 in the presence of ammonical N in the medium. A similar observation was made by Dhote and Ballal (1964) on the uptake more of P_2O_5 in the presence of nitrogen.

Maheshwar (1977) indicated that the plant analysis values of total N and total P at final stage of growth, revealed general increase in the uptake of each nutrient with the increasing levels of their application. He attributed this trend to their well developed plant structure and higher plant dry weight.

In marigold, Ingawale (1979) obtained significantly higher levels of N and P content with application of different levels o

N and P, however, combined effect of N and P significantly increased the uptake of N but not of P.

Nalawadi (1982) reported that application of 225 kg N + 120 kg P per hectare to marigold increased the total N and P uptake by 1.5 to 1.0 times more as compared to the application of 75 kg N + 60 kg P per hectare, respectively at all the stages of growth.

Mokashi (1988) noticed that the uptake of nutrients by gaillardia did not commensurate with the increase in the level of application of nutrients. Sharanabasappa *et al.* (1990) reported that total nitrogen and phosphorous uptake increased with increase in nitrogen and phosphorous levels from 0 to 150 kg per hectare.

Mantur (1988) observed that the total uptake values of N, P and K revealed a general increase in the uptake of each nutrient with increasing levels of their application. He attributed to their well developed plant structure and higher dry weight of plants and their increased availability with increased application.

2.5 EFFECT OF CHEMICALS ON VASE LIFE OF GOLDEN ROD

2.5.1 Effect of sucrose

Use of chemical preservatives to promote quality and prolong the life of cut flowers is well known. The preservatives are mainly composed of sugars, germicides, growth regulators and other ingredients.

Sucrose concentration influences fluid uptake and transpiration in cut flowers. Sucrose or preservatives containing carbohydrate substitute for the naturally depleting carbohydrates in cut flowers, reduced proteolysis. Coorts *et al.* (1973) reported that sucrose sustained quality, increased weight and prolonged cut flower life of Snapdragon, Aster and Marigold.

Kofranek *et al.* (1975) observed that China asters have lesser response to sucrose when used alone. Usually sucrose improves the water balance and osmotic potential of flowers. Sucrose enhanced effect of cytokinin in delaying senescence of flowers and reduced the effect of ethylene, there by increasing the vase life of the flowers. According to Mayak and Dilley (1976) supplying cut flowers with exogenous sugar maintains the respirable substrates in the flowers (Lukaszewska, 1981) encourages protein synthesis (Paulin, 1986). Sucrose in vase solution is found to increase the vase life of gladiolu

TR. 4902

(Sangamma, 1993) and tuberose (Balakrishna, 1987 and Reddy, 1993).

2.5.2 Effect of Aluminium

Halevy and Mayak (1979) observed that aluminium sulfate at 50 to 100 ppm used in preservative formulation reduces the transpiration, lowers the pH of petals and stabilizes the anthocyanin. Also, it reduces the bacterial growth by acidifying the holding water and improved the water uptake.

Aluminium in the holding solution reduces transpiration and improves water balance of cut flowers by inducing stomatal closure. Aluminium sulfate proved to be effective in showing the greater percentage of bloomed flowers. Significant promotion in vase life in rose (Gowda, 1987) and in tuberose (Mukhopadhyay, 1980).

Aluminium sulfate in vase water decreased the number of bacterial in the stems. The effect of the other chemicals namely HPC, AgNO_3 on the number of bacteria were variable (Doorn *et al.*, 1990 and Barendse, 1979). $\text{Al}_2(\text{SO}_4)_3$ increased the vase life with an increased fresh weight in cut roses (Stringter, 1978). Slow release chlorine compounds maintain a low count of bacteria in cut asters, gladioli and carnation.

Aluminium sulfate in combination with sucrose was found best for the normal opening of even most tightly closed buds of carnation (Basemer and Hasek, 1973), mimosa (Accati and Sulis,

1980), gladiolus (Gowda and Gowda, 1990), Rose (Ahn and Um, 1991 and Barman *et al.*, 1996) and golden rod (Patil, 1995).

2.5.3 Effect of Benzyl Adenine

Use of several growth regulators in control of flower senescence has been demonstrated. Best results were obtained with carnations (Eisinger, 1977; Mayak and Kofranek, 1976). Cytokinins not only promote longevity but also the sensitivity to ethylene was reduced and burst in ethylene produced delayed.

A momentary dip of Athurium flowers in BA₆ (10 ppm) extended longevity and increased the tolerance of the flowers to chilling (Shirakawa *et al.*, 1964).

Cook *et al.* (1985) studied the regulation of ethylene biosynthesis and action in carnation flower senescence by cytokinins. Benzyl adenine (BA₆) maintained low levels of ethylene production, delayed the decline in flower quality they observed.

Extended vase life, improved flower quality, increased fresh weight, water uptake, when cut gladiolus spikes pretreated with solution combination having 8-HQC (200 ppm) and BA (20 ppm) with four per cent sucrose, further exhibited reduced ethylene process and reduced respiration rate (Hwang and Kim, 1995).

Vase solutions containing IAA, BA and GA plus four per cent sucrose and 8-HQS at 200 mg per litre. The chlorophyll content of cut roses were generally low, when the flowers were placed in preservative solutions contain growth regulator compared with those in distilled water containing growth regulators. Flowers kept in distilled water with GA and BA showed high chlorophyll content, but they were not significant at five per cent level (Lee and Kim, 1995).

**MATERIAL
AND
METHODS**

III MATERIAL AND METHODS

Experiments were carried out in two locations during 1996-97. Nutrient management study was conducted at the Kittur Rani Chennamma College of Horticulture, Arabhavi, University of Agricultural Sciences, Dharwad. Experiment on Vase life study was carried out in the Department of Horticulture, College of Agriculture, Dharwad. The details with reference to location and the techniques adopted during the course of investigations are presented briefly.

3.1 Geographical location

Arabhavi is situated at 16°-12' North latitude and 74°-54' East longitude at an altitude of 640 m above mean sea level. The average rainfall is about 566 mm and is fairly distributed from May to September.

3.2 Experimental site

The experimental site had black clay soil having clay texture with a pH 8.0. The soil was fertile, physical and chemical properties of the soil are furnished in the Appendix.

3.3 Climatic condition

The average rainfall was 540.9 mm and fairly distributed from April to November. Mean maximum temperature varied from 38.0°C in April to 25.7°C in December. Mean minimum

temperature varied from 22.5°C in July to 12.2°C in January. The relative humidity fluctuated between 50 to 83 per cent.

The meteorological data for the year 1996-97 and mean of last ten years recorded at Agricultural Research Station, Arabhavi are given in Appendix-I.

3.4 Experimental details

3.4.1 Experiment I

Effect of nitrogen, phosphorus and potassium on plant growth, flowering and flower production in golden rod (*Solidago canadensis* L.)

The experiment was conducted during July - September 1996. The treatment consisted of two levels of N (100 and 150 kg/ha), three levels each of P₂O₅ (50, 100 and 150 kg/ha) and K₂O (50, 100 and 150 kg/ha). Totally there were 18 treatment combinations detailed below :

1. N₁P₁K₁ - 100:50:50 kg/ha
2. N₁P₁K₂ - 100:50:100 kg/ha
3. N₁P₁K₃ - 100:50:150 kg/ha
4. N₁P₂K₁ - 100:100:50 kg/ha
5. N₁P₂K₂ - 100:100:100 kg/ha
6. N₁P₂K₃ - 100:100:150 kg/ha
7. N₁P₃K₁ - 100:150:50 kg/ha
8. N₁P₃K₂ - 100:150:100 kg/ha
9. N₁P₃K₃ - 100:150:150 kg/ha
10. N₂P₁K₁ - 150:50:50 kg/ha

11. $N_2P_1K_2$ - 150:50:100 kg/ha
12. $N_2P_1K_3$ - 150:50:150 kg/ha
13. $N_2P_2K_1$ - 150:100:50 kg/ha
14. $N_2P_2K_2$ - 150:100:100 kg/ha
15. $N_2P_2K_3$ - 150:100:150 kg/ha
16. $N_2P_3K_1$ - 150:150:50 kg/ha
17. $N_2P_3K_2$ - 150:150:100 kg/ha
18. $N_2P_3K_3$ - 150:150:150 kg/ha

3.4.2 Design and layout

The experiment was laid out in a factorial randomised block design with three replications. The layout map is given in Figure 1. The size of the gross plot was 2.25 m x 1.6 m and net plot size was 1.8 m x 1.2 m. The spacing followed was 45 cm inter row spacing and 20 cm intrarow spacing.

3.4.3 Land preparation

Land was prepared and brought to a fine tilth by deep ploughing and repeated harrowing. Weeds and other debris were collected and burnt. A spacing of 0.5 m between two replications was left for laying out the irrigation channels and bunds.

3.4.4 Planting material

Suckers of golden rod collected from Floriculture Unit, College of Agriculture, Dharwad were used for planting at Arabhavi.

RI	RII	RIII	
10	03	05	
07	06	14	1. $N_1P_1K_1$
13	09	02	2. $N_1P_1K_2$
18	01	16	3. $N_1P_1K_3$
02	13	12	4. $N_1P_2K_1$
17	05	08	5. $N_1P_2K_2$
08	16	10	6. $N_1P_2K_3$
12	10	06	7. $N_1P_3K_1$
05	17	18	8. $N_1P_3K_2$
14	15	03	9. $N_1P_3K_3$
09	18	07	10. $N_2P_1K_1$
03	12	01	11. $N_2P_1K_2$
15	02	11	12. $N_2P_1K_3$
06	08	13	13. $N_2P_2K_1$
17	14	09	14. $N_2P_2K_2$
01	11	17	15. $N_2P_2K_3$
11	04	15	16. $N_2P_3K_1$
16	07	04	17. $N_2P_3K_2$
			18. $N_2P_3K_3$

FIG. 1. LAYOUT PLAN OF EXPERIMENT ON THE EFFECT OF NPK LEVELS ON PLANT GROWTH, FLOWERING AND FLOWER PRODUCTION IN GOLDEN ROD (*Solidago canadensis* L.)

3.4.5 Application of fertilizers

Nitrogen, phosphorous and potassium were applied in the form of urea, single superphosphate and muriate of potash respectively before planting in the furrows opened for planting the suckers.

3.4.6 Cultural operations

Hand weeding was carried out as and when required. Irrigation was given at regular interval ranging from seven to ten days depending on climate and soil moisture status.

3.4.7 Harvesting

The flower stalks were harvested when 20 per cent of the flowers at the top of the spikes were open and used for the studies on different aspects.

3.5 Collection of experimental data from the field experiment

For collection of data from the field five plants were selected in each treatment at random and tagged. Data were collected from these plants for vegetative characters, flowering and spike characters at 30, 60 and 90 day after planting (DAP).



Plate 2. General view of the experimental plot on effect of NPK on plant growth, flowering and flower production in golden rod

3.6 Vegetative Growth parameters

3.6.1 Height of plant

The plant height was measured from ground level to the growing tip in cm from the tagged plants at 30, 60 and 90 days after planting and average was worked out.

3.6.2 Number of leaves per plant

Number of leaves produced by plants was recorded by counting the number of leaves at 30, 60 and 90 days after planting and average number of leaves per plant was worked out.

3.6.3 Number of suckers per plant

Number of suckers per plant was counted at 30, 60 and 90 days after planting and average number of suckers per plant was worked out.

3.6.4 Dry matter production

Dry matter production was estimated at 60 days after planting. Three plants were cut to the ground level from second ring line stem and leaves were separated and oven dried separately at the temperature of 60-70°C. Dry matter at different parts was weighed in grams. Total dry matter was calculated by adding weight of leaves and stem of respective stages and average was worked out.

3.6.5 Leaf area

The leaf area (dm^2) was estimated by disc method as suggested by Johnson (1967). It was estimated at 60 days after planting. Plants uprooted for determination of dry matter production were used for this purpose. From the foliage 25 leaves were selected randomly and with the help of cork borer 25 discs were removed these discs and entire foliage were oven dried. The weight of dried discs and foliage was noted separately. The area of each leaf disc was calculated by using the formula πr^2 . Based on the weight and area of the leaf discs and the weight of the entire dried foliage the leaf area was calculated by using the following formula.

$$LA = \frac{Wa \times A}{Wd}$$

Where,

LA = Leaf area (dm^2)

Wa = Weight of foliage (inclusive of the weight of 25 discs) in grams

Wd = Weight of 25 discs in grams

A = Area of 25 discs

3.7 Reproductive parameters

3.7.1 Days to first flower appearance

The observation was recorded by counting the days from the date of planting to the stage at which the first flower bud appeared in tagged plants and average was worked out.

3.7.2 Days taken for 50 per cent flowering

The number of days taken for 50 per cent of the flowering from each plot was recorded by counting the days from the date of planting.

3.7.3 Length of flower stalk

Length of flower stalk was measured from the point of origin to the tip of the last floret of the flower stalk. This was recorded from the tagged plants.

3.7.4 Number of spikelets per flower stalk

Number of spikelets produced in each main flower stalk of the tagged plants was counted and number of spikelets per flower stalk was worked out.

3.7.5 Weight of the flower stalk

For recording the weight of the flower stalks, these were cut when the first top ten per cent had opened and were weighed. To work out the average weight of flower stalks minimum of five flower stalks were used which also included those taken and used for the vase life.

3.7.6 Length of rachis

Length of rachis was recorded from the observation plants. Length of rachis was measured as the portion of the flower stalk bearing the florets. It is measured from the base

of the origin of the first basal rachis to the tip of the flower stalk.

3.7.8 Flower yield

Number of flower stalks produced by the observation plants as well as by the entire plants in a plot were counted for three major flushes over a period of 150 days and average was worked out and used for calculation of yield per plant, plot and hectare.

3.8 Chemical analysis of the plants

The oven dried plant material used for estimation of dry matter content was used for the purpose of chemical analysis. The oven dried plant material was finally ground to fine powder and used for further analysis.

— 3.9.1 Nitrogen

Nitrogen content was estimated using Microkjeldahl method (Yoshida, 1972) after distilling ammonia into boric acid and titrating the ammonia collected against standard HCl using methyl orange as a indicator.

3.8.2 Phosphorus

Phosphorus was estimated by vandadomolybdophosphoric yellow colour method in nitric acid system (Jackson, 1967).

3.8.3 Potassium

Wet digested samples were diluted and they were fed to flame photometer to estimate potassium content (Yoshida, 1972).

3.9 Statistical analysis

Statistical analysis of the data was done by following the Fisher's analysis of variance technique as given by Panse and Sukhatme (1967). The level of significance used in "F" and "t" tests was $P = 0.05$.

Correlation studies

Correlation coefficients were worked out between important characters and flower yield per hectare. The values of correlation coefficients (r) were calculated and the test of significance was applied as per the procedure outlined by Panse and Sukhatme (1967).

3.10 Economics of returns

The cost of cultivation was worked out by considering market prices of different inputs. The prices of nitrogen, phosphorus and potassium were Rs. 3.66; 2.85 and 3.70 per kg respectively. Cut flowers were sold at the rate of Rs. 0.10 per flower stalk.

3.11 Experiment II

3.11.1 Effect of chemical on vase life of golden rod

For the vase life study, flower stalks from a crop grown under standard cultural practices were used. Flower stalks were cut when ten per cent of the florets had opened and were taken to laboratory by keeping the cut ends in water. Uniform flower stalks with special reference to size and length were selected and cut ends of the flower stalk stem was recut leaving about 20 cm uniform stem length from the basal florets, before transferring them to test solutions. All the leaves were removed except one or two near the basal florets. Test solutions were prepared by using distilled water. Distilled water was used as control. Three flower stalks were kept in conical flasks having 250 ml of test solutions or distilled water as the case may be and then the bottles were plugged with cotton wool. Details of the experiment are as follows.

Design : Completely Randomised Block Design

Replications : Three

3.11.2 Treatments

1. 6-Benzyl aminopurine (BA6) @ 5 ppm
2. 6-Benzyl aminopurine (BA6) @ 10 ppm
3. 6-Benzyl aminopurine (BA6) @ 5 ppm + Sucrose 2%
4. 6-Benzyl aminopurine (BA6) @ 10 ppm + Sucrose 2%
5. Aluminium sulphate @ 50 ppm
6. Aluminium sulphate @ 100 ppm

7. Aluminium sulphate @ 50 ppm + Sucrose 2%
8. Aluminium sulphate @ 100 ppm + Sucrose 2%
9. Distilled water (Control)

3.11.3 Observations

To collect the data, flasks with solutions and with or without flower stalks were weighed on alternative days.

3.11.4 Water uptake

The difference between the consecutive weights of the flasks with solution (without the flower stalk) represented the water uptake by the flower stalks.

3.11.5 Loss of water

The difference between the consecutive weights of conical flasks with solution plus flower stalks represented the transpiration loss of water.

3.11.6 Fresh weight of flower stalks

The difference between the weight of the conical flasks with solution plus flower stalks and weight of the conical flask plus solution represented the fresh weight of the flower stalks. Fresh weight of the flower stalk was worked on percentage basis by taking original weight as 100 per cent.

3.11.7 Water balance

The water balance in the tissue of flower stalks was calculated by deducting the total transpirational loss of water from the total water uptake.

3.11.8 Vase life

Flower stalks were discarded when fifty per cent florets wilted. This stage was considered to be the end of potential useful longevity of golden rod flower stalks and the number of days taken for this was recorded by daily observation of flower stalks till they were found unfit for continuing in the vase.

3.12 Statistical analysis

The analysis and interpretation of the data were done using the Fisher's method of analysis of variance technique as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was $P = 0.05$. Critical difference values were calculated for the $P = 0.5$ probability level whenever 'F' test was found significant.

**EXPERIMENTAL
RESULTS**

IV EXPERIMENTAL RESULTS

The results of the present investigation entitled "Studies on nutrition management and vase life of golden rod (*Solidago canadensis* L.) are presented in this chapter.

4.1 EXPERIMENT I : "EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON PLANT GROWTH, FLOWERING AND FLOWER PRODUCTION IN GOLDEN ROD"

4.1.1 Vegetative growth parameters

4.1.1.1 Plant height

The data pertaining to plant height recorded at three stages of crop growth (30, 60 and 90 days after planting) as influenced by varying levels of nitrogen, phosphorus and potassium and their interactions are presented in Table 1.

The effect of different levels of nitrogen on the plant height were significant at all the growth stages. At 90 days after planting maximum plant height (60.06 cm) was recorded with N₂ (150 kg N per ha) level. Minimum plant height (53.38 cm) was recorded with lower nitrogen level N₁ (100 kg N per ha) which differed significantly.

There were significant differences among the phosphorous levels at all the growth stages. However, plant height increased from P₁ (50 kg P₂O₅ per ha) to P₂ (100 kg P₂O₅ per ha) but decreased at P₃ (150 kg P₂O₅ per ha) levels.

Table 1. Plant height (cm) as influenced by NPK levels at different growth stages of golden rod (*Solidago canadensis* L.)

Treatments	30 DAP			60 DAP			90 DAP						
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	
N1	P ₁	14.06	13.42	12.32	13.26	55.63	43.00	41.60	43.41	54.37	52.10	50.47	52.31
	P ₂	15.80	14.36	13.70	14.62	46.96	46.80	45.19	46.31	59.74	53.14	52.00	54.96
	P ₃	14.60	10.26	13.50	12.78	44.00	43.80	42.00	43.26	54.41	53.13	51.09	52.87
	Mean	14.82	12.68	13.17	13.55	45.53	44.53	42.93	44.33	56.17	52.79	51.18	53.38
N2	P ₁	16.86	16.50	15.06	16.14	55.15	51.90	50.33	52.46	60.27	57.16	58.10	58.51
	P ₂	19.35	18.78	17.45	18.53	62.50	56.13	54.00	57.54	69.29	62.30	61.31	64.30
	P ₃	16.90	16.00	15.16	16.02	53.40	52.33	52.33	52.68	58.18	57.12	56.80	57.36
	Mean	17.70	17.09	15.89	16.89	57.01	53.45	52.22	54.23	62.58	58.86	58.73	60.06
	P ₁	15.46	14.96	13.69	14.70	50.39	47.45	45.96	47.93	57.32	54.63	54.28	55.41
	P ₂	17.57	16.57	15.57	16.57	54.73	51.46	49.59	51.93	64.51	57.72	56.65	59.63
	P ₃	15.75	13.13	14.33	14.40	48.70	48.06	47.16	47.97	56.29	55.12	53.94	55.12
	Mean	16.26	14.88	14.53	15.22	51.27	48.99	47.57	49.28	59.37	55.82	54.96	56.72
For comparison of mean													
Nitrogen (N)													
		SEm±	0.399	CD at 5%	1.148	SEm±	0.577	CD at 5%	1.659	SEm±	0.586	CD at 5%	1.684
Phosphorous (P)													
		SEm±	0.489	CD at 5%	1.406	SEm±	0.707	CD at 5%	2.031	SEm±	0.718	CD at 5%	2.063
Potassium (K)													
		SEm±	0.489	CD at 5%	1.406	SEm±	0.707	CD at 5%	2.031	SEm±	0.718	CD at 5%	2.063
	N x P		0.692	N.S.		1.000	N.S.		N.S.		1.015	N.S.	
	N x K		0.692	N.S.		1.000	N.S.		N.S.		1.015	N.S.	
	P x K		0.847	N.S.		1.224	N.S.		N.S.		1.243	N.S.	
	N x P x K		1.198	N.S.		1.731	N.S.		N.S.		1.758	N.S.	

DAP = Days after planting; N.S. = Non-significant

At 90 days after planting maximum plant height (59.63 cm) recorded with P_2 level and minimum plant height (55.12 cm) recorded at P_3 level. Whereas P_2 and P_3 levels statistically were on par.

Increasing level of potassium decreased the plant height significantly at all the three growth stages. Maximum plant height (59.37 cm) was recorded with lower level of potassium K_1 (50 kg K_2O per ha), whereas minimum plant height (54.28 cm) was recorded with higher level of potassium K_3 (150 kg K_2O per ha). However, the treatments K_2 (100 kg K_2O per ha) and K_3 (150 kg K_2O per ha) were found to be on par.

Among the interactions, none of them was significantly superior in increasing the plant height at all the growth stages. However, treatment combinations i.e., 150 kg N + 100 kg P_2O_5 + 50 kg K_2O per hectare recorded maximum plant height (69.29 cm) whereas minimum plant height (50.47 cm) recorded with treatment combinations of 100 kg N + 50 kg P_2O_5 + 150 kg K_2O per hectare at 90 days after planting.

4.1.1.2 Number of leaves

The data on the number of leaves per plant are presented in Table 2.

Application of nitrogen influenced the number of leaves per plant significantly at all the three growth stages (30, 60 and 90 DAP). At 90 days after planting N_2 level recorded

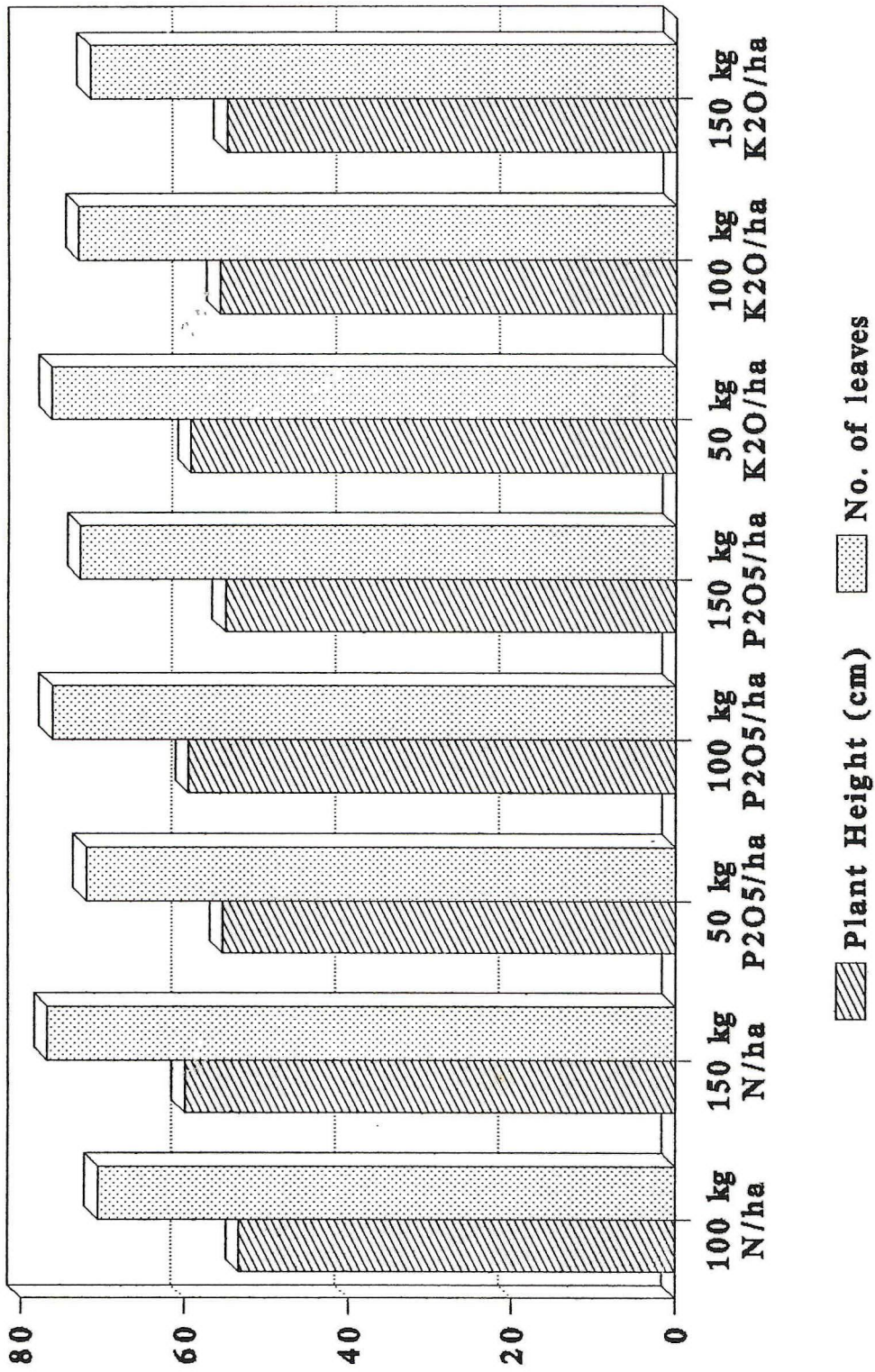


Fig. 2. Effect of nitrogen, phosphorous and potassium on plant height and number of leaves at 90 days after planting

Table 2. Effect of NPK levels on number of leaves per plant in golden rod (*Solidago canadensis* L.)

Treatments	30 DAP				60 DAP				90 DAP					
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean		
N1	P ₁	13.40	14.54	12.40	13.45	44.39	43.50	42.63	43.51	70.81	66.17	68.58	68.52	
	P ₂	14.50	13.14	12.25	13.29	46.62	44.27	43.48	44.79	73.34	72.66	70.64	72.21	
	P ₃	13.42	12.55	12.88	12.95	43.86	43.54	43.17	43.52	77.61	70.05	65.82	71.16	
	Mean	13.77	13.41	12.51	13.23	44.96	43.77	43.09	43.94	73.92	69.63	68.35	70.63	
N2	P ₁	16.94	15.16	16.04	16.04	50.18	48.75	47.18	48.70	77.30	76.59	72.59	75.51	
	P ₂	20.58	19.04	17.90	19.17	55.82	52.25	53.86	53.97	83.58	78.49	78.96	80.34	
	P ₃	15.81	16.63	16.70	16.38	50.24	50.24	50.20	50.22	75.20	74.53	73.70	74.47	
	Mean	17.77	16.94	16.88	17.20	52.08	50.41	50.41	50.97	78.69	76.54	75.10	76.78	
	P ₁	15.17	14.85	14.22	14.74	47.28	46.12	44.90	46.10	74.06	71.38	70.61	72.01	
	P ₂	17.54	16.09	15.07	16.23	51.22	48.26	48.67	49.38	78.46	75.58	74.80	76.28	
	P ₃	14.61	14.59	14.59	14.66	47.05	46.89	46.68	46.87	76.41	72.29	67.76	72.82	
	Mean	15.77	15.17	14.69	15.21	48.52	47.09	46.75	47.45	76.31	73.08	71.72	73.70	
For comparison of mean													SEM±	CD at 5%
Nitrogen (N)													0.291	0.837
Phosphorous (P)													0.357	1.025
Potassium (K)													0.357	N.S.
N x P													0.504	1.450
N x K													0.504	N.S.
P x K													0.618	N.S.
N x P x K													0.874	N.S.
SEM±													0.515	1.481
CD at 5%													0.631	1.814
SEM±													0.631	N.S.
CD at 5%													0.892	N.S.
SEM±													0.892	N.S.
CD at 5%													1.093	N.S.
SEM±													1.546	N.S.
CD at 5%													1.005	2.888
SEM±													1.231	3.537
CD at 5%													1.231	3.537
SEM±													1.741	N.S.
CD at 5%													1.741	N.S.
SEM±													2.132	N.S.
CD at 5%													3.015	N.S.

DAP = Days after planting; N.S. = Non-significant

maximum (76.78) number of leaves per plant and N_1 level recorded minimum number (70.63) of leaves per plant.

Similarly phosphorus levels increased number of leaves per plant significantly upto P_2 level, further increase in phosphorous level reduced the plant height significantly at all the growth stages. However, maximum number of leaves per plant (76.28) recorded with phosphorous at P_2 level and minimum number of leaves per plant (72.01) recorded with P_1 level. Whereas P_3 level (72.82) was statistically on par with P_1 level.

The effect of potassium was non significant both at 30 and 60 days after planting but significant at 90 days after planting. Among the potassium levels K_1 was found to be the best. Since the number of leaves per plant decreased with increasing level of potassium. However, maximum number of leaves per plant at 90 days after planting recorded with K_1 (76.31) level and minimum number of leaves (71.72) recorded with K_3 level. Whereas K_1 and K_2 levels did not differed significantly.

Among the interactions $N \times P$ at 1st stage was found significant, remaining interactions at all the growth stages found non-significant affecting the number of leaves per plant. However, 150 kg N + 100 kg P_2O_5 + 50 kg K_2O combination recorded maximum number (83.58) of leaves, whereas 100 kg N + 150 kg P_2O_5 + 150 kg K_2O combination recorded lowest (65.82) number of leaves per plant at 90 days after planting.

4.1.1.3 Sucker production per plant

The data on the sucker production per plant as influenced by different levels of N, P and K application and their interactions are presented in the Table 3.

Application of nitrogen shows significant effect on sucker production per plant at all the growth stages. At 90 days after planting N_2 level recorded maximum sucker production (6.08) per plant and N_1 level recorded minimum (4.35) number of suckers.

Application of phosphorus increased the sucker production per plant significantly upto P_2 level. The further increase in phosphorous level to P_3 reduced the sucker production significantly at all the growth stages. Maximum sucker production (5.74) recorded with phosphorus at P_2 level whereas it was minimum (4.63) in P_1 level.

Application of potassium significantly reduced the sucker production at all the growth stages. However, potassium level at K_1 recorded the highest number (5.55) of suckers per plant and lowest sucker production (5.01) per plant recorded with highest level (K_3) of potassium, they differed significantly.

The first order interaction (N x K and N x P) were significant for number of suckers at 30 and 60 days. However, in the final stage, the first order interaction N x P was significant, the maximum number of suckers in N x P combination

Table 3. Effect of NPK levels on sucker production in golden rod (*Solidago canadensis* L.)

Treatments	30 DAP				60 DAP				90 DAP					
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean		
N1	P ₁	2.62	1.80	1.73	2.05	3.12	3.10	2.97	3.06	4.76	4.37	3.95	4.36	
	P ₂	2.82	2.56	2.33	2.57	3.21	3.11	2.98	3.10	4.93	4.30	4.25	4.49	
	P ₃	2.63	2.63	1.70	2.32	3.10	3.06	2.93	3.03	4.42	4.76	4.07	4.21	
Mean		2.69	2.33	1.92	2.31	3.14	3.09	3.09	2.96	4.70	4.27	4.09	4.35	
N2	P ₁	2.80	2.32	2.73	2.62	3.25	3.24	3.19	3.22	5.14	4.69	4.89	4.90	
	P ₂	3.10	3.03	2.97	3.03	4.88	4.41	4.31	4.53	7.48	6.87	6.64	6.99	
	P ₃	2.53	2.50	2.77	2.60	4.40	4.35	4.18	4.31	6.56	6.22	6.30	6.36	
Mean		2.81	2.61	2.82	2.75	4.17	4.00	3.89	4.02	6.39	5.92	5.94	6.08	
	P ₁	2.71	2.06	2.23	2.33	3.18	3.17	3.08	3.14	4.95	4.53	4.42	4.63	
	P ₂	2.96	2.80	2.65	2.80	4.04	3.76	3.64	3.81	6.20	5.58	5.44	5.74	
	P ₃	2.58	2.56	2.23	2.46	3.75	3.70	3.55	3.67	5.49	5.19	5.18	5.28	
Mean		2.75	2.47	2.37	2.53	3.66	3.54	3.42	3.54	5.55	5.10	5.01	5.22	
For comparison of mean													SEM±	CD at 5%
Nitrogen (N)													0.067	0.193
Phosphorous (P)													0.082	0.236
Potassium (K)													0.082	0.236
N x P													0.116	N.S.
N x K													0.116	0.334
P x K													0.142	N.S.
N x P x K													0.201	N.S.
SEM±													0.076	0.271
CD at 5%													0.093	0.266
SEM±													0.093	N.S.
CD at 5%													0.131	0.376
SEM±													0.131	N.S.
CD at 5%													0.160	N.S.
SEM±													0.227	N.S.
CD at 5%													0.114	0.327
SEM±													0.139	0.401
CD at 5%													0.139	0.401
SEM±													0.197	0.567
CD at 5%													0.197	N.S.
SEM±													0.242	N.S.
CD at 5%													0.342	N.S.

DAP = Days after planting; N.S. Non-significant

was 6.99 (N_2P_2) and minimum was 4.21 (N_1P_3) and in second order interaction (N x P x K) maximum sucker production (7.48) was in combination $N_2P_2K_1$ and minimum (3.75) was $N_1P_1K_3$.

4.1.1.4 Dry weight of plants

Data pertaining to dry weight of plants recorded at 60 DAP as influenced by N, P and K levels are presented in Table 4.

Application of nitrogen influenced the fresh weight of plant significantly. Maximum fresh weight (21.22 g per plant) recorded at higher level of nitrogen (N_2) and minimum dry weight (12.64 g) recorded at lower level (N_1) of nitrogen.

Phosphorous showed significant effect on dry weight of plant, producing the highest dry weight of 17.11 g at P_2 level and with P_1 level it was lowest (14.14 g), further, P_3 level reduced dry weight significantly.

Contrary to increased levels of N and P, potassium has decreased the dry weight per plant. Among potassium levels K_1 recorded maximum dry weight (16.44 g) and minimum dry weight (15.16 g) recorded with higher level of potassium (K_3). Both K_1 and K_2 levels found to be on par.

The first order interactions were non-significant except N x P. In the combination N x P a significantly higher dry weight of plants was recorded in N_2P_2 (20.19 g) followed by N_2P_3 (18.56 g) and N_2P_1 (15.10 g) which were differing

Table 4. Effect of NPK levels on dry weight of plants (g/plant) and leaf area (dm²/plant) in golden rod (*Solidago canadensis* L.)

Treatments	Dry weight of plant at 60 Days DAP				Leaf area per plant at 60 days DAP					
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean		
N1	P ₁	13.97	12.95	12.64	13.18	6.36	6.04	5.50	5.96	
	P ₂	14.68	14.05	13.36	14.03	7.55	6.82	5.78	6.71	
	P ₃	13.91	13.43	13.31	13.55	5.99	5.60	5.44	5.67	
Mean		14.18	13.47	13.10	13.59	6.63	6.15	5.57	6.12	
N2	P ₁	15.85	14.85	14.62	15.10	8.76	8.34	8.06	8.38	
	P ₂	21.22	20.35	19.02	20.19	10.77	10.31	10.20	10.42	
	P ₃	19.04	18.63	18.03	18.56	10.55	9.88	9.56	10.00	
Mean		18.70	17.94	17.22	17.95	10.02	9.51	9.27	9.60	
	P ₁	14.91	13.90	13.63	14.14	7.56	7.19	6.78	7.17	
	P ₂	17.95	17.20	16.19	17.11	9.16	8.56	7.99	8.57	
	P ₃	16.48	16.03	15.67	16.06	8.27	7.74	7.56	7.83	
Mean		16.44	15.71	15.16	15.77	8.33	7.83	7.42	7.86	
For comparison of mean				SEm±	CD at 5%	SEm±				CD at 5%
Nitrogen (N)				0.179	0.516	0.150				0.301
Phosphorous (P)				0.220	0.631	0.120				0.368
Potassium (K)				0.220	0.631	0.128				0.368
N x P				0.311	0.893	0.181				0.521
N x K				0.311	N.S.	0.181				N.S.
P x K				0.381	N.S.	0.222				N.S.
N x P x K				0.538	N.S.	0.314				N.S.

N.S. = Not-significant

DAP = Days After Planting

significantly among themselves. The least dry weight was recorded in N_1P_1 (13.18 g).

The second order interactions, inspite being non-significant, the best combination with maximum dry weight of plant was $N_2P_2K_1$ which registered 21.22 g per plant and minimum dry weight (12.64 g) was with combination $N_1P_1K_3$.

4.1.1.5 Leaf area per plant

The data on the leaf area per plant as influenced by the different levels of N, P and K and their interaction effects are presented in Table 4.

The varying levels of nitrogen had significant effect on leaf area per plant. The higher level of nitrogen (N_2) produced the plants with maximum (9.60 dm^2) leaf area, where as the plants which received lowest nitrogen (N_1) had significantly lowest (6.12 dm^2) leaf area.

The influence of phosphorous application was also found to be significant and among all the doses tried, maximum leaf area (8.57 dm^2) was recorded phosphorous at P_2 level and minimum leaf area (7.17 dm^2) recorded at lowest (P_1) level of phosphorous.

Among potassium levels K_1 recorded maximum (8.33 dm^2), while minimum leaf area recorded (7.42 dm^2) at higher level of potassium (K_3). Medium potassium level (K_2) produced leaf area of 7.83 dm^2 , which was statistically on par with K_3 level.

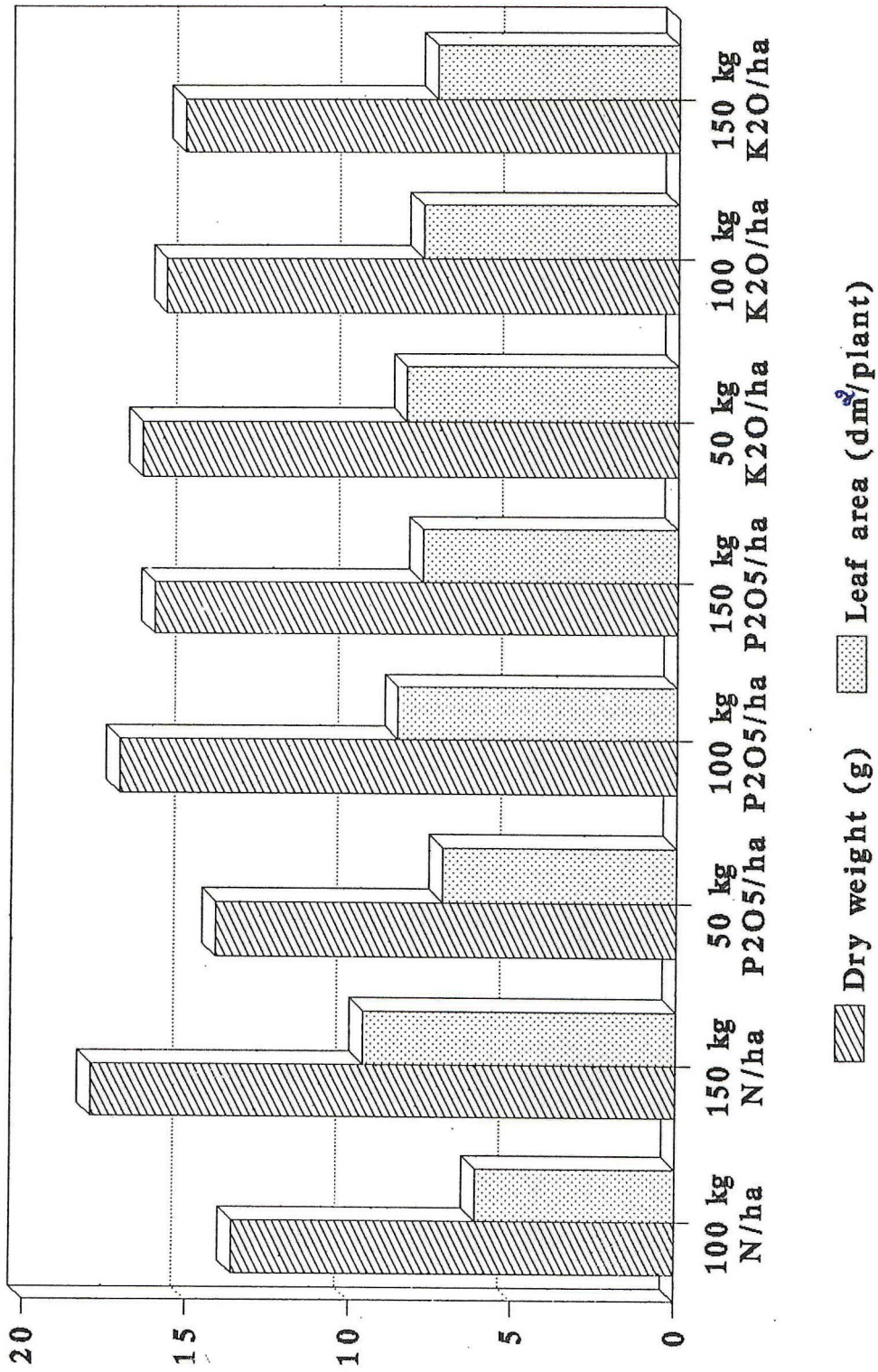


Fig. 3. Effect of NPK levels on dry weight (g) and leaf area (dm²/plant) in golden rod at 60 days after planting

One of the three first order interactions viz., N x P was significant for leaf area per plant. The combination interaction indicating maximum leaf area was N_2P_2 (10.42 dm^2) and minimum leaf area (5.67 dm^2) was with N_1P_3 combination.

The second order interaction for leaf area was non-significant. Golden rod plants with combination of treatments $N_2P_2K_1$ recorded maximum (10.77 dm^2) and minimum (5.44 dm^2) was in the combination $N_1P_3K_3$.

4.1.2 Flowering parameters

4.1.2.1 Number of days taken for flower initiation

The data on number of days taken for flower initiation is presented in Table 5.

The nitrogen level on number of days taken for flower initiation increased with increase with their application. Hence, the highest level of nitrogen (N_2) delayed the flower initiation (59.66 days) as compared to lowest level of nitrogen N_1 (54.55 days). Similarly with increasing level of phosphorus, flower initiation was delayed significantly from P_1 (56.00 days) to P_2 (58.05 days) and P_3 (57.88 days) but P_2 and P_3 levels found to be on par. The effect of potassium levels on number of days taken for flower initiation was non-significant.

The first order interactions viz., N x P and N x K were significant. The higher number of days taken in N x P combination was 60.44 days (N_2P_2), N x K combination was also

Table 5. Effect of NPK levels on number of days taken for flower initiation and time taken for 50 per cent flowering in golden rod (*Solidago canadensis* L.)

Treatments	Number of days taken for flower initiation				Time taken for 50 per cent flowering (days)				
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	
N1	P ₁	50.00	51.66	53.66	51.77	65.66	65.66	66.66	66.00
	P ₂	55.66	54.66	56.66	55.66	69.00	68.00	73.00	70.00
	P ₃	56.00	55.00	58.66	56.55	68.66	71.66	73.00	71.11
Mean	58.88	53.77	56.33	54.55	67.77	68.44	70.88	69.03	
N2	P ₁	62.66	60.66	57.33	60.22	75.66	74.66	74.66	75.00
	P ₂	59.66	61.66	60.00	60.44	75.66	76.66	75.00	75.77
	P ₃	58.66	59.00	60.00	59.22	73.66	74.00	75.66	74.44
Mean	60.33	60.44	59.11	59.96	75.00	75.11	75.11	75.07	
	P ₁	56.33	56.11	55.50	56.00	70.66	70.16	70.66	70.50
	P ₂	57.66	58.16	58.33	58.05	72.33	72.33	74.00	72.88
	P ₃	57.33	57.00	59.33	57.88	71.16	72.83	74.33	72.77
Mean	57.11	57.11	57.72	57.31	71.38	71.77	73.00	72.05	
For comparison of mean				SEm±	CD at 5%				
Nitrogen (N)				0.377	1.082	SEm± 0.588 CD at 5% 1.689			
Phosphorous (P)				0.461	1.326	0.720 2.068			
Potassium (K)				0.461	N.S.	0.720 N.S.			
N x P				0.652	1.875	1.018 2.925			
N x K				0.652	1.875	1.018 N.S.			
P x K				0.799	N.S.	1.247 N.S.			
N x P x K				1.130	N.S.	1.763 N.S.			

N.S. = Non-significant

maximum (60.44 days) with the combination N_2K_2 . The second order interaction (N x P x K) was non-significant and combination $N_2P_2K_3$ recorded maximum (61.66 days) number of days for flower initiation and minimum number of days required with $N_1P_1K_1$ (50.00 days).

4.1.2.2 Time taken for 50 per cent flowering

The data with regard to influence of N, P and K application on time taken for 50 per cent flowering are presented in Table 5.

It was noticed that the nitrogen had significant effect on number of days taken for 50 per cent flowering. The plants which received highest level (N_2) of nitrogen recorded more time (75.07 days) for fifty per cent flowering and least number of days (59.03 days) recorded with lowest level (N_1) of nitrogen.

Significant difference was also noticed among phosphorous levels on time taken for 50 per cent flowering. Maximum number of days (72.88) taken at phosphorous at P_2 level and minimum time (70.50 days) recorded with phosphorous at P_1 level. Contrary to N and P, potassium did not show significant influence on time taken for 50 per cent flowering.

One out of three first order interactions viz., N x P was significant for time taken for 50 per cent flowering. The combination N_2P_2 recorded maximum number of days of 75.77 for 50 per cent flowering which was significantly different from N P which took minimum days (66.00) for 50 per cent flowering

The second order interactions, inspite being non-significant. The combination with maximum time taken for 50 per cent flowering was $N_2P_2K_2$ (76.66) and minimum (65.66 days) was with treatment combinations $N_1P_1K_1$ and $N_1P_1K_2$.

4.1.2.3 Length of flower stalk

The data on flower stalk length influenced by different levels of nitrogen, phosphorous and potassium are presented in Table 6.

Nitrogen levels had exhibited significant difference in length of flower stalk. Significantly larger length of flower stalk was produced in N_2 (45.13 cm), while the flower stalks were shorter in N_1 (40.24 cm).

Among phosphorous levels, flower stalk length increased significantly with increasing level of phosphorous from P_1 (41.54 cm) to P_2 (44.51 cm). Further, increase in phosphorous level reduced flower stalk length significantly.

The effect of potassium on length of flower stalk was non-significant, however, increase potassium levels decreased the length of flower stalk. Among potassium levels K_1 (43.68 cm) recorded maximum length and minimum length was recorded with highest (K_3) level of potassium (41.38 cm).

All the interactions showed non-significant influence on length of flower stalk. In the interaction effects of NPK, the longest length (48.93 cm) of flower stalk recorded with

Table 6. Effect of NPK levels on flower stalk characters in golden rod (*Solidago canadensis* L.)

Treatments	Length of flower stalk (cm)			Length of rachis (cm)			No of spikelets/flower stalk								
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean			
N1	P ₁	40.67	39.29	38.92	39.62	28.80	28.00	27.08	27.96	30.56	28.16	27.20	28.64		
	P ₂	42.19	41.53	40.73	41.48	30.32	29.72	29.50	29.85	32.60	30.00	28.20	30.26		
	P ₃	40.23	39.58	39.06	39.62	27.94	27.36	26.98	27.43	28.70	28.30	27.50	28.16		
Mean		41.03	40.13	39.57	40.24	29.02	28.36	27.85	28.41	30.62	28.82	27.63	29.02		
N2	P ₁	44.83	42.84	42.73	43.46	32.52	31.84	31.18	31.84	34.00	32.80	32.50	33.10		
	P ₂	48.93	47.46	46.23	47.54	33.75	32.92	32.74	33.18	41.80	41.40	37.56	40.25		
	P ₃	45.23	44.30	43.69	44.40	30.65	30.48	29.13	30.08	37.50	36.43	36.10	36.67		
Mean		46.33	44.86	44.21	45.13	32.31	31.74	31.01	31.69	37.76	36.87	35.38	36.67		
	P ₁	42.75	41.06	40.82	41.54	30.66	29.92	29.13	29.90	32.28	30.48	29.85	30.87		
	P ₂	45.56	44.49	43.48	44.51	32.03	31.32	31.12	31.49	37.20	35.70	32.88	35.26		
	P ₃	42.73	41.94	41.38	42.01	29.29	28.92	28.05	28.76	33.10	32.36	31.80	32.42		
Mean		43.68	42.50	41.89	42.69	30.66	30.05	29.43	30.05	34.19	32.84	31.51	32.85		
For comparison of mean															
Nitrogen (N)															
		SEm±	0.415	SEm±	0.415	CD at 5%	1.194	SEm±	0.427	CD at 5%	1.228	SEm±	0.604	CD at 5%	1.736
Phosphorous (P)															
		SEm±	0.509	SEm±	0.509	CD at 5%	1.462	SEm±	0.523	CD at 5%	1.505	SEm±	0.740	CD at 5%	2.127
Potassium (K)															
	N x P	SEm±	0.509	SEm±	0.509	CD at 5%	N.S.	SEm±	0.523	CD at 5%	N.S.	SEm±	0.740	CD at 5%	2.127
	N x K	SEm±	0.719	SEm±	0.719	CD at 5%	N.S.	SEm±	0.740	CD at 5%	N.S.	SEm±	1.046	CD at 5%	3.008
	P x K	SEm±	0.719	SEm±	0.719	CD at 5%	N.S.	SEm±	0.740	CD at 5%	N.S.	SEm±	1.046	CD at 5%	N.S.
	P x P x K	SEm±	0.881	SEm±	0.881	CD at 5%	N.S.	SEm±	0.907	CD at 5%	N.S.	SEm±	1.282	CD at 5%	N.S.
	N x P x K	SEm±	1.246	SEm±	1.246	CD at 5%	N.S.	SEm±	1.282	CD at 5%	N.S.	SEm±	1.813	CD at 5%	N.S.

N.S. = Non-significant



Plate 3. Effect of nutrition on flower stalk characters in golden rod



Plate 4. Effect of nutrition on flower stalk character in golden rod



Plate 5. Effect of nutrition on flower stalk characters in golden rod

combination $N_2P_2K_1$, followed by $N_2P_2K_2$ (47.46 cm) and $N_2P_2K_3$ (47.54 cm) and least was with $N_1P_1K_3$ (38.92 cm).

4.1.2.4 Length of rachis

The data pertaining to length of rachis are presented in Table 6.

The length of rachis was considerably influenced by nitrogen and phosphorous levels. N and P at N_2 (31.69 cm) and P_2 (31.49 cm) levels recorded significantly higher length over N_1 (28.41 cm) and P_3 (28.76 cm) levels respectively, which produced lowest length of rachis.

The rachis length differed non-significantly with potassium levels. However, maximum length of rachis obtained with potassium level K_1 (30.66 cm) further increase in potassium levels to K_2 (30.05 cm) and K_3 (29.43 cm) decreased the rachis length significantly.

None of the interactions was found to have any significant effect on the length of rachis. However, treatment combination $N_2P_2K_1$ (33.75 cm) recorded maximum and $N_1P_3K_3$ (26.98 cm) recorded minimum length of rachis.

4.1.2.5 Number of spikelets per flower stalk

The data with regard to influence of N, P and K on number of spikelets are presented in Table 6.

Nitrogen has profound effect on the number of spikelets per flower stalk. The N_2 level accounted maximum (36.67) number of spikelets per flower stalk, which was significantly higher than N_1 which accounted minimum (29.02). Similar trend was observed with phosphorous also where maximum number of spikelets recorded 35.26 with phosphorous at P_2 and minimum (30.87) number of spikelets recorded with P_1 . A significant decline in number of spikelets per flower stalk observed with further increase in phosphorous levels.

Contrary to other major nutrients N and P, increased level of potassium had an adverse effect on number of spikelets per flower stalk. However, maximum number of spikelets (34.19) recorded with potassium level K_1 and minimum number (31.51) of spikelets recorded with highest level of potassium (K_3).

Among the first order interactions it was only interaction of N x P that significantly increased the number of spikelets per flower stalk. The maximum number (40.25) was obtained with N_2P_2 and the minimum (28.16) was observed in N_1P_3 . Though second order interaction was non-significant, the treatment combination $N_2P_2K_1$ (41.80) was recorded maximum number of spikelets and $N_1P_1K_3$ (27.20) combination recorded minimum number of spikelets per flower stalk.

4.1.2.6 Number of flower stalks

The data on total number of flower stalks per plant, number of flower stalks per plot and number of flower stalks per hectare are tabulated in Table 7.

With the increasing nitrogen level, number of flower stalks per plant, number of flower stalks per plot and number of flower stalks per hectare increased significantly. Maximum number of flower stalks per plant (5.13) recorded with higher nitrogen level (N_2) and least number of flower stalks (3.87) per plant recorded with N_1 level. Similarly higher number of flower stalks (205.5 per plot) recorded with higher nitrogen level (N_2) and lowest number of flower stalks per plot (154.84) recorded with lowest level of nitrogen (N_1). Similar trend with respect to number of flower stalks (1000's) per hectare also noticed. However, maximum number of flower stalks (1000's) per hectare recorded (569.18) with higher level of nitrogen (N_2) and lowest number of flower stalks (427.55 per hectare) recorded with lower level of nitrogen (N_1).

Maximum number of flower stalks per plant, per plot and per hectare (1000's) recorded with phosphorous at P_2 level, which recorded 4.91, 196.75 and 546.05 (1000's) respectively. Significantly minimum number of flower stalks per plant, per plot and per hectare obtained with phosphorous at P_1 they recorded 4.13, 165.27 and 456.27 (1000's) respectively. Further increase of P_3 level significantly decreased the above yield parameters.

Table 7. Effect of NPK levels on flower yield characters of golden rod (*Solidago canadensis* L.)

Treatments	No. of flower stalks/plant				No. of flower stalk/plot				No. of flower stalks/ha (1000's)			
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean
N												
1P ₁	3.69	3.59	3.42	3.57	147.86	143.86	136.93	142.88	395.66	399.33	380.00	391.66
P ₂	4.34	4.20	4.02	4.19	173.86	168.26	161.06	167.73	482.66	467.00	446.66	465.44
P ₃	3.98	3.82	3.74	3.85	159.33	153.00	149.86	154.06	442.66	424.66	409.33	425.55
Mean	4.01	3.87	3.73	3.87	160.35	155.04	149.28	154.89	440.33	430.33	412.00	427.55
N ₂												
P ₁	4.97	4.71	4.42	4.70	199.00	188.33	175.66	187.66	552.66	522.66	487.33	520.88
P ₂	6.15	5.51	5.26	5.64	246.00	220.66	210.66	225.77	682.66	612.66	584.33	626.66
P ₃	5.22	4.98	4.91	5.04	209.06	199.33	196.66	201.68	580.33	553.66	546.00	560.00
Mean	5.45	5.07	4.86	5.13	218.02	202.77	194.33	205.04	605.22	563.00	539.33	569.18
P ₁	4.33	4.15	3.92	4.13	173.43	166.10	156.30	165.27	474.16	461.00	433.66	456.27
P ₂	5.24	4.86	4.64	4.91	209.93	194.46	185.86	196.75	582.66	539.83	515.66	546.05
P ₃	4.60	4.40	4.33	4.44	184.20	176.16	173.20	177.87	511.50	489.16	477.66	492.77
Mean	4.73	4.47	4.30	4.50	189.18	178.91	171.81	179.97	522.77	496.66	475.66	498.37
For comparison of mean												
Nitrogen (N)			SEM±	CD at 5%				SEM±	CD at 5%		SEM±	CD at 5%
Phosphorous (P)			0.084	0.243			2.066	5.93			6.141	17.651
Potassium (K)			0.103	0.297			2.530	7.27			7.522	21.617
N x P			0.130	0.297			2.530	7.27			7.522	21.617
N x K			0.146	N.S.			3.579	N.S.			10.637	N.S.
P x K			0.146	N.S.			0.579	N.S.			10.637	N.S.
N x P x K			0.179	N.S.			4.383	N.S.			13.028	N.S.
			0.253	N.S.			0.198	N.S.			18.424	N.S.

N.S. = Non-significant

Application of potassium resulted in significant reduction in number of flower stalks per plant, per plot and per hectare (1000's). However, maximum number of flower stalks per plant (4.73), per plot (189.18) and per hectare (522.77 (1000's)) recorded with lowest level of potassium (K_1) and minimum number of flower stalks per plant (4.30), per plot (171.81) and per hectare (475.66 (1000's)) recorded with highest (K_3) level of potassium.

All the interactions failed to produce significant effects. However, maximum number of flower stalks per plant, per plot and per hectare recorded with treatment combination $N_2P_2K_1$ they recorded 6.15, 246.00 and 682.66 (1000's) respectively. While, minimum number of flower stalks per plant, per plot and per hectare recorded with treatment combination $N_1P_1K_3$, they recorded 3.57, 142.88 and 380.00 (1000's) respectively.

4.1.2.7 Weight of flower stalk (g)

Data pertaining to weight of flower stalk as influence by N, P and K levels are presented in Table 8.

Increasing in nitrogen level increased the weight of flower stalk significantly. The maximum weight (35.04 g) recorded with higher level of nitrogen (N_2), where as in lower level of nitrogen (N_1) recorded 25.95 g of flower stalk. Similarly with phosphorous also increase the weight of flower stalk from minimum at P_1 (28.08 g) to maximum at P_2 (33.11 g).

The further increase in phosphorous level to P_3 (30.29 g) decreased the weight significantly.

In case of potassium application lowest level (K_1) recorded maximum weight (32.41 g) of flower stalk, further increase in potassium level to K_2 (29.97 g) and K_3 (29.12 g) decrease the weight of flower stalk.

The first order interaction $N \times P$ was significant while the other two ($N \times K$ and $P \times K$) were non-significant. The combination N_2P_2 recorded highest weight of 39.12 g and which was significantly different from N_1P_1 which recorded lowest weight (24.55) of flower stalk.

The second order interaction was non-significant but the best combination was $N_2P_2K_1$ with an weight of 40.92 g followed by $N_2P_2K_2$ (38.92 g) and least was with $N_1P_1K_3$ (24.55 g).

4.1.2.8 Yield of flower stalk per plot

The data on flower stalk yield (kg/plot) as influenced by different levels of N, P and K are presented in Table 8.

Nitrogen levels tried, significant influence on flower stalk yield per plot was obtained. The maximum flower stalk yield obtained (7.28 kg/plot) with higher level (N_2) of nitrogen and it was significantly higher than lowest level (N_1) of nitrogen, which recorded minimum (4.06 kg/plot) weight of flower stalks per plot.

Application of phosphorous level had significant effect on the flower stalk yield per plot. Application of phosphorous at P_2 recorded maximum (6.73 kg/plot) flower stalk yield and minimum (4.74 kg/plot) recorded with phosphorous at P_1 level. The further increase in phosphorous to P_3 level decreased the flower stalk yield significantly.

Increasing the level of 'K' decreased the flower stalk yield per plot. Significantly higher flower stalk yield (6.32 kg per plot) obtained with lowest (K_1) level and significantly lower flower stalk yield (5.12 kg/plot) obtained with highest potassium (K_3) level.

The first order interactions were significant except P x K. In the combination of N x P, a significantly higher flower stalk yield per plot were recorded in N_2P_2 (8.91 kg per plot) followed by N_2P_3 (34.39 kg per plot) and N_1P_1 (3.56 kg per plot) which were differing significantly among themselves. The least flower stalk yield was recorded in N_1P_1 (3.56 kg per plot). While in the combination N x K the maximum flower stalk yield per plot was recorded in N_2K_1 (8.13 kg per plot) followed by N_2K_2 (7.13 kg per plot) which differing significantly among themselves. The least flower stalk yield per plot in N x K combination was observed in N_1K_3 (3.68 kg per plot).

The second order interactions, in spite being non-significant, the maximum flower stalk yield per plot was $N_2P_2K_1$ which registered 10.06 kg per plot.

Table 8. Effect of NPK levels on flower yield characters of golden red (*Solidago canadensis* L.)

Treatments	Weight of flower stalk (g)				Flower stalk yield/plot (kg)				Flower stalk yield/ha (t)				
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	
N1	P ₁	26.50	24.30	22.85	24.55	4.06	3.49	3.12	3.56	11.29	9.70	8.61	9.87
	P ₂	28.46	26.76	26.13	27.11	4.94	4.49	4.20	4.54	13.37	12.50	11.68	12.51
	P ₃	28.40	25.42	24.80	26.20	4.52	4.02	3.71	4.08	11.55	10.84	10.32	10.90
Mean	27.78	25.49	24.59	25.95	4.51	4.00	3.68	4.06	12.07	11.01	10.20	11.09	
N2	P ₁	32.50	31.44	30.94	31.62	6.46	5.92	5.42	5.93	17.95	16.45	15.08	16.49
	P ₂	40.92	38.92	37.52	39.12	10.06	8.79	7.90	8.91	27.95	24.42	21.95	24.77
	P ₃	37.69	32.98	32.50	34.39	7.87	6.69	6.39	6.98	21.87	18.26	17.75	19.29
Mean	37.03	34.44	33.65	35.04	8.13	7.13	6.57	7.28	22.59	19.71	18.26	20.19	
Mean	P ₁	29.50	27.87	26.89	28.08	5.26	4.70	4.27	4.74	14.62	13.07	11.85	13.18
	P ₂	34.69	32.84	31.82	33.11	7.50	6.64	6.05	6.73	20.66	18.46	16.81	18.64
	P ₃	33.04	29.20	28.65	30.29	6.19	5.35	5.05	5.53	16.71	14.55	14.03	15.10
Mean	32.41	29.97	29.12	30.50	6.32	5.56	5.12	5.67	17.33	15.36	14.23	15.64	
For comparison of mean													
Nitrogen (N)			SEmt	CD at 5%			SEmt	CD at 5%			SEmt	CD at 5%	
Phosphorous (P)			0.558	1.605			0.063	0.181			0.164	0.471	
Potassium (K)			0.684	1.965			0.077	0.221			0.201	0.576	
N x P			0.684	1.965			0.077	0.221			0.201	0.576	
N x K			0.967	2.780			0.109	0.313			0.284	0.815	
P x K			0.967	N.S.			0.109	0.313			0.284	0.815	
N x P x K			1.185	N.S.			0.133	N.S.			0.347	N.S.	
			1.675	N.S.			0.188	N.S.			0.491	1.412	

N.S. Not-significant

4.1.2.9 Yield of flower stalks per hectare (t)

The data on flower stalk yield (t/ha) tabulated in Table 8.

The nitrogen level had significant effect on yield per hectare. The maximum flower stalk yield (20.19 t per hectare) was observed in the highest nitrogen (N_2) level and minimum flower stalk yield (11.09 t per hectare) was observed in lower level of nitrogen (N_1).

Phosphorous levels also influenced the flower stalk yield per hectare significantly. Maximum flower stalk yield (18.64 t/ha) was obtained with phosphorous at P_2 level and minimum flower stalk yield (13.18 t per hectare) obtained with phosphorous at P_1 level. Further, increase in phosphorous level to P_3 decreased the flower stalk yield significantly.

Among potassium levels, maximum flower stalk yield (17.33 kg per hectare) recorded with lowest level of potassium (K_1). Further, increase in potassium levels to K_2 (15.36 t per hectare) to K_3 (14.23 t/ha) decreased the flower stalk yield significantly.

The first order interactions $N \times P$ and $N \times K$ were significant while interaction $N \times K$ was non-significant. In the combination of $N \times P$, a significantly higher flower stalk yield per hectare were recorded in N_2P_2 (24.77 t per ha) followed by N_2P_3 (19.29 t per ha) and N_2P_1 (16.49 t per ha) which were

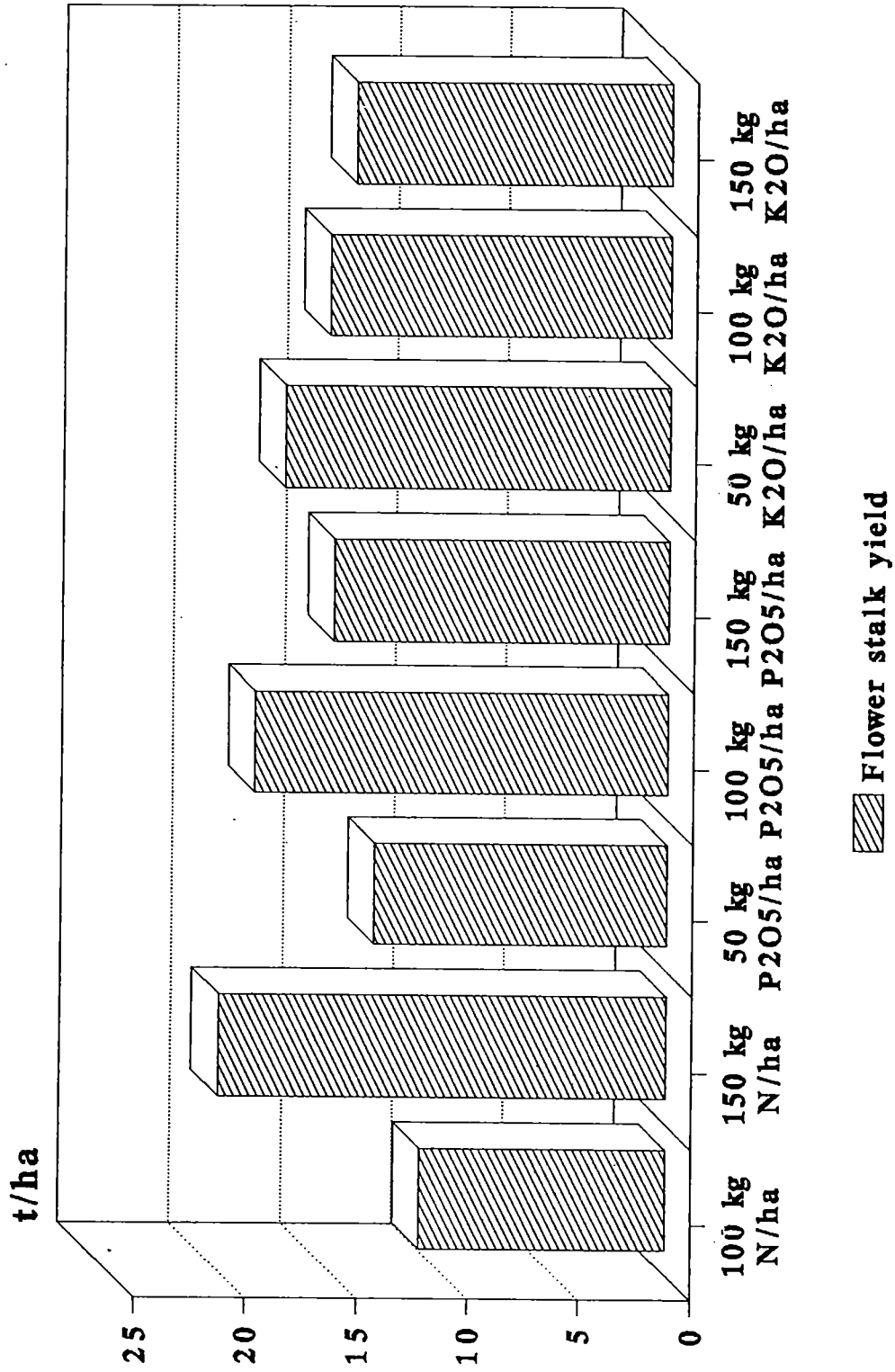


Fig. 4. Effect of nitrogen, phosphorous & potassium on flower stalk yield (t/ha) in golden rod

significantly differing among themselves. The least flower stalk yield was recorded in N_1P_1 (9.87 t per ha). While in the combination N x K, the maximum flower stalk yield per hectare was recorded in N_2K_1 (19.71 t per ha) followed by N_2K_2 (19.71 t per hectare) which differed significantly with each other. The least flower stalk yield in N x K combination was observed in N_1K_3 (10.20 t per hectare).

The second order interaction was significant for flower stalk yield per hectare. The treatment combinations $N_2P_2K_1$, $N_2P_2K_2$ and $N_2P_2K_3$ registered 27.95, 24.42 and 21.95 t per hectare respectively. The least yield was in the combination $N_2P_2K_3$ (8.61 t per ha).

4.1.3 Total uptake of major nutrients

4.1.3.1 Uptake of nitrogen

Data pertaining to N, P and K uptake by golden rod crop are presented in Table 9.

Irrespective of phosphorous and potassium levels, the nitrogen uptake increased significantly with increasing level of nitrogen. Maximum nitrogen uptake (73.77 kg per hectare) recorded with highest nitrogen (N_2) level. While in lower level of nitrogen (N_1) it was only 60.89 kg per hectare.

Highest N uptake (71.26 kg per ha) was recorded with phosphorous level P_2 and it was significantly higher than that observed with P_1 and P_3 (66.60 and 64.13 kg per hectare respectively) which differed significantly.

As the potassium levels increased the total nitrogen uptake decreased significantly. However, maximum nitrogen uptake was with K_1 (69.80 kg per ha), where as minimum uptake (64.49 kg per hectare) recorded with highest (K_3) level of potassium.

All the interactions failed to produce significant effects. However, maximum total nitrogen uptake was recorded with treatment combination $N_2P_2K_1$ (79.93 kg per ha), minimum nitrogen uptake (53.62 kg per ha) recorded with combination $N_1P_3K_3$.

4.1.3.2 Uptake of phosphorous

The total phosphorous uptake increased significantly with increasing level of nitrogen. Highest uptake of phosphorous (15.39 kg per hectare) registered with highest nitrogen (N_2) level and which differed significantly from lower (N_1) level of nitrogen (13.75 kg per hectare).

Application of phosphorous had significant effect on their uptake. The highest level of uptake of 17.68 kg per hectare was recorded in highest (P_3) level of phosphorous and least uptake (10.37 kg per hectare) recorded at lowest level (P_1) of phosphorous.

The significant increase in total phosphorous uptake was recorded with increasing level of potassium from K_1 (14.74 kg per ha) to maximum at K_2 (14.98 kg per hectare), which further

Table 9. Total uptake (kg/ha) of nitrogen, phosphorous and potassium as influenced by NPK levels in golden rod (*Solidago canadensis* L.)

Treatments	N uptake			P uptake			K uptake						
	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	K ₁	K ₂	K ₃	Mean	
N1	P ₁	63.70	60.50	58.02	60.74	10.34	10.53	9.73	10.20	49.78	55.39	59.69	54.95
	P ₂	67.21	65.42	61.64	64.75	14.02	14.25	13.56	13.94	51.68	56.65	65.20	57.84
	P ₃	60.37	57.54	53.62	57.17	17.15	17.56	16.63	17.11	46.36	53.01	57.07	52.14
	Mean	63.76	61.15	57.76	60.89	13.83	14.11	13.30	13.75	49.27	55.01	60.65	54.98
N2	P ₁	74.08	73.45	69.88	72.47	10.62	10.75	10.28	10.55	43.74	48.78	55.03	49.18
	P ₂	79.93	77.40	75.96	77.76	17.42	17.67	17.00	17.36	45.63	51.77	54.07	50.49
	P ₃	73.56	71.85	67.84	71.08	18.94	19.13	16.70	18.25	43.64	46.01	54.70	48.11
	Mean	75.85	74.23	71.22	73.77	15.66	15.85	14.66	15.39	44.33	48.85	54.60	49.26
	P ₁	68.89	66.97	63.95	66.60	10.48	10.64	10.00	10.37	46.76	52.08	57.36	52.06
	P ₂	73.57	71.41	68.80	71.26	15.72	15.96	15.28	15.65	48.65	54.21	59.63	54.16
	P ₃	66.96	64.69	60.73	64.13	18.04	18.34	16.66	17.68	45.00	49.51	55.88	50.13
	Mean	69.80	67.69	64.49	67.33	14.74	14.98	13.98	14.57	46.80	51.93	57.62	52.12
For comparison of mean													
SEM±													
CD at 5%													
Nitrogen (N)													
SEM±													
CD at 5%													
Phosphorous (P)													
SEM±													
CD at 5%													
Potassium (K)													
SEM±													
CD at 5%													
N x P													
SEM±													
CD at 5%													
N x K													
SEM±													
CD at 5%													
P x K													
SEM±													
CD at 5%													
N x P x K													
SEM±													
CD at 5%													

N.S. Not-significant

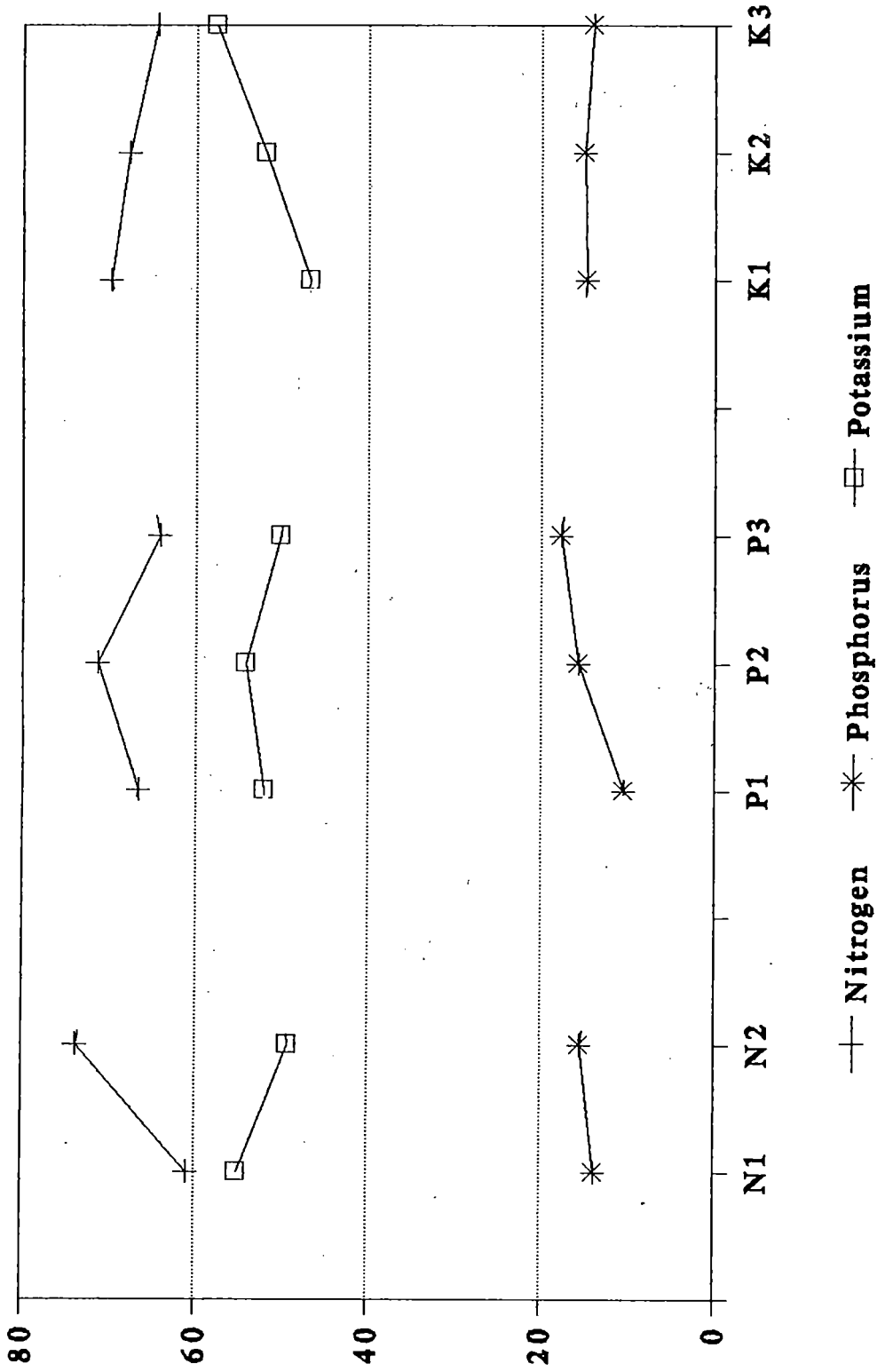


Fig. 5. Effect of nitrogen, phosphorous and potassium on total N, P and K uptake at harvest in golden rod

increase to K_3 decreased (13.68 kg per ha) uptake of phosphorous.

Only N x P interaction showed significant effect on phosphorous uptake. Among N x P interactions, it was N_2P_3 that gave maximum phosphorous uptake (18.25 kg per hectare) as against the minimum of 10.20 kg per hectare in case of N_1P_1 .

The second order interaction was non-significant for phosphorous uptake. However, treatment combination $N_2P_3K_2$ (19.13 kg per hectare) which closely followed by $N_2P_3K_1$ (18.94 kg per hectare) and $N_2P_2K_2$ (17.67 kg per hectare) recorded maximum phosphorous uptake and least uptake (9.73 kg per hectare) recorded with combination $N_1P_1K_3$.

4.1.3.4 Uptake of potassium

Nitrogen fertilization showed significantly negative effect on potassium uptake. Significantly higher uptake of 54.98 kg per hectare was seen in the plants received lowest (N_1) level of nitrogen and it was 49.26 kg per hectare with highest level (N_2) of nitrogen.

Application of phosphorous had significant effect on potassium uptake from P_1 (52.06 kg per ha) to P_2 (54.16 kg per ha) which was recorded maximum and further increase to P_3 (50.13 kg per hectare) significantly reduced the potassium uptake.

Potassium fertilization increased the uptake of potassium significantly. Maximum uptake of 57.62 kg recorded at highest (K_3) level of potassium and minimum potassium uptake 46.80 kg per hectare recorded with lowest level (K_1).

All the interactions showed non-significant effect on K uptake. However, maximum uptake (65.20 kg per hectare) recorded with treatment combination $N_1P_2K_3$ and least uptake of 43.64 kg per hectare recorded with combination $N_2P_3K_1$.

4.1.4 Correlation studies

The correlation coefficients (r) between flower yield per hectare and other parameters are presented in Table 10.

The correlation showed significantly positive correlation between flower yield and plant height ($r = + 0.91$), number of leaves per plant ($r = + 0.84$), sucker production per plant ($r = + 0.95$), total dry matter production per plant ($r = + 0.79$), number of flower stalks per plant ($r = + 0.98$), weight of flower stalk ($r = + 0.98$), total nitrogen uptake ($r = + 0.90$) and total phosphorous uptake ($r = + 0.49$) at harvest stage. However, the correlation between the flower yield per hectare and total potassium uptake ($r = - 0.53$) was negative but significant.

4.1.5 Economics of returns

The cost of cultivation of golden rod as influenced by N, P and K is given in Appendix **III AND IV**.

Table 10. Correlation between flower yield and other characters in golden rod (*Solidago canadensis* L.)

Sl. No.	Parameters	Correlation coefficient (r)
1.	Plant height at III stage	0.91*
2.	Number of leaves at III stage	0.84*
3.	Sucker production per plant at III stage	0.95*
4.	Dry matter production	0.79*
5.	Number of flower stalks per plant	0.98*
6.	Weight of flower stalk	0.98*
7.	Total N uptake	0.90*
8.	Total P uptake	0.49*
9.	Total K uptake	-0.53*

* Significant at 5 per cent probability level

The maximum net profit was Rs. 52,835.00 per hectare with treatment combination $N_2P_2K_1$ (150 kg N: 100 kg P_2O_5 : 50 kg K_2O per hectare) followed by Rs. 45,348.00 and Rs. 42,363.00 per hectare with treatment combinations of $N_2P_2K_2$ (150 kg N : 100 kg P_2O_5 : 150 kg K_2O per ha) and $N_2P_2K_3$ (150 kg N : 100 kg P_2O_5 : 50 kg K_2O per ha) respectively. While the least net profit was Rs. 22,290.00 with the treatment combination $N_1P_1K_3$.

4.2 EXPERIMENT II : EFFECT OF CHEMICALS ON VASE LIFE OF GOLDEN ROD

4.2.1 Fresh Weight

The fresh weight as influenced by different preservatives are presented in Table 11.

All the treatments including distilled water (control) increased fresh weight upto fourth day, there onwards decline in fresh weight was evident in all the treatments except BA_6 10 ppm + 2 per cent sucrose and $Al_2(SO_4)_3$ 100 ppm + 2 per cent sucrose.

Maximum fresh weights of flowers was noticed in treatments BA_6 10 ppm with two per cent sucrose (122.23%) which was closely followed by $Al_2(SO_4)_3$ 100 ppm with two per cent sucrose (122.08%) which are statistically on par with each other. Minimum fresh weight (88.42%) was recorded in distilled water on eighth day and maintained maximum fresh weight of 108.05 per cent and 110.08 per cent respectively on 14th day.

LEGEND

1. $N_1P_1K_1$ - 100:50:50 kg/ha
2. $N_1P_1K_2$ - 100:50:100 kg/ha
3. $N_1P_1K_3$ - 100:50:150 kg/ha
4. $N_1P_2K_1$ - 100:100:50 kg/ha
5. $N_1P_2K_2$ - 100:100:100 kg/ha
6. $N_1P_2K_3$ - 100:100:150 kg/ha
7. $N_1P_3K_1$ - 100:150:50 kg/ha
8. $N_1P_3K_2$ - 100:150:100 kg/ha
9. $N_1P_3K_3$ - 100:150:150 kg/ha
10. $N_2P_1K_1$ - 150:50:50 kg/ha
11. $N_2P_1K_2$ - 150:50:100 kg/ha
12. $N_2P_1K_3$ - 150:50:150 kg/ha
13. $N_2P_2K_1$ - 150:100:50 kg/ha
14. $N_2P_2K_2$ - 150:100:100 kg/ha
15. $N_2P_2K_3$ - 150:100:150 kg/ha
16. $N_2P_3K_1$ - 150:150:50 kg/ha
17. $N_2P_3K_2$ - 150:150:100 kg/ha
18. $N_2P_3K_3$ - 150:150:150 kg/ha

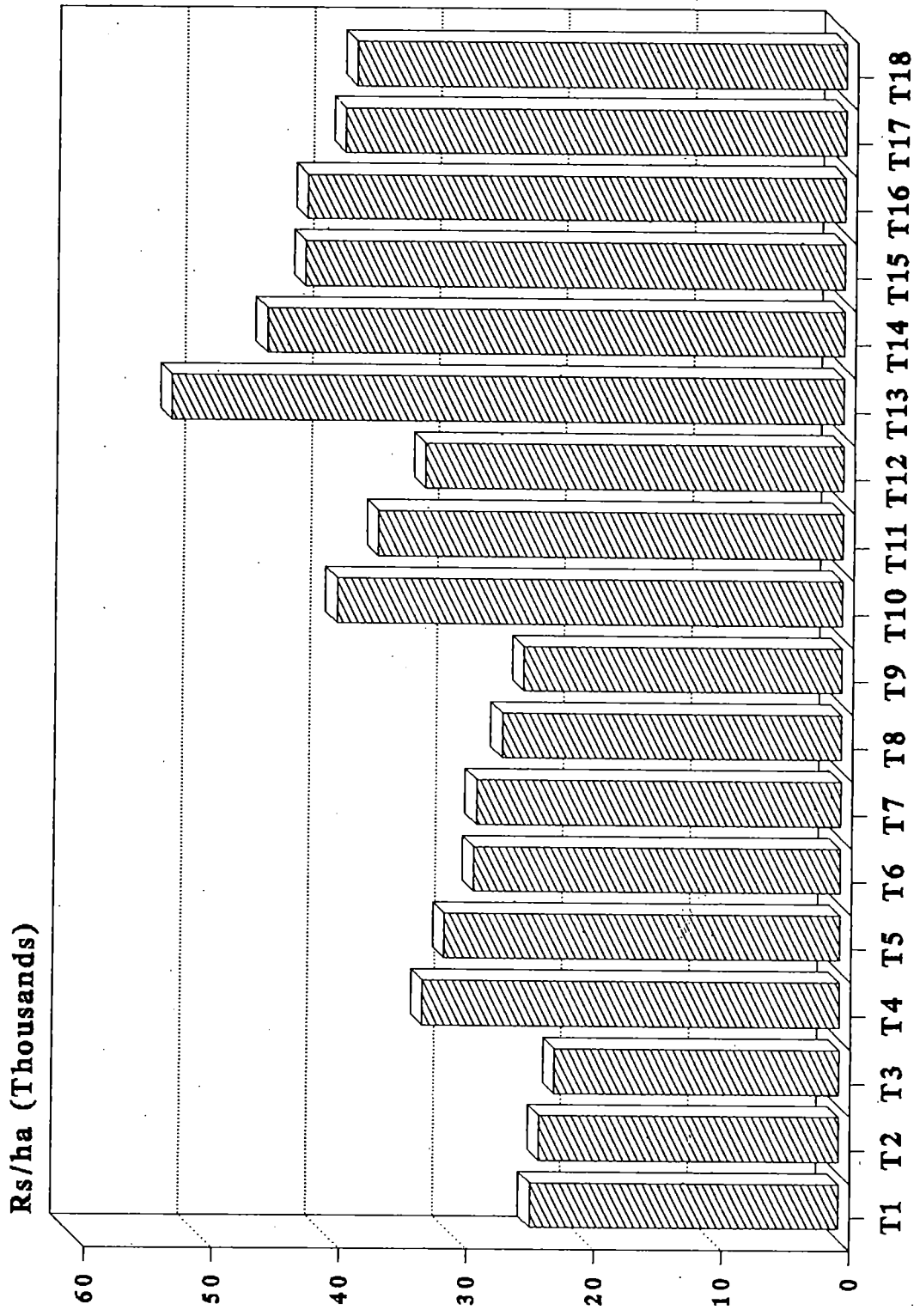


Fig. 6. Net returns as influenced by NPK levels in golden rod

Table 11. Effect of chemicals on fresh weight and vase life of flower stalks of golden rod (*Solidago canadensis* L.)

Treatments	Fresh weight (%) on different days during vase life							Vase life
	2nd	4th	6th	8th	10th	12th	14th	
BA ₆ @ 5 ppm	105.63	110.04	101.19	99.84	99.84	80.14	65.94	10.33
BA ₆ @ 10 ppm	107.43	109.23	100.96	87.78	80.07	63.30	62.40	11.00
BA ₆ @ 5 ppm + 2% Sucrose	106.83	110.56	113.15	114.11	98.11	73.51	66.90	12.33
BA ₆ @ 10 ppm + 2% Sucrose	109.82	113.76	117.28	122.23	121.29	112.39	108.05	13.33
Al ₂ (SO ₄) ₃ @ 50 ppm	109.49	110.34	103.94	94.41	85.40	75.26	70.86	11.66
Al ₂ (SO ₄) ₃ @ 100 ppm	105.05	110.12	99.12	90.36	82.15	74.22	66.53	11.33
Al ₂ (SO ₄) ₃ @ 50 ppm + 2% sucrose	108.58	114.41	116.96	109.97	102.02	84.81	78.47	12.00
Al ₂ (SO ₄) ₃ @ 100 ppm + 2% Sucrose	109.56	114.50	117.19	122.08	121.78	110.78	110.78	14.00
Distilled water	108.48	109.87	101.60	88.42	77.03	64.09	57.76	7.66
S.Em. ±	2.42	2.01	2.08	2.23	2.31	1.82	2.16	0.38
C.D. at 5%	N.S.	N.S.	6.19	6.64	6.89	5.42	6.44	1.14

N.S. = Non-significant

Flower stalks held in the solutions having $\text{Al}_2(\text{SO}_4)_3$ at 100 ppm along with two per cent sucrose maintained maximum (110.78%) fresh weight which was more than their initial (109.56%) on 14th day.

4.2.2 Water uptake

The final water uptake by golden rod flower stalks after 14 day showed significant difference with different chemicals are presented in Table 12.

Among all the chemical the flowers kept in vase solutions containing chemicals like $\text{Al}_2(\text{SO}_4)_3$ 100 ppm with two per cent sucrose and BA_6 10 ppm with two per cent sucrose had high amount of water uptake of 234.38 g and 226.50 g respectively as compare to those held in other chemicals and lowest water uptake (127.53 g) recorded with distilled water.

4.2.3 Water loss

Amount of water lost from the flower stalks held in different chemical preservatives varied significantly (Table 12). Flower stalks which absorbed maximum amount of water were the ones which also lost maximum amount of water of 249.10 g ($\text{Al}_2(\text{SO}_4)_3$ 100 ppm + 2% sucrose) and 243.10 g (BA_6 10 ppm + 2% sucrose) which are statistically on par with each other. While those held in distilled water had lost minimum amount of water (151.26 g).

Table 12. Effect of chemicals on water relations of flower stalks of golden rod during 14 days of vase life

Treatments	Water uptake (g/3 flower stalks)	Water loss (g/3 flower stalks)	Water loss and uptake ratio
BA ₆ @ 5 ppm	138.20	160.92	1.164
BA ₆ @ 10 ppm	157.58	182.81	1.163
BA ₆ @ 5 ppm + 2% Sucrose	162.28	182.13	1.115
BA ₆ @ 10 ppm + 2% Sucrose	226.50	243.10	1.073
Al ₂ (SO ₄) ₃ @ 50 ppm	146.27	167.37	1.144
Al ₂ (SO ₄) ₃ @ 100 ppm	160.23	178.84	1.116
Al ₂ (SO ₄) ₃ @ 50 ppm + 2% sucrose	191.00	208.03	1.089
Al ₂ (SO ₄) ₃ @ 100 ppm + 2% Sucrose	234.38	249.10	1.062
Distilled water	127.53	151.26	1.186
S.Em.±	3.55	3.62	0.019
C.D. at 5%	10.55	10.76	0.056

N.S. = Non-significant

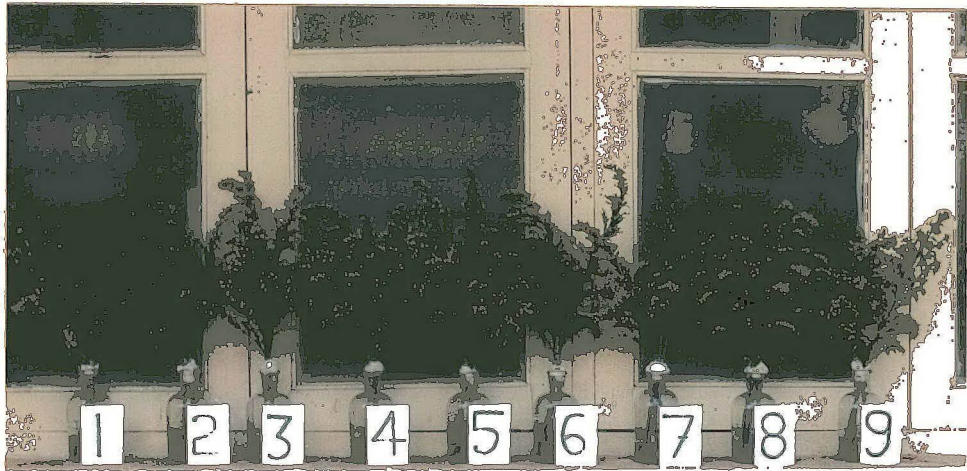


Plate 6. Vase life as influenced by chemicals

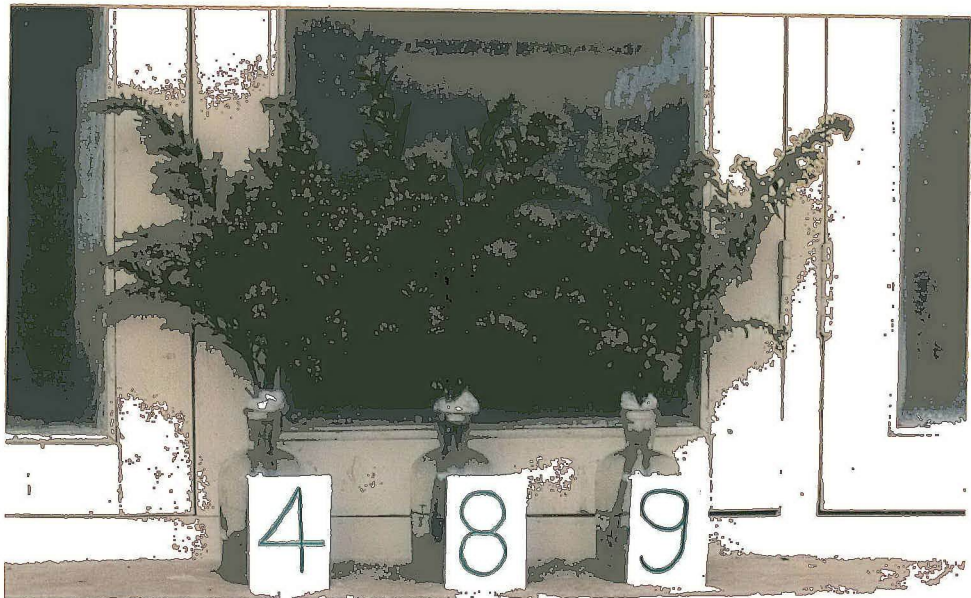


Plate 7. Golden rod flower stalks in best vase solutions having sucrose (2%) + Aluminium sulphate (100 ppm) i.e., T₈ and sucrose (2%) + Benzyl adenine (10 ppm) i.e., T₄ and distilled water (control) i.e., T₉

4.2.4 Water loss and uptake ratio

Golden red flower stalks held in solutions containing $\text{Al}_2(\text{SO}_4)_3$ at 100 ppm + two per cent sucrose and BA_6 at 10 ppm + two per cent sucrose had minimum water loss and uptake ratio of 1.062 and 1.073 respectively suggesting better water balance in their tissues during display period. Flower stalks held in distilled water (control) had the highest ratio (1.186) during display period.

4.2.5 Vase life

Flower stalks held in sucrose solutions having $\text{Al}_2(\text{SO}_4)_3$ and BA_6 had enhanced shelf life as compare to those held in distilled water. However, flower stalks held in solutions having $\text{Al}_2(\text{SO}_4)_3$ and BA_6 along with two per cent sucrose had highest vase life of 14.00 days and 13.33 days respectively and they are statistically on par with each other. The lowest vase life obtained with distilled water (7.66 days).

LEGEND

1. 6-Benzyl aminopurine @ 5 ppm
2. 6-Benzyl aminopurine @ 10 ppm
3. 6-Benzyl aminopurine @ 5 ppm + Sucrose 2%
4. 6-Benzyl aminopurine @ 10 ppm + Sucrose 2%
5. Aluminium sulphate @ 50 ppm
6. Aluminium sulphate @ 100 ppm
7. Aluminium sulphate @ 50 ppm + Sucrose 2%
8. Aluminium sulphate @ 100 ppm + Sucrose 2%
9. Distilled water (Control)

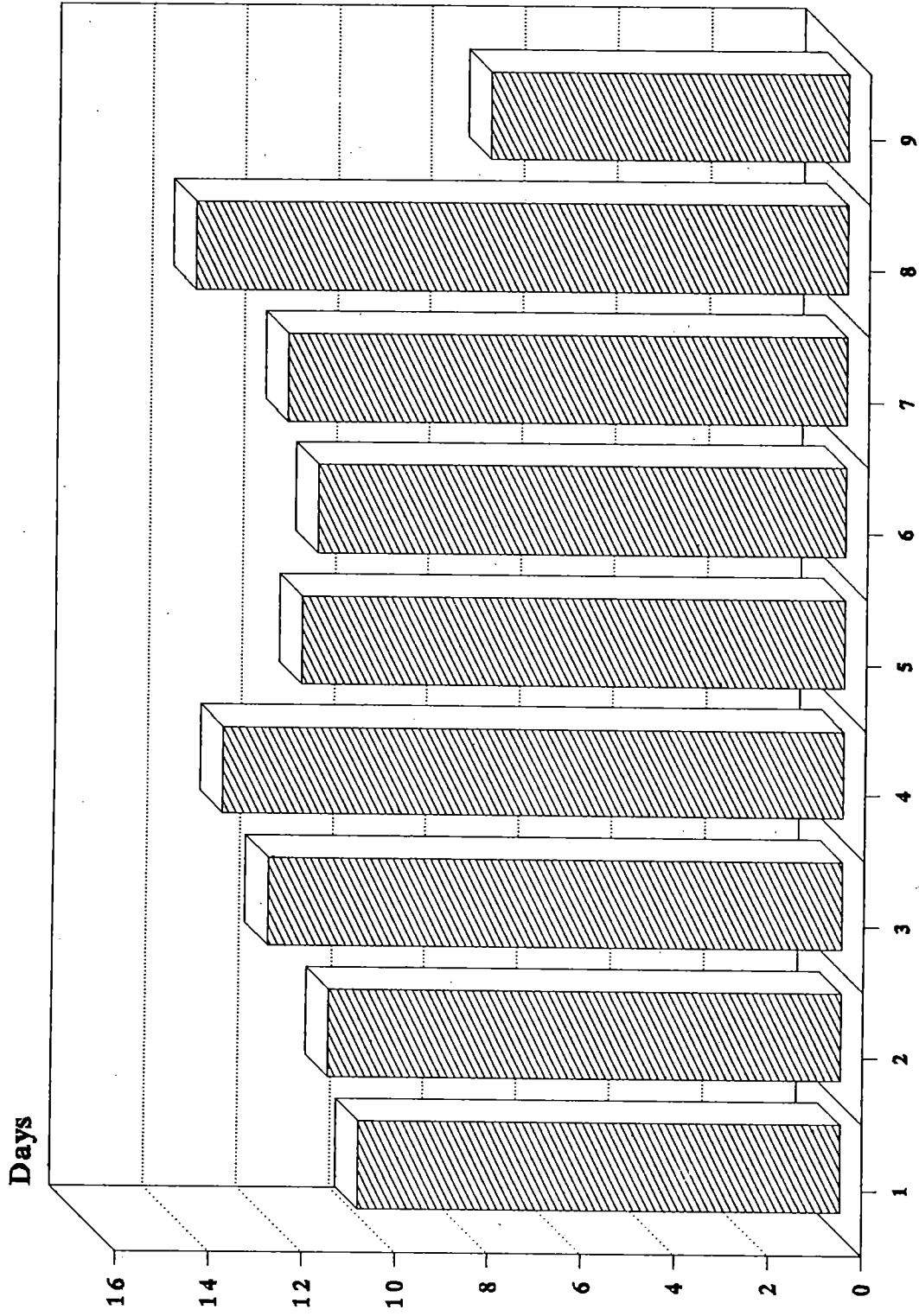


Fig. 7. Effect of chemicals on vase life of golden rod

DISCUSSION

V DISCUSSION

5.1 EXPERIMENT-I : EFFECT OF NITROGEN, PHOSPHOROUS AND POTASSIUM ON PLANT GROWTH, FLOWERING AND FLOWER PRODUCTION IN GOLDEN ROD

Judicious and balanced use of nutrients are known to influence the overall growth parameters, flower yield and quality in many flowering annuals. Whenever there is an interruption in plant nutrition even for a short period a negative effect on yield attributes may be noticed. Therefore, balanced supply of nutrients combined with appropriate cultural practices is important for obtaining higher yield and quality.

Importance of balanced nutrition and nutrient requirement in flowering annuals for a good growth and production of flowers has been recognised by many workers in ornamental flower crops (Tayama *et al.*, 1974; Arora and Saini, 1976; Nalawadi, 1982; Mantur, 1988; Mokashi, 1988 and Zile Singh *et al.*, 1996). While very little is known on the production technology of golden rod. An attempt has been made to investigate the response of golden rod to different levels of nitrogen, phosphorous and potassium on growth and flower production.

The results obtained from the investigation are discussed under the following headings to arrive at conclusion fo

the cultivation of golden rod to increase profitable higher flower yield.

5.1.1 Effect of nitrogen

The results obtained from the experiment indicated that application of nitrogen increased the flower stalk yield significantly from N_1 and N_2 level, which recorded 11.09 and 20.19 tonnes per hectare flower stalk yield. The difference in flower stalk yield due to nitrogen levels could be related to their weight of flower stalk and number of flower stalks per plant which showed significantly varying differences as that of flower stalk yield per hectare.

The difference in weight of flower stalk due to nitrogen levels observed may be attributed to the corresponding difference in yield components like length of flower stalk, length of rachis, number of spikelets per flower stalk. The flower yield per hectare was positively correlated with number of flower stalks per plant. This is in confirmity with research findings of Ramachandra (1982) and Mantur (1988) in China aster.

The difference in the flower stalk yield and yield components due to nitrogen levels could be related to the differences in plant growth characters.

The number of leaves, leaf area and total dry matter production per plant also increased with increase in nitrogen

levels from N_1 to N_2 . These findings of favourable effect of nitrogen in increasing the leaf area, number of leaves and total dry matter production are in conformity with the findings of Maheshwar (1977) in China aster, Ingawale (1979); Nalawadi (1982) and Dongre (1984) in marigold, Jana and Pal (1991) in Cosmos and Lodhi and Tiwari (1993) in Chrysanthemum, who suggested that these attributes to be the indices of yield and productivity.

Application of nitrogen had profound effect on plant height with increase in nitrogen level the plant height increased significantly at all the growth stages. Similar results in golden rod and dahlia regarding the increase in plant height with increasing level of nitrogen had reported by Ryagi (1994) and Zile Singh (1996).

Nitrogen application increased the number of days taken for flower initiation and time taken for 50 per cent flowering. The delayed flowering due to increased levels of nitrogen had been reported by Joiner and Smith (1962) in chrysanthemum, Penningsfeld (1973) in phlox, Words Worth and Butters (1973) and Singh Lodhi *et al.* (1990) in chrysanthemum and Amargeet Singh *et al.* (1996) in tuberose. The delay in reaching the flowering stage is mainly due to depression in the synthetic processes in plants because of prolonged vegetative phase and shortened reproductive cum maturation phases.

Application of nitrogen increased the total nitrogen uptake per hectare. This may be attributed to increased

availability of nitrogen at higher levels of nitrogen. These results are in line with research findings of Haby *et al.* (1982) in safflower; Sharanabasappa (1990) in helichrysum and Nalawadi (1988) in marigold, contrasting to present findings, Mokashi (1988) in gaillardia, observed increase N application did not comensurate with increased application of nitrogen.

With the increase in application of nitrogen the phosphorous uptake increased from P₁ and P₂. This may be attributed to increased availability of phosphorous with nitrogen. These results are in confirmity with the findings of Maheshwar (1977) in chinaaster; Heby *et al.* (1982) in safflower and Ramachandra (1982) in china aster.

As the nitrogen level increased, the total potassium uptake per hectare decreased significantly. This may be due to the antagonostic effect of nitrogen on potassium uptake. These results are in line with research findings of Mantur (1988) in china aster.

5.1.2 Effect of phosphorous

The flower stalk yield was maximum with phosphorous level P₂ (18.64 t/ha). The further increase of phosphorous to P₃ level reduced the flower stalk yield significantly.

The difference in flower yield due to phosphorous levels could be related to the differences in weight of flower stalk and number of flower stalk per plant. The differences in weight of flower stalk due to phosphorous level may be substituted to the

differences in yield components like length of the flower stalk, length of rachis and number of spikelets. The number of flower stalks per plant were found to be maximum with phosphorous at P_2 and further increase to P_3 reduced significantly. The number of flower stalks per plant and weight of the flower stalk positively correlated with flower yield per hectare. Similar increase in flower yield due to higher levels of phosphorous has been reported by Joiner (1967) in chrysanthemum; Winsor (1962) in carnation; Anuradha *et al.* (1990) in marigold; Lodhi and Tiwari (1993) in chrysanthemum; Amargeet Singh *et al.* (1996) in tuberose.

The difference in the flower yield and yield components due to phosphorous levels could be related to the differences in growth characters.

The plant height, number of leaves, leaf area and total dry ~~matter~~ production per plant were recorded maximum with phosphorous at P_2 , further increase to P_3 resulted in significantly reduction at all stages. These findings of favourable effect of phosphorous in increasing plant height, number of leaves, leaf area and dry matter production are in confirmity with research findings of Kumara (1987) in marigold, Ramachandra (1982) and Narayanagouda (1985) in china aster; Sigedar ~~et al.~~ (1991) in calendula and Zile Singh *et al.* (1996) in dahlia.

~~The number~~ of days taken for flowering and time taken for 50 per cent flowering was found to increase significantly

with increased application of phosphorous. This may be due to the fact that, the application of phosphorous might have increased the nitrogen uptake, which in turn might have delayed, the flowering. Similar delayed flowering due to higher phosphorous levels has been reported by Mantur (1988) in china aster and Amargeet Singh *et al.* (1996) in tuberose. Contrary to above finding Maheshwar (1977) in china aster and Singh Lodhi *et al.* (1990) in chrysanthemum observed early flowering with phosphorous levels.

The application of phosphorous at P₂ increased the total nitrogen uptake per hectare. This increased nitrogen uptake may be due to increased drymatter production at P₂ than P₁ and P₃. Similar findings of nitrogen uptake with phosphorous levels has been reported by Hiremath (1984) in sunflower; Maheshwar (1977) in china aster; Sharanabasappa (1990) in helichrysum.

The total phosphorous uptake increased significantly with every step increase in the phosphorous levels. This may be mainly attributed to increased availability and absorption of phosphorous from soil.

Application of phosphorous at P₂ recorded significantly more potassium uptake than at P₁ and P₃. This increased uptake of potassium with phosphorous at P₂ is mainly due to the higher dry matter accumulation. The increased uptake of potassium with phosphorous at P₂ may be attributed to more availability of potassium than at P₁ and P₃. Similar increase in

potassium uptake with phosphorous were reported by Maheshwar (1977) in china aster; Nalawadi (1982) in marigold and Sharanabasappa (1990) in helichrysum.

5.1.3 Effect of potassium

The flower stalk yield per hectare was found to be maximum with potassium application at K_1 (17.33 t/ha). The flower yield decreased with increasing level of potassium significantly.

The difference in flower stalk yield per hectare due to potassium level could be attributed to weight of flower stalk and number of flower stalks per plant. They showed similar difference as that of flower yield per hectare.

The difference in weight of flower stalk observed due to potassium may be attributed to the difference in the yield components like length of the flower stalk, length of rachis and number of spikelets per flower stalk. The length of the flower stalk was higher with potassium at K_1 compared to K_2 and K_3 . Flower stalk yield correlated positively with number of flower stalks per plant and weight of the flower stalk. Similar results of higher flower yield with lower level of potassium was recorded by Gilly (1974) in chrysanthemum; Tschernewa Dimowa (1976) and Mantur (1988) in chinaaster.

The difference in the flower stalk yield and yield components due to potassium levels were due to differences observed in growth parameters.

The plant height, number of leaves, leaf area and total dry matter production per plant decreased with increasing potassium levels at all the growth stages. The findings are in line with the results obtained by Pal (1981) in sunflower and Mantur (1988) in China aster.

With increase in level of potassium, total nitrogen uptake decreased significantly. This may be due to the decreased dry matter production with increased potassium levels. This also may be due to antagonistic effect of potassium on nitrogen uptake.

Application of potassium at K_2 recorded maximum total phosphorous uptake over K_1 and K_3 . This increase in P uptake due to potassium at K_2 level may be attributed to more dry matter production.

As the potassium level increased, the uptake of total potassium increased significantly. This increase in potassium uptake may be due to increased availability and absorption of potassium.

5.1.4 Interaction effect of N, P and K

Crop production and the resultant yield is a complex phenomenon interacted by several factors. In nature, it is difficult to grow plants in isolation. Variables acting on the plants often bring about different effects than when they are i

isolation. The synergism of their action is often taken advantage and should be considered in totality than individually.

It is interesting to be observe that golden rod responded significantly to the combination of factors than their individual effects. Flower stalk yield differed significantly while nutrients were supplied in combinations.

In the present study, the over all assessment of interaction effects on growth attributes and yield parameters indicates variation in the levels of nitrogen and phosphorous, while level of potassium in the nutrient combination varies between K_1 and K_2 .

However, among the growth attributes, plant height was highest with $N_2P_2K_1$. Number of leaves, leaf area, sucker production and total dry matter production per plant was maximum with $N_2P_2K_1$ in all the growth stages.

With respect to attributes at reproductive phase, the interaction effect $N_2P_1K_1$ and $N_2P_2K_2$ were the best with respect to maximum number of days taken for flower initiation and time taken for 50 per cent flowering respectively. While the combination $N_2P_2K_1$ found best as it yielded maximum length of flower stalk, length of rachis and maximum number of spikelets per flower stalk. Further, number of flower stalks per plant, per plot and per hectare were found maximum with $N_2P_2K_1$. Weight of flower stalk, flower stalk yield per plot and flower stalk yield per hectare were also found maximum with $N_2P_2K_1$.

The nutrient uptake studies with respect to nitrogen, phosphorous and potassium projected different set of combinations. The total nitrogen uptake was maximum with $N_2P_2K_1$ while total uptake of phosphorous and potassium was maximum with $N_2P_3K_1$ and $N_1P_2K_3$ respectively.

The critical analysis of plant growth parameters in relation to interaction effects of N, P and K indicated enhanced plant height at highest level of nitrogen along with P_2 and K_1 . This infact is the basis that differentiates vegetative and reproductive phases which intern is being evidently contrasted with respect to flower stalk yield. Since, in general, it is the nutrient combination level of N_2P_2 along with K_1 has proved to yield more than any other combinations, as highest level of phosphorous and potassium have tended to interfere to a great extent in plant metabolism. Since, the efficiency of leaves in the transfer of solar energy into ATP, required for the assimilation of photosynthetes depends considerably on the levels of K and P nutrition (Watanabe and Yoshida, 1970).

Further, similar results with respect to interaction effect of N and P in combination with K at different levels have been evidently proved by Boyd (1970), where there was depressed yields levels at higher levels of K nutrition in combination with optimum level of P. Similar results to those discussed earlier have been obtained by Mantur (1988).

These results are seen infact in practical farming on soils with high yielding potential when nutrients are not applied at not excessive level. Hence, interaction of N, P and K at optimum levels is a must to achieve highest possible yield on practically adoptable farming condition. Similar observations regarding interaction of N, P and K at optimal levels for getting higher yields were reported by Holliday (1963); Sharanabasappa (1990) in helichrysum; Parthiban and Khader (1991) in tuberose; Sigedar *et al.* (1991) in calendula; Mantur (1988) in china aster.

The economic analysis reveal that the combination of factors $N_2P_2K_1$ which yielded maximum flower stalk yield provided the maximum net returns (Rs. 52,835.00 per hectare).

Thus, the foregoing investigation reveal that golden rod with nutrient levels of 150 kg N, 100 kg P_2O_5 and 50 kg K_2O to obtain an economic yield.

5.2 EXPERIMENT-II : EFFECT OF CHEMICAL PRESERVATIVES ON VASE LIFE OF GOLDEN ROD

The cut flower is a more complex organ than seeds, fruits and most vegetables, since an inflorescence/flower is combined expression of many morphological units including sepals, petals, androecium, gynoecium and often leaves, which are complex in their own right and differ both morphologically and physiologically. Therefore, longevity of the cut flowers referred to as vase life, shelf life, display life, keeping quality

and lasting quality is often determined by the composition of the holding solution and the quality of the water. Infact, vase life represents the potential useful longevity of the flower at the final consumers home. Inspite of the great importance of vase life in determining the quality and consumer preference for flowers, breeders have given little attention to this characteristic (Sink, 1976). Therefore, efforts in the direction that promote quality and vase life of cut flowers by using preservative solutions was made to arrive at a best preservative that prolongs vase life of cut golden rod flowers.

The results obtained on the vase life of golden rod flowers indicated superiority of all chemical in prolonging the keeping quality of cut flowers over distilled water. The increased vase life of flowers in the chemicals could be related to increased weight of flower stalks in the initial stages and later maintaining the fresh weight for longer period and due to increased uptake of preservative solutions having benzyl adenine and aluminium sulphate, used either alone or in combination with sucrose.

Benzyl adenine significantly increase the vase life of golden rod flower stalks. Increased vase life by Cytokinins (BA_6) when used at concentration varying from 10 to 100 ppm in holding solution maintains low levels of ethylene production, delay the decline in flower quality, thus extends the vase life of flowers (Cook *et al.*, 1985). Improvement in vasselife due to effect of BA_6 has been reported in carnation (Eisinger, 1977;

Mayak and Kofranek, 1976) and in anthurium (Shirakawa *et al.*, 1964). In the present investigation, benzyladenine in combination with two per cent sucrose enhanced the vase life more than benzyl adenine alone. Similar, enhanced effect of sucrose on cytokinins in delaying senescence of flowers and reduced effect of ethylene, there by increasing the vase life of the flowers (Mayak and Dilley, 1976) and in gladiolus (Hwang and Kim, 1995).

Similarly, aluminium sulphate significantly influenced the vase life of golden rod flower stalks. Aluminium sulphate in preservative formulation reduces transpiration, lowers the pH of petals and stabilizes the anthocyanin. It also reduces the bacterial growth by acidifying the holding water and improves the water uptake (Halevy and Mayak, 1979). Aluminium sulphate increased the vase life with an increased fresh weight in cut roses (Stringter, 1978). Slow release chlorine compounds maintain a low count of bacteria in cut asters, gladioli and carnations. In the present investigation, aluminium sulphate extended the vase life of golden rod flower stalks. Similar enhanced vase life has been observed in calendula (Shobha and Narayana Gowda, 1992), in roses (Dias, 1994) and in tuberose (Mukhopadhyay, 1980). Vase life of golden rod flower stalks increased due to interaction of sucrose and aluminium sulphate. Similar improvement in vase life due to combined effect of aluminium sulphate and sucrose has been reported in gladiolus (Gowda and Gowda, 1990), Rose (Ahn and Um, 1991 and Barman *et al.*, 1996) and in golden rod (Patil, 1995).

Improved water balance and osmotic potential observed with sucrose (Kofranek *et al.*, 1975). Supplying cut flowers with exogenous sugar maintains the respirable substrates in the flowers (Lukaszewska, 1981) and encourages protein synthesis (Paulin, 1986). Sucrose in vase solution is found to increase the vase life of gladiolus (Sangamma, 1993) and tuberose (Balakrishna, 1987 and Reddy, 1993).

FUTURE LINE OF WORK

In the light of outcome gained with the investigation, the following future line of work is suggested.

1. Since golden rod is a long duration crop, studies on split application of nutrients may be tried.
2. As there was increased response for higher levels of nitrogen i.e., 150 kg per hectare still higher doses may be tried.
3. Studies on water requirement.

SUMMARY

VI SUMMARY

The results of the investigation carried on the "Studies on nutrition management and vase life of golden rod (*Solidago canadensis* L.) at the Kittur Rani Channamma College of Horticulture, Arabhavi, University of Agricultural Sciences, Dharwad during 1996-97 are summarised in this chapter.

6.1 EXPERIMENT-I : EFFECT OF NITROGEN, PHOSPHOROUS AND POTASSIUM ON PLANT GROWTH, FLOWERING AND FLOWER PRODUCTION IN GOLDEN ROD

1. The plant height and number of leaves were significantly increased at all the three crop growth stages due to application of nitrogen, phosphorous and potassium. Maximum plant height and number of leaves recorded (62.30 cm and 83.58 leaves/plant, respectively) with nutrient combination of N₂ (150 kg/ha), P₂ (100 kg/ha) and K₁ (50 kg/ha).
2. Significantly more sucker production (7.48/plant) was recorded with N₂ (150 kg/ha), P₂ (100 kg/ha) and K₁ (50 kg/ha) combination at harvest.
3. Significantly higher dry weight per plant recorded with nitrogen at (150 kg/ha), P₂ (100 kg/ha), but potassium effect was found to be non-significant. However, nutrient

combination of $N_2P_2K_1$ (150:100:50 kg/ha) produced higher dry matter (21.22 g) per plant.

4. The maximum leaf area ($10.77 \text{ dm}^2/\text{plant}$) was recorded with treatment combination of $N_2P_2K_1$ (150:100:50 kg NPK/ha).
5. Application of nitrogen and phosphorous delay both number of days taken for flower initiation and time taken for 50 per cent flowering, but potassium in its individual capacity found to be non-significant. The maximum number of days taken for flower initiation and time taken for 50 per cent flowering (64.66 days and 76.66 days, respectively) recorded with treatment combination $N_2P_1K_1$ (150:50:50 kg/ha) and $N_2P_2K_2$ (150:100:100 kg/ha) respectively.
6. The maximum length of the flower stalk (48.93 cm), length of the rachis (33.75 cm) and number of spikelets (41.80/flower stalk) were recorded with nutrient combination $N_2P_2K_1$ (150:100:50 kg/ha).
7. Significantly higher number of flower stalks per plant (6.15), per plot (246.00) and per hectare (682.66 thousands) obtained with nutrient combination N_2 (150 kg/ha), P_2 (100 kg/ha) and K_1 (50 kg/ha).
8. The maximum weight of flower stalk (40.92 g), flower stalk yield (10.06 kg) per plot and flower stalk yield per hectare (27.95 t/ha) were recorded with nitrogen, phosphorous and

potassium at N_2 (150 kg/ha), P_2 (100 kg/ha) and K_2O (50 kg/ha) individually and in combination.

9. The total nitrogen uptake was recorded maximum with nitrogen at N_2 (150 kg/ha), phosphorous at P_2 (100 kg/ha) and potassium at K_1 (50 kg/ha) individually and with the combination at same levels.
10. The nitrogen, phosphorous and potassium at N_2 (150 kg/ha), P_3 (150 kg/ha) and K_2 (100 kg/ha) individually recorded maximum total phosphorous uptake and same levels in combination was found to be the best.
11. The total potassium uptake was maximum with nitrogen, phosphorous and potassium individually at N_1 (100 kg/ha), P_2 (100 kg/ha) and K_3 (150 kg/ha) and with the combination at same levels.
12. The significantly positive correlation was noticed between flower stalk yield per hectare and plant height, number of leaves, sucker production per plant, total dry weight per plant, number of flower stalks per plant, weight of the flower stalk, total nitrogen uptake and total phosphorous uptake and significantly negative correlation was observed between flower stalk yield and total potassium uptake.
13. The economics of returns obtained from cultivation of golden rod flower production indicated the realisation of maximum net profit (Rs. 52,835/ha) with the nutrient combination $N_2P_2K_1$ (150:100:50 kg/ha) and minimum net

profit (Rs. 24,160) obtained with nutrient combination $N_1P_1K_1$ (100:50:50 kg/ha).

6.2 EXPERIMENT-II : EFFECT OF CHEMICALS ON VASE LIFE OF GOLDEN ROD (*Solidago canadensis* L.)

The following are the salient findings of the vase life studies.

1. Significantly higher fresh weight of flower stalks was recorded with chemical over distilled water at all the days. Among the chemicals in holding solution BA_6 10 ppm with two per cent sucrose and $Al_2(SO_4)_3$ at 100 ppm with two per cent sucrose recorded significantly higher fresh weights at eighth day after keeping in chemical preservative solutions.
2. The water uptake and loss by flower stalks differed significantly with different chemicals and water uptake and loss were more with $Al_2(SO_4)_3$ at 100 ppm along with two per cent sucrose and it was closely followed by preservative containing BA_6 at 10 ppm with two per cent sucrose.
3. Water loss and uptake ratio was minimum with chemical containing $Al_2(SO_4)_3$ at 100 ppm with two per cent sucrose and it was closely followed by preservative containing BA_6 at 10 ppm with two per cent sucrose.

4. All the chemicals used in vase life studies increased the vase life significantly over distilled water. Among different chemicals, $\text{Al}_2 (\text{SO}_4)_3$ at 100 ppm along with two per cent sucrose closely followed by BA_6 at 10 ppm along with two per cent sucrose were found to be the best for prolonging the vase life of golden rod.

REFERENCES

VII REFERENCES

- *ACCATI, E.G. AND SULIS, S., 1980, Experimental results on the possibilities of early harvesting of mediterranean carnations and their cold storage. *Analele Institutului de Experimentale Pentru Floricotura*, 8: 15-27.
- *AHN, K.Y. AND UM, S.K., 1991, A study of vase-life extension of cut roses (*Rosa hybrida* L. cv. Marina). II. Effect of vase water management and addition of sucrose and aluminium sulfate. *Journal of Korean Society for Horticultural Science*, 32: 497-505.
- AMARJEET SINGH, GODARA, N.R. AND ASHOK KUMAR, 1996, Effect of NPK on flowering and flower quality of tuberose (*Polianthes tuberosa* L.) Cv. Single. *Haryana Agricultural University Journal of Research*, 26: 43-49.
- ANURADHA, K., PAMPAPATHY, K. AND NARAYANA, N., 1990, Effect of nitrogen and phosphorous on flowering, yield and quality of marigold. *Indian Journal of Horticulture*, 47: 353-357.
- ARORA, J.S. AND SAINI, S.S., 1976, A note on the effects of different levels of nitrogen and plant densities on flower production of aster. *Haryana Journal of Horticultural Sciences*, 5: 196-197.

- BALAKRISHNA, H.A., 1987, Post harvest physiology of tuberose (*Polianthes tuberosa* L.) as influenced by metal salts and sucrose. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- *BARENDSE, L.V.J., 1979, A alsmeer research station introduces a new pre-treatment chemical (for cut flowers). *Vokblad Voor de Bloenisterji*, 34: 38-39.
- BARMAN, D., BANIK, A.K. AND DUTTA, P., 1996, Effect of aluminium sulphate and sucrose on vase life of chrysanthemum Recent Var. Chandrama. *Orissa Journal of Horticulture*, 20: 39-41.
- BASEMER, S.T. AND HASEK, R.F., 1973, Opening of improved 'white sim' carnation buds, fresh cut and stored. *Flower and nursery report*, November, pp. 8-9.
- BOOTH, T., 1957, An Encyclopedia of Annual and Biennial Garden plants. *Faber and Faber limited*, London, pp. 203-204.
- BOSE, T.K. AND DAS, S.M., 1966, Studies on the nutrition of ornamental plants. The effect of nitrogen, phosphorous and potassium on growth and flowering of Dianthus, cosmos, coreopsis. *Indian Journal of Horticulture*, 25: 76-81.

- BOYD, D.A., 1970, Some recent ideas on fertilizer response curves : Role of fertilization in the Intensification of agricultural production. *International Potash Institute* Berne. pp. 461-473.
- COOK, D., RASCHE, M. AND EISINGER, W., 1985, Regulation of ethylene biosynthesis and action in carnation flower senescence by cytokinins. *Journal of American Society for Horticultural Science*, 110: 24-27.
- COORTS, G.D., 1973, Internal metabolic changes in cut flowers. *Hortscience*, 8: 195-198.
- COORTS, G.D., GARTNER, J.B. AND Mc COULUM, J.P., 1973, Effect of senescence and preservatives on respiration in cut flowers of *Rosa hybrida* 'Velvet times'. *Proceedings of the American Society for Horticultural Science*, 86: 779-790.
- DHOTE, G.S. AND BALLAL, D.K., 1964, Effect of N, P and K on growth and composition of safflower. *Indian Oilseeds Journal*, 8: 17-22.
- DIAS, S.M.F., 1994, Performance of elite rose varieties at different population levels for cut flower production under transitional tract of northern Karnataka. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.

- DONGRE, G.N., 1984, Standardisation of Horticultural practices for commercial production of marigold (*Tagetes erecta* L.) *M.Sc. (Hort.) Thesis* University of Agricultural Sciences, Bangalore.
- DOORN, W.G., VAN, WITTE, Y. DE AND PERIK, R.R.J., 1990, Effect of antimicrobial compounds on the number of bacteria in stems of the cut rose flowers. *Journal of Applied Bacteriology*, 68: 117-122.
- EISINGER, W., 1977, Role of cytokinins in carnation flower senescence. *Plant Physiology*, 59: 707-709.
- ELENGOVAN, R., 1975, Studies on the influence of nitrogen, phosphorous and potassium nutrition on nutrient uptake, growth, flower production and seed yield of *Petunia hybrida* vilm. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- EL-GAMASSY, A.M., HUSSEIN, M.F. AND EL-BAKLY, S.A., 1965, Effect of planting dates and fertilization levels on seed production of some summer flowering annuals, *Annals of Agricultural Science* (cairo), 10: 361-374.
- *GILLY, G., 1974, The fertilization of chrysanthemum for cut flower production. *Comptes Rendus. Academic d'Agriculture de France*, 12: 983-987.

- GOWDA, J.V.N., 1987, Effect of chemicals on the keeping quality of Rose cv. Montezuma. *The Indian Rose Annual*, I: 148-150.
- GOWDA, J.V.N. AND GOWDA, V.N., 1990, Effect of calcium, aluminium and sucrose on vase life of gladiolus. *Crop Research*, 3: 150-166.
- GOWDA, J.V.N., JACOB, S. AND HUDDAR, A.G., 1991, Effect of N, P and K on growth and flowering of tuberose (*Polianthes tuberosa* Linn.). cv. Double. *Indian Perfumer*, 35: 100-101.
- GRUNES, D.L., 1959, Effect of nitrogen on the availability of soil and fertilizer phosphorous to plants. *Advances in Agronomy*, 11: 369-396.
- HABY, V.A., BLACK, A.L., BERGMAN, J.W. AND LARSON, R.A., 1982, Nitrogen fertilizer requirements in irrigated safflower in the Northern Great Plains. *Agronomy Journal*, 74: 331-335.
- HALEVY, A.H. AND MAYAK, S., 1979, Senescence and post harvest physiology of cut flowers. Part I. In *Horticultural Reviews*. Ed. Janick, J. U.S.A., pp. 204-236.

- HIREMATH, B.R., 1984, Response of sunflower (*Helianthus annus* L.) genotypes to different levels of nitrogen and phosphorous under rainfed conditions. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- *HOLLIDAY, R., 1963, Effects of fertilization upon potato yields and quality. In *The growth of the potato*, Ed. Ivins, J.D. and Milthorpe, F.L. Butter Worths, London, pp. 248-264.
- *HWANG, M.J. AND KIM, K.S., 1995, Post harvest physiology and prolonging of vase life of cut gladiolus. *Journal of the Korean Society for Horticultural Science*, 18: 411-419.
- INGAWALE, R.B., 1979, Studies on the response of African Marigold (*Tagetes erecta* L.) to different levels of nitrogen and phosphorous on the growth and flower production. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- JACKSON, M.L., 1967, *Soil chemical analysis* Pub. Prentice Hall of India Pvt. Ltd., New Delhi, p. 183.
- JANA, B.K. AND PAL, A., 1991, Response of nitrogen and phosphorous on growth, flowering and seed yield of cosmos (*Cosmos sulphureus*) Cv. Super Sunset. *Indian Horticulture*, 35: 113-118.
- JOHNSON, R.E., 1967, Comparison of methods for estimating cotton leaf area. *Agronomy Journal*, 60: 1894-1895.

- JOINER, J.N., 1967, Effect of P, K and Mg levels on growth, yield and chemical composition of *Chrysanthemum morifolium* Indianapolis white. *Proceedings of the American Society for Horticultural Science*, 90: 389-396.
- JOINER, J.N. AND SMITH, T.C., 1962, Effect of N and K levels on the growth, flowering responses and foliar composition of *Chrysanthemum morifolium* Blue chip. *Proceedings of the American Society for Horticultural Science*, 80: 571-580.
- *KAZIMIVORA, R.N., 1975, Certain characteristics of chrysanthemum mineral nutrition, *Byulleten Glavnogo Botanicheskogo Sada* (Leningrad), 3: 74-77.
- KHIMANI, R.A., 1991, Standardization of production technology of gaillardia (*Gaillardia pulchella* var *Picta* Fouger). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.
- KOFRANEK, A.M., KOHIL, H.C. AND KUBOTA, T., 1975; Stabilised chlorine compound as a vase water additive. *Flower and nursery report*, California University, U.S.A., Jan.-Feb., pp. 5-7.
- KUMARA, K.P., 1987, Studies on the effect of nutrients and growth retardants on growth, flowering and quality of African Marigold (*Tagetes erecta* Linn.), *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.

- *LEE, J.S. AND KIM, D.S., 1995, Effect of plant growth regulators on change in petal colour in cut flower of *Rosa hybrids* L. cv. Red Sandra. *Journal of Korean Society for Horticultural Science*, 36: 107-112.
- LODHI, A.K.S. AND TIWARI, G.N., 1993, Nutritional requirement of chrysanthemum under field condition. *Fertilizer News*, 38: 39-45.
- *LUKASZEWSKA, A.J., 1981, Effect of selected chemical substances on vase life and quality of gladioli, *Institute of Produkji Agroduicezes SGGCO-AR*, Warsaw, Poland, pp. 24-29.
- MAHESHWAR, D.L., 1977, Influence of nitrogen and phosphorous on growth and flower production of china aster (*Callistephus chinensis* (L.) Ness.). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- *MANTROVA, E.Z., MIKITIMA, G.N. AND ZDASYAK, V., 1976, Some characteristics of the mineral nutrition of green house carnations. *Canadian Horticulture and Home Magazine*, 67.
- MANTUR, S.M., 1988, Studies on nutrition, growth regulators and soil salinity on flower and seed production of China aster (*Callistephus chinensis* Nees) Cv. Ostrich Plume mixed. *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad.

- MAYAK, S. AND DILLEY, D.R., 1976, Effect of sucrose on response of cut carnation to kinetin, ethylene and abscissic acid. *Journal of American Society for Horticultural Science*, 101: 583-585.
- MAYAK, S. AND KOFRANEK, A., 1976, Altering the sensitivity of carnation flowers (*Dianthus caryophyllus* L.) to ethylene. *Journal of American Society for Horticultural Sciences*, 101: 503-506.
- MENGEL, K., 1969, Factors limiting maximum yield. Transition from extension to intensive agriculture with fertilizers. *International Potash Institute*, Berne, Switzerland, pp. 27-33.
- MOKASHI, V.A., 1988, Effect of plant density and levels of nitrogen and phosphorous on growth and flower yield of gaillardia (*Gaillardia pulchella* Foug.)Cv. Kanabargi local. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- MUKHOPADHYAY, T.P., 1980, Effect of chemicals on floral development and vase life of tuberose (*Polianthes tuberosa*). *South Indian Horticulture*, 28: 281-284.
- NALAWADI, U.G., 1982, Nutrition studies in some varieties of marigold (*Tagetes erecta* L.). *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore.

- NARAYANAGOWDA, J.V., 1985, Investigations on horticultural practices in the production of China aster (*Callistephus chinensis* Nees) Cv. Vick's Branching. *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore.
- NOGGLE, G. ROY. AND FRITZ, J. GEORGE, 1979, *Introductory Plant Physiology*, Prentice Hall of India Pvt. Ltd., New Delhi, pp. 216.
- PAL, M., 1981, Effect of soil moisture regimes and fertility levels on yield and quality of sunflower varieties. *Indian Journal of Agriculture Research*, 15: 74-78.
- PANSE, V.G. AND SUKHATME, B.V., 1967, Statistical methods for Agricultural workers. ICAR, Publ. New Delhi, pp. 100-109 and 152-161.
- PARTHIBAN, S. AND KHADER, M.A., 1991, Effect of N, P and K on yield components and yield of tuberose. *South Indian Horticulture*, 39: 363-367.
- PATIL, S.R., 1995, Effect of growth substances and chemicals on growth, development and shelf life of golden rod (*Solidago canadensis* L.). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.
- *PAULIN, A., 1986, Physiology of Senescence of flowers. *Academic de Agriculture de France*, 71: 1201-1210.

- *PENNINGSFELD, F., 1973, Soil and fertilizer problems in the cultivation of perennials. *International Sdiensst weinenstphar-II*, p. 18.
- RAMACHANDRA, C., 1982, Studies on the effect of dates of planting with different levels of nitrogen and phosphorous on (*Callistephus chinensis* Nees.) CV. Ostrich plume. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore.
- RAMAN, K.R., SEETHAMANI, B., AHMEDSHAH, H. AND SHANMUGAN, A., 1967, Recent advances in plant nutrition, studies on nutrient and water requirements of annual chrysanthemum (*Chrysanthemum morifolium*). Paper presented in *International Tropical and Sub-tropical Horticulture* held at Bangalore.
- REDDY, B.S., 1993, Pre and post-harvest management in tuberose (*Polianthes tuberosa* L.) Cv. Double. *Ph.D. Thesis*, Choudhary Charan Singh Haryana Agricultural University, Haryana.
- *ROBER, R., 1971, The influence of N-nutrition on flower formation and development in chrysanthemum. *Gartenbau wisaen schaft*, 36: 189-200.

- RYAGI, Y.H., 1994, Effect of plant density and nitrogen on flower production and quality of golden rod (*Solidago canadensis* L.). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.
- SANGAMMA, 1993, Effect of preservatives on vase life of rose var. Happiness. *Golden Jubilee Symposium Horticulture Research Changing Scenario*, Bangalore, pp. 367.
- SHARANABASAPPA, H., 1990, Studies on the effect of nitrogen and phosphorous on growth and flower production of everlasting flower (*Helichrysum bracteatum* Andr.) Cv. Tall double mixed. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.
- SHIRAKAWA, T., DEDOLPH, P.R. AND WATSON, D.P., 1964, N-6-Benzyladenine, effects on chilling injury, respiration and keeping quality of *Anthurium andreanum*. *Proceedings of the American Society for Horticultural Science*, 85: 642-646.
- SHOBHA, K.S. AND NARAYANA GOWDA, J.V.N., 1992, Effect of pulsing and aluminium sulphate on vaselife of calendula flowers (*Calendula officinalis*). *National Seminar on commercial floriculture in India : Present and Potential*, Bangalore, pp. 81.

- SIGEDAR, P.D., ANSERWADEKAR, K.W. AND RODGE, B.M., 1991, Effect of different levels of nitrogen, phosphorous and potassium on growth and yield of *Calendula officinalis* Linn. *South Indian Horticulture*, 39: 308-311.
- SINGH LODHI, A.K., TEWARI, G.N. AND PATHAK, R.K., 1990, Effect of various levels of nitrogen and phosphorous on flowering of chrysanthemum (*Chrysanthemum morifolium* Ram.). *Horticultural Journal*, 3: 56-58.
- SINK, K.C., 1976, First International Symposium Floriculture, Plant Breeding and Genetics (Ed.). *Acta Horticulturae*, pp. 63.
- *SIRCAR, S.M. AND SEN, S.K., 1941, The behaviour of phosphorous in alkaline irrigated soil in washington. *Proceedings of Soil Science Society of America*, 13: 205-212.
- *STRINGTER, H.C.M. de, 1978, The vase life of roses. *Bedrifsontwikkeling*, 10: 934-936.
- *TAYAMA, H.K., KIPLINGER, D.C., WILLIAM, M.G., GEORGE, L.R., POWELL, C.C., PARTYKA, R.C. AND LINDGQUIST, R.K., 1974, *Tips on growing ornamentals and vegetable bedding plants*. Ohio state University Co-operating with the U.S.D.A. Columbus, pp. 1-21.

- *TSCHERNEWA DIMOWA, S.S., 1976, Investigations on the influence of major nutrients and the time of application of fertilizers on yield of China aster. *Archiv fuer Gartenbau*, 24: 335-349.
- WATANABE, H. AND YOSHIDA, S., 1970, Effect of nitrogen, phosphorus and potassium on phosphorylation in rice in relation to the photosynthetic rate of single leaves. *Soil Science and Plant Nutrition*, 16: 163-166.
- *WINSOR, G.W., 1962, Carnations like liberal NPK progress report on nutrition trials at the G.C.R.L. *Grower*, 58: 309-334.
- WITWER, S.H., 1969, Regulation of phosphorous nutrition of horticulture crops. In : Symposium on the role of phosphorous in plant growth, *Hortscience*, 4: 309-324.
- *WORDSWORTH, G.A. AND BUTTERS, R.C., 1973, The nutrition of A.Y.R. Spray Chrysanthemum in loamless media. In Colloquium proceedings. *The Nutrition of Protected Crops*, 18: 202-210.
- YOSHIDA, S., 1972, Physical aspects of grain yield. *Annal Review of Plant Physiology*, 23: 437-464.
- ZILE SINGH, A.K., GUPTA AND GOYAL, R.K., 1996, Effect of NPK on growth and flowering of *Dahlia variabilis* Cv. Powder puff. *Haryana Journal of Horticultural Sciences*, 25: 4-8

APPENDICES

Appendix I. Monthly Meteorological data for the year 1996-97 and the past 10 years (1985-95) as recorded at the meteorological observatory, Agricultural Research Station, Arabhavi

Months	Rainfall (mm)			Temperature (°C)			Relative humidity (%)				
	1996-97	1985-95	1996-97	Mean Maximum		1996-97	Mean Minimum		1985-95	1996-97	1985-95
				1985-95	1996-97		1985-95	1996-97			
April	15.2	18.8	38.0	37.9	17.4	20.1	50.0	51.5			
May	50.0	68.5	34.0	34.1	19.5	21.1	56.5	55.8			
June	21.5	56.8	30.1	29.8	20.5	20.1	66.4	65.0			
July	54.3	63.8	31.8	27.1	22.5	19.1	73.2	75.0			
August	42.0	42.8	34.4	27.1	20.9	20.1	83.5	79.0			
September	131.6	151.5	29.6	28.9	20.5	18.9	77.6	73.0			
October	185.8	123.4	28.5	27.1	18.3	19.1	73.3	68.0			
November	15.4	31.6	28.4	29.1	15.6	19.8	63.0	66.0			
December	-	8.8	25.7	28.0	13.5	13.9	65.5	61.0			
January	-	-	26.9	28.6	12.2	14.0	68.0	65.5			
February	-	-	30.6	30.6	14.1	15.1	59.0	53.5			
March	-	-	31.7	35.1	17.5	19.1	53.7	55.1			

Appendix II. Physical and chemical properties of soil from experimental site

Sl. No.	Particulars	Value obtained
<u>A. Physical properties</u>		
	Clay (%)	58.86
	Silt (%)	15.62
	Sand (%)	25.33
<u>B. Chemical properties</u>		
1.	Available nitrogen (kg/ha)	219
2.	Available P ₂ O ₅ (kg/ha)	37.5
3.	Available K ₂ O (kg/ha)	338
4.	pH	8.1

Appendix III. Details of cost of cultivation per hectare (Rs.)

	N ₁ P ₁ K ₁	N ₁ P ₁ K ₂	N ₁ P ₁ K ₃	N ₁ P ₂ K ₁	N ₁ P ₂ K ₂	N ₁ P ₂ K ₃	N ₁ P ₃ K ₁	N ₁ P ₃ K ₂	N ₁ P ₃ K ₃
1. Land preparation (phoughing + harrowing)	1800	1800	1800	1800	1800	1800	1800	1800	1800
2. Cost of plant material	1000	1000	1000	1000	1000	1000	1000	1000	1000
3. Transplanting and ferti- lizer application	885	885	885	885	885	885	885	885	885
4. Fertilizer cost	695	880	1065	839	1024	1209	983	1168	1353
5. Intercultivation and weeding	3260	3260	3260	3260	3260	3260	3260	3260	3260
6. Irrigation	1250	1250	1250	1250	1250	1250	1250	1250	1250
7. Harvesting	2750	2750	2750	2750	2750	2750	2750	2750	2750
8. Transportation and marketing charges	3200	3200	3200	3200	3200	3200	3200	3200	3200
9. Land Rent	500	500	500	500	500	500	500	500	500
10. Total cost	15340	15525	15710	15484	15669	15854	15628	15813	15998
11. Gross Returns	39500	39000	38000	48200	46700	44600	44200	42400	40900
12. Net Returns	24160	23475	22290	32716	31031	28746	28572	26587	24902

Appendix IV. Details of cost of cultivation per hectare (Rs.)

	N ₂ P ₁ K ₁	N ₂ P ₁ K ₂	N ₂ P ₁ K ₃	N ₂ P ₂ K ₁	N ₂ P ₂ K ₂	N ₂ P ₂ K ₃	N ₂ P ₃ K ₁	N ₂ P ₃ K ₂	N ₂ P ₃ K ₃
1. Land preparation (ploughing + harrowing)	1800	1800	1800	1800	1800	1800	1800	1800	1800
2. Cost of plant material	1000	1000	1000	1000	1000	1000	1000	1000	1000
3. Transplanting and fertilizer application	885	885	885	885	885	885	885	885	885
4. Fertilizer cost	878	1063	1248	1020	1207	1392	1166	1351	1536
5. Intercultivation and weeding	3260	3260	3260	3260	3260	3260	3260	3260	3260
6. Irrigation	1250	1250	1250	1250	1250	1250	1250	1250	1250
7. Harvesting	2750	2750	2750	2750	2750	2750	2750	2750	2750
8. Transportation and marketing charges	3200	3200	3200	3200	3200	3200	3200	3200	3200
9. Land Rent	500	500	500	500	500	500	500	500	500
10. Total cost	15523	15708	15873	15665	15852	16037	15811	15996	16181
11. Gross Returns	55200	52200	48700	68500	61200	58400	58000	55300	54600
12. Net Returns	39677	36492	32807	52835	45348	42363	42189	39304	38419

ಕೆ.ಸಿ. ವಿದ್ಯಾನಿಲಯ
ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ಗಣಕಯಂತ್ರ
ಗಾ.ಕೆ.ವಿ.ಲೆ., ಬೆಂಗಳೂರು-65

19 AUG 1998

ಅನುವೃದ್ಧಿ ಸಂ. **Th. 4902**

ಪ. ಸಂ.