

**EFFECT OF NITROGEN LEVELS AND CERTAIN PLANT GROWTH
REGULATORS ON GROWTH AND YIELD OF BANANA
CV. NEY POOVAN (AB)**

*Thesis submitted in part fulfilment of the requirements for the degree of
MASTER OF SCIENCE (AGRICULTURE) in CROP PHYSIOLOGY
to the Tamil Nadu Agricultural University, Coimbatore – 641 003.*

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COIMBATORE – 641 003.**

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CERTIFICATE

This is to certify that the thesis entitled “**EFFECT OF NITROGEN LEVELS AND CERTAIN PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF BANANA CV. NEY POOVAN (AB)**” submitted in part fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **CROP PHYSIOLOGY** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Ms. C. TAMILSELVI** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place : Coimbatore

(Dr. U. BANGARUSAMY)

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External Examiner

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ABSTRACT

EFFECT OF NITROGEN LEVELS AND CERTAIN PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF BANANA CV. NEY POOVAN (AB)

By

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Degree : **Master of Science (Agriculture) in Crop Physiology**

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Studies were carried out to understand the effects of certain plant growth regulators under different nitrogen levels on growth, physiological and biochemical changes in relation to yield improvement of banana cv. Ney Poovan. Foliar spray of salicylic acid 100 ppm, mepiquat chloride 500 ppm, chlormequat chloride 1000 ppm, nitrobenzene 50 ppm, benzyl adenine 20 ppm and 25 ppm of 2, 4-D at 3rd, 5th and 7th month after planting were given and compared with untreated control. In banana, 200 g N plant⁻¹ with foliar spray of two per cent urea at 3,5 and 7th month after planting enhanced various growth characters and most of physiological parameters. Among the different growth regulator treatments, salicylic acid 100 ppm significantly increased the morphological traits, such as, pseudostem height and girth, and functional leaf number and area. However, high pseudostem girths were recorded in growth retardant treated plants which were with reduced pseudostem heights.

The salicylic acid treatment significantly increased chlorophyll *a*, *b* and total chlorophyll contents among the growth regulators. Soluble protein content and nitrate reductase activity were also high in salicylic acid treated plants. Salicylic acid treated leaves showed high stomatal resistance with low transpiration. The treatment also enhanced leaf nitrogen, phosphorous and potassium contents. However, chlorophyll fluorescence and chlorophyll stability index were found high in benzyl adenine treated leaves. Benzyl adenine came close to salicylic acid treatment in many of the other parameters.

The yield components were favourably influenced by higher level of N application. Soil application of 200 g N plant⁻¹ and giving two per cent urea spray on 3rd, 5th, and 7th month after planting distinctly enhanced all the yield components.

Salicylic acid spray at 100 ppm improved the number of hands, fingers and finger size. Benzyl adenine at 20 ppm spray also was found beneficial in increasing yield components. More number of fingers per bunch were observed in benzyl adenine treatment. With maximum fruit weight, salicylic acid spray surpassed benzyl adenine by recording maximum bunch weight of 12.58 kg (13.9 % increase over control), while benzyl adenine recorded 12.52 kg (13.4 % increase).

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ABBREVIATIONS USED

| | |
|----------|----------------------------|
| CCC | - Cycocel |
| MC | - Mepiquat Chloride |
| NB | - Nitrobenzene |
| SA | - Salicylic Acid |
| hr | - Hour |
| ha | - Hectare |
| % | - Percentage |
| PGRs | - Plant Growth Regulators |
| NR | - Nitrate Reductase |
| N | - Nitrogen |
| P | - Phosphorous |
| K | - Potassium |
| cm | - Centimetre |
| µg | - Microgram |
| Kg | - Kilogram |
| g | - Gram |
| m | - Meter |
| mg | - Milligram |
| s | - Second |
| me | - Milli equivalent |
| fw | - Fresh weight |
| cv. | - Cultivar |
| ppm | - Parts per million |
| r | - Correlation co-efficient |
| CD | - Critical difference |
| dS | - Deci Siemen |
| rS | - Stomatal resistance |
| <i>E</i> | - Transpiration |

CHAPTER- I

INTRODUCTION

Banana is one of the important fruit crops of the world, especially in the tropics. The world produces 40 million tonnes of banana each year, but most of them are consumed locally. In India, banana is being cultivated in 3, 92,000 ha with a total production of 10.4 million tonnes, contributing 34 per cent of the world production. In Tamil Nadu, it is being grown in an area of 83,308 hectares with a total production of 29,190 metric tonnes (Anon, 2001). In India, to meet the increasing food demand of the ever increasing population, stepping up of fruit production is part of the strategy to solve the food crisis. And, banana has a dominant role to play among the fruit crops.

Commercial banana production in Tamil Nadu is limited to cultivars like Robusta, Grand Nain, Dwarf Cavendish, Poovan (syn : Mysore), Rasthali (syn : Silk), Nendren (French Plantain), Red banana and Hill banana for dessert purposes, and predominantly Monthan (Bluggoe) for cooking. Of late, cultivation of the diploid cultivar 'Ney Poovan' (Musa 'AB' Syn : kadali, Flakki bale, Njali Poovan etc.,) is becoming popular and the variety is fast emerging as a major commercial cultivar due to the premium price it fetches in the market, especially if its production is so adjusted to coincide with major festivals. The cv. 'Ney Poovan' is a medium stature variety. It is conventionally fertilized with 110:35:330 g of NPK (Crop Production Guide, 1998).

Normally banana, being a gross feeder, removes huge quantity of nutrients from the soil. It requires more nitrogen and potassium and responds well to application of these nutrients (Venkatesan *et al.*, 1965; Langenegger, 1994). For increasing commercial production of banana to large scale, judicious application of

nitrogen and potassium can be exploited for tapping the crop potential fully for higher productivity. A balanced dose of nitrogen and potassium can optimize the leaf production and early shooting in the commercial cultivation of banana. Tamil Nadu soils are known for optimum K content and the question of K deficient situation may not often arise, unless banana is continuously cropped without K application. But, nitrogen is low in the most of the banana growing areas of Tamil Nadu. Many workers have reported good response of bananas for enhanced levels of nitrogen (Satheeshkumar, 2002).

Tropical conditions impose several hazards in soil nutrient management. Quick leaching of soil nutrients occurs due to rapid decomposition of the organic matter and rainfall during the monsoon season. But, the heavy requirement of nutrients by banana is normally being met by soil application of fertilizers in split doses during different stages of crop growth. Considerable portion of applied fertilizers to banana are prone to seepage, runoff and also evaporative losses (Lahav, 1995).

The source-sink relationship of banana can be altered by using appropriate plant growth regulators, which may result in higher yield. Apart from this, any improvement in the physiological efficiency of the crop by using PGR may have a significant impact on productivity. At harvest, banana retains a part of the assimilates and nutrients in pseudostem and leaves and so, the crop is relatively less efficient in translocation of assimilation to sink. (Simmonds, 1966). To overcome this malady, use of a suitable growth regulator may be advantageous.

With a view to manipulate vegetative growth, source size and its activity by varying nitrogen levels, and to convert the increased biomass to yield advantage by improving the assimilate translocation to developing sink by using various growth

regulating chemicals, the present study has been taken up with the following objectives.

1. To study the effects of different doses of nitrogen and various growth regulators on vegetative growth and source strength of banana cv. Ney Poovan.
2. To understand the inter-relationships of nitrogen levels and growth regulators on important physiological parameters.
3. To integrate the influences of nitrogen and growth regulators in terms of yield enhancement in banana by altering source-sink relationship.

CHAPTER- II

REVIEW OF LITERATURE

Banana is a major fruit crop grown in all the tropical and sub-tropical regions of the world. Being a surface feeder and a nutrient exhausting crop, basic knowledge on nutrient management and chemical manipulation in banana is must for sustained production and productivity. This can be achieved by employing recent advances in the field of mineral nutrition and plant growth regulators research. It is of paramount importance to maintain high degree of soil fertility by soil application of optimum level of nutrients, if production has to be maintained at economic level for a longer period.

A banana crop should produce sufficient number of leaves to harness light energy and synthesize adequate photosynthates for biomass production to feed a larger bunch.

For increased levels of nitrogen, banana appears to respond well in terms of phyllochron, leaf area production and biomass production, but may delay shooting (Hassen *et al.*, 2001). Several reports have suggested that the vegetative growth of banana has been largely influenced by adequate or excessive supply of nitrogen, thereby increasing the source strength. This increased source strength has to be harnessed by effectively partitioning the assimilates from source leaves and pseudostem to the developing bunch by curtailing excess vegetative growth through the employment of a suitable plant growth regulating chemical. Hence, the present experiment was undertaken to standardize the dose of nitrogen and identifying a suitable plant growth regulator for increasing yield in the commercial cultivar cv. Ney Poovan. The research works carried out earlier using different plant growth regulators and nutrients are briefed here under.

2.1. Nutrient

2.1.1. Nitrogen

Banana, in general, is responsive to nitrogen in early vegetative stages of growth. An increase in the nitrogen, not only stimulates growth, but also changes plant morphology in a typical manner (Levin *et al.*, 1989). Nitrogen induces the growth of pseudostem and leaves. The number of leaves and effective leaf area are found to increase with the nitrogen level. Besides, the nitrogen has a profound influence on number of days taken for unfolding of leaf. A healthy and robust vegetative frame is an essential prerequisite for obtaining high yield in bananas. For the formation of such a desired vegetative frame, nitrogen plays an important role (Marschner, 1995). Considering the multifaceted role of nitrogen, it is imperative that utilizing this macronutrient at optimum level is helpful for higher production in banana. It is obvious that split application of nitrogen results in an effective utilization of nitrogen with a least loss of this leaching prone nutrient. Even as early as 1957, Steinhausen recorded that nitrogen promoted vegetative growth of petiole. The indispensability of nitrogen among the nutrients for better vegetative growth in banana has been well demonstrated (Lahav, 1973).

The favourable effect of nitrogen in increasing the number of leaves was reported even long back by many workers (Battikhah and Khalidy, 1962; Singh *et al.*, 1971; Chattopadhyay *et al.*, 1980). Arunachalam (1972) suggested the promotive effect of nitrogen in almost all characters, namely pseudostem height, girth, leaf area and number of leaves. Nitrogen application also increased the sucker production with the increase of nitrogen level upto 170 g plant⁻¹.

Sharma and Roy (1973) have reported that increased dose of nitrogen resulted in increased plant height, girth, number of leaves in cv.Basrai dwarf. Ramaswamy

and Muthukrishnan (1974) found that the highest responses, in terms of number of leaves plant⁻¹ and earliness of leaf production, were with nitrogen at 225 g plant⁻¹. Kohli *et al.* (1984) observed significant effect of nitrogen on the height of the plant, pseudostem girth and production of leaves.

Chattopadhyay *et al.* (1980) have reported the significant increase in the number of leaves, size of lamina and sucker production, height and girth of banana cv. Giant Governor with increase in levels of nitrogen upto 240 g plant⁻¹.

In a field experiment with Basrai banana, Shinde *et al.* (1992) confirmed that 200 g nitrogen per plant resulted in significant increase in all growth parameters over control. They also revealed that application of higher doses of fertilizer nitrogen beyond 400 g plant⁻¹ resulted in depressive effect.

Maladas and Bhattacharya (1992) studied the influence of nitrogen on phyllochron upto shooting in cv. Barjahaji at six levels of nitrogen namely 50, 100, 200, 300, 400, 500 g plant⁻¹, applied at 3rd, 5th and 7th month after planting. The highest mean phyllochron of 10.38 days was recorded in 50g nitrogen plant⁻¹ against the lowest of 7.74 days, recorded in 400 g nitrogen plant⁻¹. The results indicated the increase in the earliness of leaf production with relative increase in dose of applied nitrogen.

However, Reddy (1992) observed that application of nitrogen at 200 g plant⁻¹ in four splits at 30, 75, 120 and 165 days after planting was sufficient for better growth and development of crop, which was also confirmed by the work carried out at the All India Coordinated Fruit Improvement Scheme at Coimbatore (Anon., 1984), and by Prabhuram (1992) that 200 g of nitrogen plant⁻¹ as urea had resulted in the highest plant height, plant girth, number of leaves with lowest phyllochron.

Foliar nutrition of nitrogen

Interest in foliar nutrition has grown recently because of increased cost of fertilizers, environmental concerns and advances in the knowledge of plant nutrient requirement. Nutrients applied to foliage are absorbed more rapidly and efficiently than the nutrients applied to soil. Critical concentrations of nutrients of spray fluids have been fixed by many researchers. In banana, no scorching effect was observed upto six per cent foliar spray of urea (Shanmugavelu *et al.*, 1992). Anay *et al.* (1998) studied the effect of urea spray at five per cent concentration in banana cv. Nendren. Freiberg and Payne (1957) revealed that lower surfaces of banana leaves absorb urea more rapidly than upper surfaces.

Application of 300 grams of nitrogen as urea in five splits significantly produced higher bunch weight of 21.21 kg plant⁻¹ accompanied by higher number of hands (10.67) and fingers (216) per bunch in Dwarf Cavendish tissue cultured banana.

Krishnan and Shanmugavelu (1983) found significant relationship with leaf area at shooting with bunch weight. Number of fingers had the highest correlation of 0.938, while finger weight and number of hand had 0.880 and 0.877 respectively with leaf area.

Effect of nutrients on physiological parameters

Those plants with leaves that hydrolyze urea rapidly would be the most likely to benefit from urea sprays. Banana leaves were able to absorb 65 per cent of foliar applied urea within 25 minutes (Frieberg and Payne, 1957) indicating that urea is easily absorbed and efficiently utilized by banana.

Effect of split application of nitrogen in banana

In tropical conditions, nitrification of ammonia and leaching of nitrate occur rapidly. Therefore, to ensure regular availability of nitrogen throughout the growth period and to minimize the loss of nitrogenous fertilizers, nitrogen should be applied in small doses in splits at short intervals of time. Summerville (1944) and Alexandrovitz (1955) reported that the time of application of fertilizer was obviously important and for obtaining better results, it should be applied during early stages of growth. Ramaswamy and Muthukrishnan (1974), and Pillai *et al.* (1977) recommended the application of nitrogen in two split doses for better growth and yield of Robusta banana.

However, Battikhah and Khalidy (1962), Leigh (1969), Champion (1970), and Pillai and Abdul Khaddar (1980) reported that the application of nitrogen in three split doses was beneficial for the vegetative growth and better yield in banana.

Selvarajan and Azhakiamaavalan (1992) also recommended the application of nitrogen and potash in three split doses at third, fifth and seventh month of the crop and phosphorus in two splits in third and fifth months after planting for Rasthali, Poovan and Nendren banana under wetland system of cultivation

Maladas and Bhattacharya (1992) applied nitrogen at three split doses in third, fifth and ninth month after planting, while Kohli *et al.* (1985) applied nitrogen with phosphorus and potassium in four split doses and recorded the highest plant height and girth in Basrai banana. Similarly, Rajeevan and Mohanakumaran (1992) reported that application of nitrogen, phosphorus and potassium in four split doses at second, fourth, sixth and eighth months after planting that resulted in better growth and yield in Mysore banana.

At Jalgaon (Maharashtra), application of nitrogen at the rate of 200 g plant⁻¹ in four split doses increased the plant height, girth and number of leaves at shooting (Anon, 1999).

2.2. Plant growth regulators and chemicals

2.2.1. Chlormequat chloride (CCC)

Chlormequat chloride (cycocel) is a growth retarding compound, thought to affect the structural components of protoplasm. CCC application influences the activities of enzymes like α -amylase and peroxidases as observed by Das and Pandey (1985). Therefore, interest in this field has developed in the past few years with the realization that cycocel (CCC) influences in reducing plant height, increasing dry weight of root and leaf area without much adverse effect on biochemical components and yield (Barathkumar *et al.*, 2001). Root growth in terms of length was significantly altered by the application of cycocel.

2.2.2. Mepiquat chloride

Mepiquat chloride (1,1- dimethyl piperidium chloride) is one of the widely used water-soluble plant growth retardant, which acts systematically after its absorption primarily *via* the leaf. Mepiquat chloride was used to reduce shoot vegetative growth and to increase the yield. Urwillar and Oosterhuis (1986) reported that foliar or root application of mepiquat chloride had a tendency to increase root dry matter.

2.2.3. Salicylic acid

Salicylic acid, a naturally occurring phenolic compound in a large number of plants, is known to influence different biological and biochemical processes, ranging from induction of pathogenesis-related proteins to production of heat in arum lilies.

Foliar application of salicylic acid exerted a significant effect on plant growth metabolism when applied at physiological concentration, and thus acted as one of the plant growth regulating substances (Kalarani *et al.*, 2002).

2.2.4. Benzyl adenine

Benzyladenine is one of the synthetic cytokinin, involved in cell division, delaying senescence and favouring translocation of assimilates in addition to counteracting apical dominance. Cytokinin is also known to increase the productivity through altering source-sink relationship, postponing senescence, increasing CO₂ fixation and sink activity (Brault and Maldiney, 1999).

2.2.5. Ethylene

Ethylene is the simplest unsaturated hydrocarbon and the structure is H₂C=CH₂. Ethylene is a plant hormone and it regulates ripening process of fruits. It also regulates many aspects of growth including a rise in respiration, changes in colour, texture, aroma and flavour. Ethylene is biosynthesized from S-adenosyl methionine *via* 1-aminocyclopropane-1-carboxylic acid (ACC), catalyzed by ACC oxidase. Based on the observation, two systems of ethylene production were introduced by McMurchie *et al.* (1972). System 1 is the low rate of ethylene production in the early preclimacteric period of fruit before onset of ripening. System 2 represents the autocatalytic burst of ethylene production accompanied by ripening process. Ethylene plays a major role in physiological events involving senescence and stress (Abeles *et al.*, 1992).

2.2.6. 2, 4-D

Being a synthetic auxin, 2,4-D causes cell elongation by many ways *viz.*, by increasing osmotic solutes of the cell, by increasing the permeability of cells to water by an increase in the wall synthesis, reducing the synthesis of specific DNA

dependent ,new m-RNA and specific enzymatic proteins, which later bring about increase in cell wall plasticity and extension. Adequate supply of auxin is pre-requisite for assured fertilization and fruit set.

2.3. Effect of nitrogen and plant growth regulators on morphological characters of banana

2.3.1. Nitrogen

Excess or deficiency of nitrogen had a marked effect on fruit composition, which also influenced the quantity of nutrients removed from the soil. Srikul and Turner (1995) found that applying 450 kg of N per hectare for cv. Williams increased the relative fruit growth rate by seven per cent, hastened the relative loss of green life by 46 per cent and quickened the maturation rate by 25 per cent.

Among the nutrients, banana first responds to nitrogen, and then to potassium application (Shivashankar and Narayana, 2000). A significant variation in phyllochron was observed after third and fifth month after planting due to the different levels of nitrogen. The results of Satheeskumar (2002) confirmed that nitrogen has positive influence on plant height, plant girth, leaf production, leaf area, yield, bunch weight, and increased the number of hands and fingers. In apple, Ferree and Cahoon (1987) observed more number of leaves per fruit with foliar application of urea. Urea spraying at one per cent level delayed the leaf senescence, prolonged leaf survival and increased number of leaves (Saad *et al.*, 1990). Urea application resulted in increased leaf area in soybeans (Kalarani, 1991) and leaf number in pearl millet (Parihar *et al.*, 1997). In C₃ plants Millard (1988) reported that increased supply of nitrogen resulted in elevated synthesis of Rubisco and stored in the chloroplast.

2.3.2.Plant growth regulators

2.3.2.1. Pseudostem height

Height is one of the important parameter controlled by growth hormones. A reduction in height helps the plant to direct the dry matter to sinks where the requirement is more. Plant height reduction in corn was reported with the application of ethrel and mepiquat chloride (Christensen, 1990), and the same result was confirmed by the same author in maize. Ethephon application reduced the plant height in rape during spring season (Deuker Isermeyer *et al.*, 1991).

Plant height was reduced by the application of cycocel with increasing dry weight of the root and leaf area without much adverse effect on biochemical components and yield in corn (Khosravi and Anderson, 1991), in *Braleria cristata* (Henry, 1995), and in wheat (Lima *et al.*, 1995). Application of urea in rice significantly increased the plant height, as observed by De and Haque (1994) and Sarandon and Asborn (1996). The highest value for plant height was observed in the plants that received salicylic acid in rice (Kalpana, 1997) and in pearl millet (Sivakumar, 2000).

Foliar application of 25 or 50 ppm mepiquat chloride at the flower initiation stage decreased the shoot length in cotton (Xu and Taylor, 1992; Mc Connell *et al.*; 1992), in sunflower (Shashidar *et al.*, 1995), in rice (Jayachandran *et al.*, 2000), and in potato (Jayakumar *et al.*, 2001). Mepiquat chloride application showed drastic reduction of plant height in cotton by inhibiting GA synthesis, as GA has a role in cell division and expansion (Reddy *et al.*, 1990).

Cycocel at 1500 mg litre⁻¹ and mepiquat chloride at 300 mg litre⁻¹ decreased the shoot growth rate in grapes (Albuquerque *et al.*, 2000). Mostafa (2000) reported that cycocel at 3000 ppm reduced the internode length and K content in *Senecio cruentus* cv. Alkamene. Albuquerque *et al.* (2000) also reported that mepiquat chloride at 300 mg litre⁻¹, sprayed at 35 and 70 days after pruning, decreased the shoot growth rate,

increased the fruiting buds and generally increased the concentration of macro nutrients in shoots and petioles of Thompson seedless and Italia cultivars of grapes. Foliar spraying of benzyladenine (20 ppm) recorded significantly higher values for plant height due the acceleration of photophosphorylation in the chloroplast (Anandha Krishnaveni *et al.*, 2001). The combination of phosphobacteria along with cycocel 2000 ppm retarded the plant height in Ashwagandha (Barathkumar *et al.*, 2001). Papageorgiou *et al.* (2002) reported that cycocel at 4000 mg litre⁻¹ reduced plant height with little effect on flowering in lavender.

2.3.2.2. Pseudostem girth

In banana cv. Karpuravalli, increase in the pseudostem growth was attributed to the increased cell wall plasticity by the stimulatory action of auxin (Tagawa and Bonner, 1967). The increase in stem girth consequent to auxin application was also reported in sugarcane (Kaleeswari, 1990). Cycocel at 1000 ppm recorded the highest values in number of branches and stem thickness in potato (Pravin prakash *et al.*, 1999). Al Humaid (2001) reported that cycocel at 800 ppm had a beneficial effect on flowering and stem thickness in *Gladiolous gandavensis* cv. Rose Supreme.

2.3.2.3. Number of leaves

Arora *et al.* (1990) reported an increase in the number of leaves due to cycocel treatment in wheat. Foliar spray of mepiquat chloride at 1000 ppm concentration on 45th day after sowing reduced the number of leaves in sunflower genotype (Shashidhar *et al.*, 1995). Leaf is considered as a functional unit of plants contributing to the synthesis of assimilates and hence, leaf number was positively correlated with the yield of rice as reported by Kalpana (1997).

2.3.2.4. Phyllochron

Anitha (2003) reported that cycocel spray at 1000 ppm during fourth and sixth month after planting recorded lesser number of days for leaf emergence in banana cv. Grand Nain.

2.3.2.5. Leaf area

Leaf area is a fundamental determinant of the total photosynthesis by plant. The application of cytokinin arrested the chlorophyll degradation and protease activity, and promoted the synthesis of soluble protein content and photosynthetic enzymes (Sivakumar, 2000) resulting in more assimilatory surface area for longer period.

Greater leaf area aids the plant to synthesize more metabolites during the period of maximum growth and development. Total leaf area was reduced in cotton with mepiquat chloride application (Zhang *et al.*, 1990; Xu and Taylor, 1992), Similar results were observed in cotton by Reddy *et al.* (1990) that mepiquat chloride spray reduced leaf size, and fewer leaves were caused by the reduced number of nodes.

In sunflower genotype, mepiquat chloride treatment significantly reduced the numbers of leaves and leaf area (Shashidhar *et al.*, 1995). Highest leaf area was reported in rice with foliar spray of salicylic acid (Kalpana, 1997). Datta *et al.* (1986) and Umadevi (1998) found that salicylic acid increased leaf area in pearl millet and sesamum respectively.

2.4. Effect of nutrients, plant growth regulators on physiological and biochemical characters of banana

2.4.1. Chlorophyll content

An increase in chlorophyll content was reported by foliar application of nitrogen (Kalarani, 1991). Increased chlorophyll due to cycocel spray was observed

by Stahli *et al.* (1995) in wheat. Spraying *Vigna mungo* plants with one and ten ppm salicylic acid at the seedling stage increased the chlorophyll content (Chander *et al.*, 1988).

In a study to know the effect of cycocel on alteration of metabolism of sunflower, cycocel at 0.4, 0.6 or 0.8 per cent concentrations increased the chlorophyll content of leaf by decreased protease activity (Kumari *et al.*, 1990; Kumari and Bharti, 1992). Xu and Taylor (1992) reported an increase in chlorophyll content of cotton leaves by the application of mepiquat chloride. Similar result was also observed in groundnut (Jeyakumar and Thangaraj, 1998).

Salicylic acid treatment was reported to increase the chlorophyll contents in green leaves of maize (Sinha *et al.*, 1994), rice (Kalpana, 1997), mungbean (Zhao Huijie *et al.*, 1995) and in wheat as reported by Ameregouda *et al.* (1994). Channakeshava *et al.* (1999) reported that cycocel at 750 ppm significantly improved the chlorophyll content in potato and cheena millet respectively.

Zhao Rui *et al.* (2000) observed that cycocel at 25 ppm increased the chlorophyll content in tomato similar results were reported in brinjal (Prakash and Ramachandran, 2000), and in *senecio cruentus* (Mostafa, 2000). Cycocel at 750 ppm and 1500 ppm markedly improved the total chlorophyll content, while foliar application of mepiquat chloride at 62.5 g ha⁻¹ (Jayakumar *et al.*, 2001) also resulted in increased chlorophyll content. Shehata *et al.* (2001) reported increase in chlorophyll content of maize due to foliar application of benzyl adenine. Chlorophyll *a*, *b*, total sugars and starch contents were increased in grapes when treated with cycocel at all the stages of growth and development (Patil *et al.*, 2001). Zhao Rui *et al.* (2000) observed that 10 mg litre⁻¹ PP₃₃₃ and 25 mg litre⁻¹ cycocel controlled shoot

growth, promoted root activity, increased chlorophyll content, and imparted cold resistance in tomato, besides increasing the contents of macro elements.

2.4.2. Chlorophyll fluorescence

Chlorophyll fluorescence is an important tool in basic and applied plant physiology. The loss of excess energy absorbed by the chlorophyll molecules takes place in a number of ways, such as, light, heat and re-emission, which is known as fluorescence. When a leaf is replaced from dark and brightly illuminated, fluorescence rises rapidly from a low-level (I) to a peak level (F_m) and then decreases gradually through several intermediates to a level close to a lowest F_o level.

The difference between maximum fluorescence signal (F_m) and the low level (F_o) is called variable component of fluorescence (F_v). The fluorescence induction of plantain was more similar to apple leaves than to that of banana (Schreiber, 1983). Chlorophyll fluorescence is a good indicator of Calvin cycle activity in many fruit species (Smillie, 1992). Lurie *et al.* (1994) used chlorophyll fluorescence as a predictor of chilling injury in green pepper (*Capsicum annuum* L.) before tissue damage became visible. Prange *et al.* (1997) examined the possibility of using chlorophyll fluorescence technique in the controlled atmosphere storage conditions for apples.

2.4.3. Soluble protein

Activity of RUBPcase was positively correlated with soluble protein and indirectly indicates the measure of photosynthetic rate (Evans *et al.*, 1975). Soluble protein and Rubisco content per unit leaf area was positively correlated (Diethelm and Shibles, 1989). Kozyreva (1985) reported increase in protein synthesis of rye plants by application of cycocel. Foliar spray of mepiquat chloride increased overall protein content in spring barley (Johnson and Macleod, 1987).

Kalarani (1991) stated that foliar spray of one per cent urea increased the soluble protein content of soybean. Zhao Huijie *et al.* (1995) reported that foliar application of salicylic acid increased the soluble protein content in soybean and similar result was reported in rice (Kalpana, 1997). CCC application influenced the activities of enzymes like α -amylase and peroxidase as observed by Das and Pandey (1985). Cycocel spray at 5mM increased leaf chlorophyll, soluble protein and photosynthetic rate in brinjal (Prakash and Ramachandran, 2000).

The application of salicylic acid increased the nitrate reductase activity, soluble protein and nitrogen contents of *Vigna mungo*. The enhancement of amino acid biosynthesis may also be due to stimulation of the activity of nitrogen utilizing enzyme (Mathur *et al.*, 1998). Application of salicylic acid (SA) has been shown to induce a variety of biological responses namely, inhibition of ethylene synthesis (Huang *et al.*, 1992). Salicylic acid has also been reported to protect nitrate reductase activity (Chunxiang *et al.*, 2000). Salicylic acid is known to induce many genes coding for pathogenesis-related proteins in response to abiotic stresses (Yalpani *et al.*, 1994).

2.4.4. IAA oxidase activity

IAA stimulates the cellulose synthetase and regulates cell wall synthesis (Aref and Ray, 1967), and the hormone is known for many growth functions including apical dominance. Nira Retig and Rudich (1972) reported significant increase in IAA oxidase activity in cucumber with the application of ethrel at two-leaf stage.

IAA oxidase activity determines the auxin levels, it was also reported that IAA oxidase activity was low in region of high auxin content and high in region of low auxin content in cotton and tomato plants (Djanaguiraman, 2004).

Ethrel treatment at 500 ppm increased the IAA oxidase activity in banana (Annadurai and Shanmugavelu, 1977). Lowest IAA oxidase activity was reported in sesame with the application of salicylic acid (Umadevi, 1998). Lu Xin *et al.* (2001) stated that foliar application of salicylic acid increased the internal IAA content in broad bean leaves.

2.4.5. Stomatal resistance

Eris (1983) observed increased stomatal resistance 24 hours after salicylic acid treatment upto five days in pepper. Similar effects were also reported by Castro and Ballesterro (1977) in pepper by spraying 2000 ppm cycocel. Vitagliano and Hoad (1978) revealed that ethrel treatment increased stomatal resistance in leaves of apple, cherry, peach, fig, olive, coffee and pepper.

2.4.6. Transpiration

Saavedra (1978) indicated that salicylic acid reduced the transpiration rate in different plants. Tan *et al.* (1981) and Hesse and Lenz (1982) observed that the transpiration was drastically reduced under water stress condition in tomato and French bean respectively.

Relative water content

Kumari and Bharti (1992) observed higher RWC in water stressed sunflower sprayed with cycocel.

2.5. Effect of nitrogen and plant growth regulators on yield and yield components of banana

2.5.1.1. Nitrogen

Nitrogen is reported to promote early pulp growth and thereby determines the final fruit fresh weight in banana (Ramaswamy and Muthukrishnan, 1974). Srikul and

Turner (1995) recorded increased fruit growth rate in banana with the increase in nitrogen dose. They also revealed that application of nitrogen in excess of 300 kg ha⁻¹ year⁻¹ promoted the tendency to ripen early. Simmonds (1966) stated that N always hastened the rate of maturity and the bunch weight increases with added doses. Champion *et al.* (1970) observed that 160 grams of N in combination with 240 grams of K₂O per plant gave an yield of 35.2 tons per hectare in Robusta banana.

Mustaffa (1983) concluded that N and K exerted significant positive influence on fruit number and bunch weight when applied at the rate of 191 g and 301 g per plant respectively. Ram and Prasad (1988) in their investigations with the banana cv. Campiargans local (AAB) reported that individual effect of NPK were not significant, but recorded highest TSS (21.21%) with the application of 200 grams of N, 80 grams P₂O₅ and 200 grams K₂O per plant.

Banana normally requires larger quantity of potassium during fruit filling stage whereas nitrogen is required in larger quantity during vegetative stage (Hassen *et al.*, 2001).

2.5.2. Plant growth regulators

In early spongy gourd, cycocel at 750 ppm produced the highest seed yield due the higher number of female flowers, higher number of fruits and low sex ratio (Patil *et al.*, 2001). Kebede and Zelleke (1993) reported that cycocel 1500 ppm resulted in a slight increase in the number of berries per cluster. The greatest yield was recorded with cycocel 1000 ppm in potato (Pravinprakash *et al.*, 1999).

Application of cycocel at 500 ppm significantly increased the yield by 90 per cent without affecting berry size in red raspberry cv. Autumn Bliss (Ghora *et al.*, 1998). Fruit drop was reportedly minimized in litchi (Khan *et al.*, 1976) and in mango (Singh and Ram, 1983) due to cycocel application. Barathkumar *et al.* (2001) recorded that phosphobacteria along with 2000 ppm of cycocel increased the quality

parameters of ashwagandha. Mepiquat chloride at 150 ppm, sprayed at 45 days after transplanting, increased the total potato tuber yield (Eyob and Krishnappa, 1999). Albuquerque *et al.* (2000) reported that mepiquat chloride 300 mg litre⁻¹, sprayed at 35 and 70 days after pruning, decreased the shoot growth rate, increased the fruiting buds and generally increased the concentrations of macro nutrients in both shoots and petioles of Thompson seedless and Italia, cultivars of grapes. Phenolics play a significant role in the initiation and development of floral buds of tomato, which increased the fruit number and yield as reported by Kalarani *et al.* (2002). They also reported that 100 ppm salicylic acid was optimum for enhancing productivity and quality of tomato fruits.

CHAPTER - III

MATERIALS AND METHODS

A field experiment in banana cv. Ney Poovan was conducted with various levels of nitrogen and plant growth regulators at Orchard, Tamil Nadu Agricultural University, Coimbatore during 2003-2004. The objectives of the experiment were to study the influences and interrelationships of varying levels of nitrogen with certain growth regulators in altering source – sink relationship of banana.

3.1. Materials

The banana cv. Ney Poovan was used as experimental material.

3.1.1. Location

The study was conducted at Orchard of Tamil Nadu Agricultural University, Coimbatore which is located at 11⁰ N latitude and 77⁰ E longitude and at an elevation of 426.6 m MSL during 2003-2004.

3.1.2. Soil characters

The soil type of the experimental field is sandy loam and its chemical properties are furnished below

| Chemical properties | Value |
|----------------------------|--------------------------|
| pH | 8.15 |
| EC | 0.219 dS m ⁻¹ |
| Available N | 301 kg ha ⁻¹ |
| Available P | 140 kg ha ⁻¹ |
| Available K | 411 kg ha ⁻¹ |

3.1.3. Cultural practices

Recommended packages of practices like irrigation, weeding, earthing up, plant protection measures *etc.*, were followed according to Crop Production Guide (1998), and released by Department of Horticulture and Plantation Crops, Tamil Nadu.

3.1.3.1. Field preparation and planting

The field was ploughed and levelled properly. Pits were dug out and furadon granules (40 g pit⁻¹) were applied to each pit. The cultivar Ney Poovan suckers were planted on 11.09.2003 at the recommended spacing of 1.8 X 1.8 m.

3.1.3.2. Fertilizer application

All plants were given with uniform fertilizer dose of 35:330 g P₂O₅: K₂O plant⁻¹ as super phosphate and muriate of Potash. P was applied in full at planting and potassium in three splits during third (66g plant⁻¹), fifth (132 g plant⁻¹) and seventh months (132g plant⁻¹) after planting.

3.2. Experimental details

- | | | |
|---------------------|---|---------------------------|
| 1. Variety | : | Ney Poovan |
| 2. Design | : | Split plot |
| 3. Replication | : | Three |
| 4. Number of plants | : | Nine plants per treatment |

3.2.1. Treatment details

3.2.1.1. Main plot

In the main plot, the levels of nitrogen were considered as detailed below.

| | | |
|--------------------------|---|---|
| M ₁ (Control) | : | 150 g N plant ⁻¹ (45g + 75g +30g N plant ⁻¹) at 3,5 and 7 MAP, respectively) |
| M ₂ | : | M ₁ + Urea 2% foliar spray |
| M ₃ | : | 200 g N plant ⁻¹ (60g + 100g + 40g N plant ⁻¹) at 3,5 and 7 MAP respectively) |
| M ₄ | : | M ₄ + Urea 2% foliar spary |

3.2.1.2. Sub plot

In the subplots, the plant growth regulators were considered as detailed below.

| | | |
|----------------|---|--|
| S ₁ | : | Control (water spray) |
| S ₂ | : | Mepiquat chloride (MC) 500 ppm |
| S ₃ | : | Chlormequat chloride (CCC) 100 ppm |
| S ₄ | : | Ethrel 500 ppm |
| S ₅ | : | Salicylic acid (SA) 100 ppm |
| S ₆ | : | Nitrobenzene 100 ppm |
| S ₇ | : | Benzyl adenine (BA) 20 ppm |
| S ₈ | : | 2,4- Dichlorophenoxy acetic acid (2, 4-D) 25 ppm |

3.2.2. Stages of application

Foliar spray of urea in main plots and foliar spray of bioregulators in subplots were imposed at third, fifth and seventh months after planting separately.

3.2.3. Method of application

For soil application of nitrogen, the required quantity of urea is mixed with muriate of potash and applied as per treatment schedule. For foliar spray respective

PGR was dissolved in appropriate quantity of water. Plant growth regulators, namely CCC, MC, Ethrel, 2,4-D, BA and nitrobenzene and SA were sprayed at third, fifth and seventh

month after planting as foliar spray between 6.00 - 8.00 AM, using knapsack and rock sprayer. Teepol was added to the spray fluid as surfactant at 1.5 ml L⁻¹ for effective absorption of chemicals.

3.2.2. Time of Harvest

The plants which were planted on 11.09.2003 in the present investigation, came to shooting during first fortnight of May, 2004. The duration taken for shooting from planting ranged from 225 to 239 days and bunches were harvested as and when 90 days of reproductive growth was completed after shooting as the first angularity disappeared.

3.3. Observations recorded

The following observations were recorded during third, fifth and seventh month after planting, in five labelled plants in each treatment and mean values were arrived at.

3.3.1. Morphological attributes

3.3.1.1. Pseudostem height

Height of the pseudostem was measured at different stages from the base of the trunk just above the soil to the axil of the youngest leaf and expressed in cm.

3.3.1.2. Pseudostem girth

The girth of the pseudostem was measured at different stages at 30cm height above the ground level and expressed in cm.

3.3.1.3. Number of functional leaves

The total number of functional leaves, produced at different growth phenophases, were counted and expressed in number.

3.3.1.4. Phyllochron study

The date of emergence of each leaf was recorded and from that the rate of leaf emergence was calculated (Summerville, 1944) and expressed in days.

3.3.1.5. Leaf area

Total leaf area was calculated by non destructive method by multiplying the product of length and breadth of all the leaves by 0.8 (Murray, 1960) and expressed in m².

3.3.1.6. Leaf area index

Leaf area index was calculated using the following formula (Williams, 1946).

$$\text{LAI} = \frac{\text{Leaf area per plant (m}^2\text{)}}{\text{Ground area occupied by the plant (m}^2\text{)}}$$

3.3.2. Physiological and biochemical parameters

Various physiological and biochemical parameters were estimated at 3rd, 5th, 7th MAP and harvest stages. For destructive sapling, samples were taken from plants other than the five labelled ones.

3.3.2.1. Chlorophyll content

The content of chlorophyll *a*, *b* and total chlorophyll were estimated by adopting the procedure of Yoshida et al. (1972) and the contents were expressed as mg g⁻¹ of fresh weight.

3.3.2.2. Chlorophyll stability index (CSI)

CSI was assessed following the method of Murty and Majumder (1962). Two samples (each 0.5 gram) of fresh leaves were placed in test tubes with 20 ml of

distilled water and one set was heated in the water bath for 60 minutes at 65⁰C. Leaf tissues of both heated and unheated (check) were removed from the distilled water after

1 hour, blotted and transferred to mortar containing acid washed sand and 80 per cent acetone. The sample was ground to a pulp and centrifuged at 5000 rpm for 15 min in a refrigerated centrifuge (HITACHI, Japan). The supernatant was made up to 25 ml volume with 80 per cent acetone and light absorbance was taken at 663 nm immediately with a Spectronic 20 Colorimeter, and total chlorophyll content of treated and untreated samples were arrived at. CSI was calculated as follows and expressed as percentage.

$$\text{CSI} = \frac{\text{Total chlorophyll content of treated sample}}{\text{Total chlorophyll content of control sample}} \times 100$$

3.3.2.3. Chlorophyll fluorescence

The fluorescence measurement was done by using Plant Efficiency Analyzer (PEA) (Hansatech, UK), that uses a fast analyzing system capable of recording in 10 s was used to assess the chlorophyll fluorescence. Measurements were on intact leaves, which were dark adapted for 30 min prior to measurement. The minimal fluorescence level (F_o) with all PS II reaction centres open was assessed by measuring the modulated light which was sufficiently low (< 0.1 (mol m⁻² s⁻¹)) not to induce any significant variable fluorescence. The maximum fluorescence level (F_m) with all PS II reaction centres closed were determined by a 0.8 s saturating pulse at 8000 (mol m⁻² s⁻¹) in dark adapted leaves. Using both light and dark fluorescence parameter it was calculated that the maximal efficiency of PS II photochemistry in dark adapted state, F_v/F_m = (F_m-F_o)/F_m (Lu *et al.* 1992).

3.3.2.4. Leaf temperature

Leaf temperature was recorded between 10.00 A.M to 12.00 noon at 3rd, 5th and 7th month after planting and at harvest stage using Steady State Porometer (LICOR 1600, Licor Inc, Nebraska, USA) and expressed as °C.

3.3.2.5. Stomatal resistance (rS)

Stomatal resistance was measured at 3,5th and 7th month after planting and at harvest by using Steady State Porometer between 10.00 AM to 12.00 noon (LICOR 1600, Licor Inc, Nebraska, USA) and expressed as s cm⁻¹.

3.3.2.6. Transpiration rate (E)

Transpiration rate was measured by using Steady State Porometer (LICOR-1600, Licor Inc, Nebraska, USA) at 3rd,5th,7th month after planting and at harvest and expressed as µg H₂O cm⁻² s⁻¹.

3.3.2.7. Soluble protein content

Soluble protein content of leaf was estimated by following the procedure of Lowry *et al.* (1951), by using folin ciocalteau reagent and expressed in mg g⁻¹ of fresh weight.

3.3.2.8. Nitrate reductase activity

Nitrate reductase activity was estimated using naphthalene ethylene diamine dihydrochloride by following the method described by Nicholas *et al.* (1976) and expressed as µg NO₂ g⁻¹h⁻¹ (fresh weight).

3.3.2.9. IAA oxidase

The IAA oxidase activity was quantified by estimating residual IAA, as suggested by Parthasarathy *et al.* (1970) and expressed as µg of unoxidised IAA g⁻¹ h⁻¹.

3.3.2.10. Relative water content (RWC)

Relative water content of leaf samples was determined as per the method of Barrs and Weatherly (1962). Turgid weight was determined by taking the leaf samples of 1.5 cm diameter in petridishes containing water for four hours (Bennett *et al.*, 1981). Dry weight was arrived by keeping the samples in hot air oven at 60⁰C. From these data, the RWC was worked out and expressed as per cent.

$$\text{RWC} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Turgid weight} - \text{dry weight}} \times 100$$

3.3.3. Nutrient content

Leaf nutrient content were estimated during 3rd, 5th and 7th MAP and at harvest.

3.3.3.1. Leaf nutrient content

The second leaf from the top was taken as sample leaf in each treatment from the plant other than the labelled plant. Ten cm width of middle portion of lamina perpendicular to midrib was cut and removed from each of the sample plants (Lahav and Turner, 1995), dried, powdered and analyzed for the following nutrients.

3.3.3.2. Leaf nitrogen content

The leaf nitrogen content was estimated by microkjeldahl method (Humphries, 1956) and expressed in per cent.

3.3.3.3. Leaf phosphorus content

The leaf phosphorus content was estimated by adopting vanadomolybdate phosphoric yellow colour method (Jackson, 1973) and expressed in per cent.

3.3.3.4. Leaf potassium content

The potassium content of the leaf sample was estimated by flame photometric method using triple acid extract (Jackson, 1973) and the values were expressed in percentage.

3.3.4. Yield and yield components

Five plants in each treatment were tagged for recording yield and yield components and the mean values of each treatment were worked out and expressed.

3.3.4.1. Bunch weight

Bunch weight was recorded including the peduncle measuring 20 cm above the first hand and expressed in kg.

3.3.4.2. Number of hands and fingers per bunch

Total numbers of hands and fingers in each bunch were counted and recorded. The mean values were expressed in number.

3.3.4.3. Finger weight

Two middle fingers each from top and bottom rows of the second hand of each bunch were removed with a sharp knife at the point of pedicel attachment with the fruit and the individual finger weight was recorded. The mean value was worked out and expressed in g.

3.3.4.4. Fruit length

Length of the fruit was measured from the base of the pedicel to the tip of the fruit along the outer curvature and expressed as cm.

3.4. Statistical analysis

The statistical analysis of the data and the correlation co-efficients were done by adopting the standard procedure of Gomez and Gomez (1984).

CHAPTER IV

EXPERIMENTAL RESULTS

The effect of different doses of nitrogen with plant growth regulators was studied in banana cv. Ney Poovan, for improving the yield attributes by altering the source and sink activity, at Orchard, Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore, during 2003-2004. The results of the present investigation are presented with suitable Tables and Figures as hereunder.

4.1. Morphological attributes

4.1.1. Pseudostem height (cm plant⁻¹) (Table 1a, 1b)

Growth, in terms of pseudostem height, was increased upto shooting (Table 1a, 1b). Application of different levels of nitrogen and plant growth regulators distinctly influenced the pseudostem height and the effect of nitrogen application on pseudostem height was more pronounced at 5 MAP and 7 MAP. Application of nitrogen at 200 g plant⁻¹ + urea 2% foliar spray (M₄) recorded significantly enhanced pseudostem height at all stages of crop phenophase. The increase was 8.35 per cent over control (M₁) at 7th MAP, whereas soil application of 200 g N plant⁻¹ (M₃) recorded only five per cent increase.

Among the subplot treatments, salicylic acid 100 ppm (S₅) recorded the maximum pseudostem height at 7th month after planting (199.9) followed by benzyl adenine 20 ppm (S₇) but with comparable value (198.4). The treatments S₅ and S₇ recorded plant height increase of 9.5 and 8.7 per cent over control (S₁). Growth retardants, namely mepiquat chloride, CCC and ethrel recorded lower pseudostem heights than control. The treatments differed significantly at all growth stages except at 3 MAP.

The interaction effects were significant 5 MAP onwards. The combination of the best performing factors namely M₄S₅ recorded the maximum pseudostem height at 7th month after planting (219.3). This was very closely followed by M₄S₇ (214.9). In all the treatment combinations, the growth retardants, mepiquat chloride (S₂), CCC (S₃) and ethrel (S₄) effected reduced plant growth.

4.1.2. Pseudostem girth (cm plant⁻¹) (Table 2a, 2b)

The pseudostem girth of banana was steep upto 5 MAP and thereafter, the increment in girth was very low. Application of nitrogen 200 g plant⁻¹ + urea 2% foliar spray (M₄) at 7th month after planting significantly increased the pseudostem girth over control (M₁) to the maximum value of 57.93 followed by M₃ among main plot treatments. The per cent increase of girth by M₄ over control was 2.7 at 7th month after planting.

Among the plant growth regulators, the growth retardant mepiquat chloride at 500 ppm (S₂) was found to be superior over other treatments, by recording a girth of 60.54 cm, which was 12.9 per cent increase over control. However, ethrel at 25 ppm recorded pseudostem girth of 60.52 cm with a per cent increase of 12.9 at 7th month after planting which is on par with S₂. Salicylic acid (100 ppm), benzyl adenine (20 ppm), 2, 4-D (25 ppm) and nitrobenzene (50 ppm) performed moderately with per cent increase of 6.3, 5.6, 1.2 and 2.9, respectively over control.

However, the interaction effects of main and subplot failed to differ significantly among themselves. Obviously, M₄S₂ (nitrogen 200 g plant⁻¹ + urea 2% foliar spray with mepiquat chloride 500 ppm) produced maximum pseudostem girth of 62.0 cm at shooting stage followed by M₃S₃ (200 g nitrogen plant⁻¹ with CCC

1000 ppm) recording the girth of 61.0 at shooting stage. The girth of control (M_1S_1) was 53.0 at this stage, which was the lowest among the treatments.

4.1.3. Number of functional leaves plant⁻¹ (Table 3a, 3b)

Data on number of leaves, recorded at different growth stages in banana revealed that there was a sudden spurt in number of leaves between 3 MAP and 5 MAP followed by a steady increase from 5 to 7 MAP, and thereafter a reduction in leaf number was observed. Application of nitrogen 200 g plant⁻¹ + urea 2% foliar spray (M_4) facilitated in producing significantly more leaves from 3 MAP onwards, and it had 16.87 leaves at shooting which was 28.6 per cent higher over control (M_1) at 7 MAP. At harvest also, this treatment registered four per cent increased green leaf area over control.

The plant growth regulators, irrespective of their mode of action, recorded higher number of leaves than control (S_1) in every growth stage. However, salicylic acid 100ppm (S_5) proved significantly its superiority by producing an early increase in (14.52) number of leaves at 5 MAP and maintained significantly the enhanced level throughout the crop duration. It recorded the maximum number of leaves of 16.34 (16.8 %) at shooting stage, while in control (S_1), the number was only 13.99. Benzyl adenine 20 ppm (S_7) spray aided in enhancing number of leaves moderately over control but next to salicylic acid treatment. Among the growth regulators, salicylic acid and benzyl adenine appeared to favour the retention of green leaves throughout the crop duration.

The best treatment combination, 200 g nitrogen plant⁻¹+ urea 2% foliar spray and salicylic acid 100 ppm (M_4S_5) excelled other treatments by producing significantly higher number of leaves from 5 MAP onwards. This treatment recorded 15.34, 17.75 number of leaves at 5 MAP and at shooting stage (7 MAP) respectively. The corresponding values in control treatment (M_1S_1) were 10.00, 12.00 and 12.50 respectively.

M₄S₇ followed the suite. The results clearly indicated that soil application of 200 g nitrogen plant⁻¹ + 2 % urea spray either with 100 ppm salicylic acid spray or with 20 ppm benzyl adenine spray might help in maintaining high green leaf number throughout the ontogeny of banana crop .

4.1.4. Phyllochron (Table 4a, 4b)

The phyllochron was found to differ significantly among the treatments at all growth stages (table 4a, 4b). Nitrogen at 200 g plant⁻¹ + urea 2% foliar spray (M₄) distinctly favoured the phyllochron production rate by reducing the interval between two leaves in banana. At 5th month after planting, it requires only 7.36 days which was

8.7 per cent decrease over control. Whereas, the decrease was 13.9 per cent at 7th MAP. M₃ and M₂ followed this treatment.

Among the subplot treatments, salicylic acid 100 ppm requires significantly lesser number of days (6.61 at 5 MAP) and 6.99 at 7 MAP than other treatments. All the chemicals and plant growth regulators were found to decrease the days of leaf emergence over control. Salicylic acid recorded decrease of 23.9 per cent and 31.4 per cent over control at 5 MAP and 7 MAP respectively. Benzyl adenine spray at 20 ppm also produced quicker leaf production.

In the interaction effects, M₄S₅ took lesser number of days for leaf emergence. At 7 MAP only the interactions exercised significant differences. As M₄ and S₅ are the best performing treatment among the doses of nitrogen and plant growth regulators respectively, the treatment M₄S₅ recorded the best results by having a lower days for leaf emergence at 3 MAP (8.00), 5 MAP (6.25) and 7 MAP (6.50). This was closely followed by M₄S₇ and M₄S₂ at shooting stage.

4.1.5. Leaf area ($\text{cm}^2 \text{ plant}^{-1}$) (Table 5a, 5b)

Leaf area was found to increase gradually from 3 MAP to shooting stage and declined thereafter towards maturity. The differences in leaf area among nitrogen doses were significant at all growth stages except 3 MAP. Data presented in Table 5a and 5b revealed that application of nitrogen 200 g plant^{-1} + urea 2% foliar spray (M_4) was found to be effective in increasing the leaf area plant^{-1} . The increase in the photosynthetic area was to a tune of 3.1 per cent over control (M_1) at 7 MAP and the same maintained about five per cent increased green leaf area at harvest.

Among different plant growth regulators, application of salicylic acid 100 ppm (S_5) recorded higher leaf area at all stage, the per cent increase in leaf area by S_5 being 20.4, 20.2, 23.6 and 46.8 at 3, 5, 7 MAP and at harvest, respectively over control (S_1). This treatment was followed by S_7 and S_8 .

The interaction of nitrogen doses with plant growth regulators produced significant differences in leaf area among the other treatments in all the growth stages. M_4S_5 maintained its superiority over other interaction treatments from 3 MAP onwards. It recorded the maximum leaf area of 19.01 m^2 , followed S_7 (18.60 m^2) at shooting stage. The corresponding leaf area of control (M_1S_1) was 15.00 m^2 , which was the lowest among the treatments.

4.1.6. Leaf area index (Table 6a, 6b)

Doses of nitrogen distinctly favoured the leaf area index. Among the dose of nitrogen 200 g plant^{-1} + urea 2% foliar spray (M_4) recorded a value of 1.25, 2.77, and 5.34 at 3, 5 and 7 MAP respectively. At harvest also, it maintained high leaf area index with 5.1 per cent increase over control. The treatments showed an increasing trend from 3 MAP to 7 MAP, and the leaf area index values declined at harvest stage. The treatment M_4 recorded percentage increases of 15.7, 3.0 and 3.1 at 3, 5 and 7 MAP, respectively over control (M_1).

Among the sub plot treatments, S₅ (salicylic acid 100 ppm) recorded highest leaf area indices at all stages (1.17, 3.06, 5.76 and 4.82 at 3, 5, 7 and at harvest respectively followed by benzyl adenine 20 ppm (S₇). S₅ and S₇ recorded increases of 23.61 and 21.24 per cent over control at shooting stage respectively. These treatments also maintained above 40 per cent increased LAI over control at harvest.

At every growth stages, the interaction treatments exercised significant differences except at 3 MAP. As M₄ and S₅ are the best performing treatments, the combination M₄S₅ recorded the best results by having the highest leaf area index of 5.87 at shooting stage. This was closely followed by M₄S₇ (4.44). M₄S₅ and M₄S₇ recorded per cent increases of 26.78 and 23.97 over control (M₁S₁), respectively.

4.2. Biochemical and physiological attributes

4.2.1. Chlorophyll *a* (mg g⁻¹) (Table 7a, 7b)

The data on chlorophyll *a* content are presented in the Table 7a and 7b. The results revealed that chlorophyll *a* increased steadily from 3 MAP to shooting stage, and thereafter decreased. Application of nitrogen at 200 g plant⁻¹ + urea 2% foliar spray (M₄) proved its effectiveness over control (M₁) in increasing the content by recording per cent increases of 6.9, 13.2 and 9.7 at shooting stage, 5 and 3 MAP, respectively.

Among the sub plot treatments, salicylic acid 100 ppm (S₅) was the best treatment, by recording a significantly higher content of chlorophyll *a* over other treatments at shooting stage (0.96) and it was 18.75 per cent increase over control (S₁). Apparently, the increase in chlorophyll *a* at harvest by this treatment was 21.6 per cent over control. Application of benzyl adenine 20 ppm (S₇) also closely followed with enhanced values at every stage.

Both main plot and sub plot and their combinations resulted in significant increase in chlorophyll *a* content. M₄S₅ recorded (0.99) the highest chlorophyll *a* content than other treatments and accounted for 28.57 per cent increase over control (M₁S₁). M₄S₇ followed the suite at all stages.

4.2.2. Chlorophyll *b* (mg g⁻¹) (Table 8a, 8b)

Like chlorophyll *a*, chlorophyll *b* also continued to increase from 3 MAP upto shooting beyond which it started to decline. Among the main plot treatments, M₄ surpassed the other treatment by recording values of 0.56, 0.64, 0.67, 0.64 at 3, 5, 7 MAP and at harvest stage respectively, which were 12.00, 14.3, 8.1 and 18.5 per cent increases over control (M₁), respectively. M₃ followed the suite.

Among the sub plot treatments, salicylic acid sprayed at 100 ppm (S₅) was found to be significantly the best, followed by benzyl adenine 20 ppm (S₇). At shooting stage, these recorded values of 0.72 and 0.70, respectively.

In the interaction treatments, M₄S₅ recorded on early lead of 0.62 at 3 MAP, by recording a per cent increase of 31.91 over control (M₁S₁) at shooting stage, and maintained its superiority at all the crop phenophases. There existed significant differences in chlorophyll *b* content due to nitrogen dose, chemicals and plant growth regulators.

4.2.3. Total chlorophyll (mg g⁻¹) (Table 9a, 9b)

The data on total chlorophyll content is presented in Table 9a and 9b. The results revealed that total chlorophyll content increased steadily from 3 MAP onwards upto shooting, and thereafter it decreased. Total chlorophyll content, recorded at different growth stages in banana, indicated that application of nitrogen at 200 g plant⁻¹ + urea 2% foliar spray facilitated in producing more total chlorophyll content at shooting stage than other nitrogen doses. It was 8.0 per cent over control.

Foliar application of urea over respective soil application treatments (M₂ and M₄) explicitly produced increased chlorophyll contents as compared to the respective soil application alone (M₁ and M₃).

In the sub plot treatments all the treatments differed significantly at all stages. Among the treatments S₅ (salicylic acid 100 ppm) recorded highest total chlorophyll content followed by benzyl adenine 20 ppm (S₇) at all growth stages. The maximum pigmentation was observed at shooting stage (1.48 and 1.47, for S₅ and S₇ respectively), which recorded increases of 5.0 and 4.3 per cent over control respectively.

At every growth stages the interaction treatments exercised significant differences. As M₄ and S₅ are the best performing treatment among the doses of nitrogen, and plant growth regulators, the treatment M₄S₅ recorded the best result by producing a higher value of 1.55 total chlorophyll content during shooting stage. This was closely followed by M₄S₇ (1.53).

4.2.4. Chlorophyll stability index (Table 10a, 10b)

The maximum chlorophyll stability index was recorded at shooting stage followed by 5 MAP. The main plot, subplot and the interaction were significant at 3,5,7 MAP and at maturity stages. At shooting stage, application of nitrogen 200 g plant⁻¹ + 2% urea foliar spray (M₄) surpassed other treatments in a significant manner to the tune of 80.73 per cent which is 1.2 per cent increase over control (M₁).

Foliar spray of all plant growth regulators significantly increased the chlorophyll stability index over control, and among the treatments, S₇ (benzyl adenine 20 ppm) and salicylic acid 100 ppm (S₅) recorded values of 83.95 and 83.64

respectively, which were 21.1 and 21.6 per cent increase over control (S_1) at shooting stage and both were on par with each other.

M_4S_7 recorded significantly the maximum chlorophyll stability index in every phenological stage and it was closely followed by M_4S_5 .

4.2.5. Chlorophyll fluorescence (Fv/Fm) (Table 11a, 11b)

Fv/Fm ratio estimated during various growth stages revealed that the ratio was low at initial stage and as a growth advanced towards shooting stage there was an increase. During reproductive growth, the ratio started to decline till harvest showing low quantum. However, the values showed significant differences among treatments in all stages of observations except at 3 MAP. At 7 MAP, both M_4 and M_3 treatments recorded 0.785 and 0.767 which were 8.4 and 5.9 per cent higher than control (M_1). The results indicated that enhanced dose of nitrogen at 200 g plant⁻¹ (M_3) produced appreciable increase in photochemical effects and by additionally giving foliar spray with urea amplified the effect significantly.

It was revealed from the present study that the plant growth regulator salicylic acid at 100 ppm might elevate the chlorophyll fluorescence to the highest level of 0.847 at 7 MAP which was 34.2 per cent increase over control. Next to salicylic acid, benzyl adenine at 20 ppm also recorded good results with 23.9 per cent increase at the corresponding stage. These growth regulators maintained their lead upto harvest

At 5, 7 MAP and at maturity all the factors and their interactions were significant. As, M_4 and S_5 are the best performing treatments among the main and subplots, the combinations of these two treatments namely M_4S_5 recorded the best results (0.87) at 7 MAP. It was closely followed by M_4S_7 (0.84). These two treatments performed well throughout the crop duration.

4.2.6. Soluble protein (mg g^{-1}) (Table 12a, 12b)

Soluble protein is one of the important parameter reflecting the photosynthetic ability. Banana plants appeared to have high content of soluble protein upto shooting stage and thereafter, it started to decline as indicated by the data.

Doses of nitrogen and of different plant growth regulators distinctly influenced the soluble protein content from 3 MAP to harvest except at 3 MAP. Application of 200 g nitrogen plant^{-1} + urea 2% spray (M_4) recorded significantly greater soluble protein than M_3 , M_2 and M_1 at 7MAP (27.75). The per cent increase was 24.11 over M_1 (100 g nitrogen plant^{-1}) at shooting stage.

Among the chemicals and plant growth regulators, salicylic acid 100 ppm (S_5) recorded significantly the maximum (26.85) soluble protein followed by S_7 (26.18) at shooting stage. The best treatment (S_5) recorded an increase of 30.6 per cent over control at shooting stage. The treatments differed significantly among themselves at all the growth stages.

The interaction effects were significant from 3 MAP onwards upto harvest. The combination of best performing treatment namely M_4S_5 recorded the maximum soluble protein content (33.26) at shooting stage, which was followed by M_4S_7 (30.76). However, all the growth regulator treatments performed better than control treatment (M_1S_1).

4.2.7. Nitrate reductase activity ($\mu\text{g NO}_2 \text{ g}^{-1} \text{ h}^{-1}$) (Table 13a, 13b)

Nitrate reductase activity showed an increasing trend over the period of growth upto shooting stage. The data on nitrate reductase activity recorded at 3, 5, 7 MAP and harvest stages of banana revealed significant differences among treatments. M_4 (nitrogen 200-g plant^{-1} + urea 2% foliar spray) was the best (225.05) followed by M_3

(nitrogen 200 g plant⁻¹) and M₂ (nitrogen 150 g plant⁻¹). The best treatment recorded an increase of 4.24 per cent increase in activity over control at shooting stage. Among the plant growth regulators, salicylic acid 100 ppm (S₅) clearly established the lead by recording significantly higher enzyme activity at all the stages. Benzyl adenine 20 ppm (S₇) was found to be the next best treatment. At shooting stage, the value of nitrate reductase in S₅ treatment was 268.40, which declined to 202.40 at harvest stage. The corresponding values of S₇ were 256.43 and 192.13 and that of control (S₁) were 168.19 and 137.95 respectively.

Distinctly high nitrate reductase activity was observed in M₄S₅ treatment combination among various interactions of doses of nitrogen and plant growth regulators. This was closely followed by M₄S₇ in every stage.

4.2.8. IAA oxidase activity (unoxidised auxin g⁻¹ h⁻¹) (Table 14a, 14b)

The IAA oxidase enzyme attained the lowest activity during shooting stage as unoxidised auxin contents were higher at the stage and the activity started to increase thereafter till harvest. Doses of nitrogen proved its effectiveness in producing a significant variation during all stages of crop growth. At shooting and maturity, M₄ (200 g nitrogen plant⁻¹ + urea 2% foliar spray) exhibited a decrease in activity, by recording values of 750.31 and 370.98 of unoxidised auxin content, whereas control recorded only 652.06 and 315.91, respectively.

Significant differences were observed among various chemicals and plant growth regulator treatments at all stages of crop growth. S₅ (salicylic acid 100 ppm) portrayed a value of 728.18 during shooting stage and it maintained the superiority over the other treatments in every growth stage by recording higher unoxidised auxin contents. S₇ closely followed in all the growth phenophases.

Distinctly low IAA oxidase enzyme activity was observed in M₄S₅ treatment among various interactions of main and subplot treatments with maximum unoxidised auxin content of 853.8 at 7 MAP. It consistently showed a lower value of enzyme activity *i.e.*, higher unoxidised auxin content in every growth stages (347.12, 598.48, and 853.83 during 3, 5 and 7 MAP, respectively). This was closely followed by M₄S₇.

4.2.9. Total phenolic content (mg g⁻¹) (Table 15a, 15b)

Data on total phenolic content revealed that there were a significant impacts due to different doses of nitrogen, types of plant growth regulators used on phenolic content at all growth stages. The values were almost uniform in all the chosen stages of observation ranging from 0.72 to 0.62.

At 5 MAP, minimum phenol contents were observed in nitrogen 200 g plant⁻¹ + urea 2% foliar spray (M₄), and with salicylic acid 100 ppm (S₅). These two treatments maintained low contents at later stages also. M₄ recorded decreased contents of 0.68, 0.64, 0.65 and 0.62 at 3, 5, 7 MAP and at harvest, which were 5.6, 5.9, 3.1 and 9.7 per cent lower than control. The treatment S₅ also recorded a decrease of 16.9, 18.1, 14.9, and 24.4 per cent from control values at 3, 5, 7 and at harvest respectively. Interestingly, all the growth regulator treatments recorded lower phenolics content than control.

M₄S₅ recorded the minimum total phenol content from 3 MAP onwards and it was closely followed by M₄S₇. The interaction effects were significant at all the chosen stages.

4.2.10. Relative water content (%) (Table 16a, 16b)

Relative water content in banana leaves clearly showed increasing trend upto shooting stage. Among the main plot treatments, M₄ (nitrogen 200 g plant⁻¹ + urea 2% foliar spray) and M₃ (200 g nitrogen plant⁻¹) were found to be superior over

control with comparable values at 5 MAP. Nitrogen application at 150 g plant⁻¹ either with (M₂) or without urea spray (M₁) behaved almost uniformly in terms of relative water content. However, the differences were insignificant at 3 and 7 MAP stages.

In subplot treatments, salicylic acid 100 ppm (S₅) had more relative water content at shooting stage (83.63), which was 4.18 per cent increase over control (S₁). This was followed by S₇ (benzyl adenine 20 ppm) with a per cent increase of 3.82. M₄S₅ treatment maintained its superiority over other interactions at all the stages. This was followed by M₄S₇ and M₄S₂. However, the interaction differences were significant only at 5 MAP stage of observation. The results indicated that higher nitrogen level at 200 g plant⁻¹ and foliar spray of salicylic acid at 100 ppm might facilitate banana leaves to maintain higher water status.

4.2.11. Transpiration ($\mu\text{g H}_2\text{O cm}^{-2}\text{s}^{-1}$) (Table 17a, 17b)

Data on transpiration rate revealed there were significant impacts of various plant growth regulators on transpiration rate at all growth stages. However, nitrogen levels failed to elicit any significant differences among themselves.

Among the subplots treatments, high transpiration rate was observed in control plants in all the chosen stages except at 3 MAP, when 2, 4-D and benzyl adenine treatments registered enhanced rates over control. Almost all the growth regulator treatments distinctly recorded lower transpiration rate than control. Among them salicylic acid spray at 100 ppm recorded lowest rate at 3 and 7 MAP (21.8 and 21.4 per cent lower than control respectively), mepiquat chloride and CCC registered lower transpiration rate at 5 MAP and at harvest by 19.5 and 27.2 per cent respectively below the values of control. Among the growth regulators, nitrobenzene, benzyl adenine and 2,4-D showed high transpiration rate almost nearer to that of untreated control plants.

Significant interaction effects were observed in the stages of observation M₂S₈ showed maximum transpiration rate at 3 MAP (8.44) which were comparable with that of M₃S₈. At 5 MAP and at harvest, M₁S₇ revealed lower rates at 5 and 7 MAP; control recorded the highest rate (8.50), on the contrary, M₄S₅ recorded lower rates at 5 and 7 MAP (6.91 and 6.14) respectively. Considering the mean values of all the stages, M₃S₈ recorded the maximum value of 6.97, while M₁S₅ recorded the lowest mean value of 5.10.

4.2.12. Leaf temperature (⁰C) (Table 18a, 18b)

In banana, leaf temperature appeared to decrease consistently with advancement of age of the crop. Doses of nitrogen proved ineffective in producing significant variations during all the stages of crop growth. However, increasing dose of nitrogen decreased the leaf temperature marginally.

But, significant differences were observed among various plant growth regulators at all stages of crop growth. All the growth regulator treatments recorded the leaf temperature below that of control treatment and salicylic acid appeared to lower the leaf temperature consistently in all the stages. Mepiquat chloride and cycocel also reduced the temperature considerably. On the other hand, nitrobenzene (S₆), benzyl adenine (S₇) and 2, 4-D (S₈) effected high leaf temperature among the chemicals tried.

Distinctly, low leaf temperatures were observed in M₄S₂, M₄S₃ and M₄S₅ treatments among various interactions of main and subplot treatments. Main plot treatments in combination with control (S₁) recorded uniformly higher leaf temperatures than other combinations.

4.2.13. Stomatal resistance ($s\text{ cm}^{-1}$) (Table 19a, 19b)

Stomatal resistance in banana clearly established showed an increasing trend upto shooting stage. There existed significant differences in main plot and subplot treatments at all the stages. The interaction effects were also found to be significant at all the growth stages. Among the doses of nitrogen, M_4 was found to be poorer in stomatal resistance than M_3 , M_2 or M_1 by recording 12.7, 29.1 and 5.7 per cent lower values than control at 5, 7 MAP and at harvest stages.

Among the plant growth regulators, salicylic acid spray (S_5) recorded values of 1.46, 5.18, 6.55 and 1.24 at 3, 5, 7 MAP and at harvest which were 19.7, 12.4, 14.3 and 49.4 per cent increase over control respectively. Benzyl adenine (S_7) and 2, 4-D performed poorly with low values in most of the stages. The results indicated that salicylic acid and growth retardant chemicals tended to increase stomatal diffusive resistance, while nitrobenzene, benzyl adenine and 2,4-D appeared to reduce the resistance.

M_1S_1 and M_2S_5 recorded maximum values at 7 MAP (7.98) and at harvest (1.37), while M_4S_5 recording high value at 3 MAP (1.59) and M_3S_4 at 5 MAP (5.49). Very low values were mostly seen in M_4S_7 and M_4S_8 which recorded the lowest mean values of 2.66 by pooling observations of all the stages.

4.3. Nutrient status of leaves

4.3.1. Nitrogen content (%) (Table 20a, 20b)

Results from the experiment showed that nitrogen content increased from 5 MAP to shooting stage. In leaf, the highest value for nitrogen content (3.02) recorded by M_4 (200 g N plant⁻¹+ 2% urea foliar spray) followed by M_3 (200 g nitrogen plant⁻¹) (2.90) at shooting stage when M_1 and M_2 recorded 2.78 and 2.82 respectively. At this stage,

the per cent increase over control for M₄ and M₃ were 8.51 and 4.27, respectively. The treatments differed significantly at all stages.

Among the subplot treatments, salicylic acid 100 ppm (S₅) recorded highest leaf nitrogen content than other plant growth regulators. At shooting stage, the treatment recorded a content of 3.18, which was followed by S₇ (3.08).

In the interaction effects, M₄S₅ was recorded the highest leaf nitrogen content followed by M₄S₇ (3.28) at 7 MAP. Salicylic acid spray (S₅) also recorded increases under each main plot treatment over other subplot treatments.

4.3.2. Phosphorus content (%) (Table 21a, 21b)

Phosphorus content had the same trend as that of nitrogen with maximum values at shooting stage. At shooting stage among the main plot treatments M₄ recorded the highest value of 0.968 followed by M₃ (0.957), which resulted in 2.87 and 1.70 per cent increase over control, respectively.

Among the plant growth regulators, salicylic acid 100 ppm (S₅) recorded the highest content (1.06) followed by benzyl adenine (S₇) (1.04) at 7 MAP which accounted for 43.2 and 40.1 per cent increases over control at shooting stage, respectively.

Obviously, in the interaction treatment, M₄S₅ recorded significantly maximum phosphorus content of 1.09 at 7 MAP, when the control recorded as low as 0.73. The next best interaction combination was M₄S₇ (1.045). Various doses of nitrogen, chemicals and plant growth regulators showed significant differences among themselves at all growth stages except at 3 MAP.

4.3.3. Potassium content (%) (Table 22a, 22b)

Potassium content showed an increasing trend over the period of growth, upto shooting stage. Application of nitrogen 200 g plant⁻¹ +urea 2% foliar spray (M₄) in the main plot significantly increased the potassium content by 3.22 and 1.90 per cent over control at 7 MAP and harvest stages, respectively. Obviously increase in nitrogen dose appears to effect concomitant increase in K uptake in banana.

Among the subplot treatments, salicylic acid 100 ppm (S₅) recorded a value of 4.34, and benzyl adenine 20 ppm (S₇) of 4.31 potassium contents, which were 14.51 and 13.72 per cent increases over control at shooting stage.

Under all the stages of application, nitrogen 200 g plant⁻¹ +urea 2% foliar spray with salicylic acid 100 ppm registered the highest accumulation of potassium content. Next to this, M₄S₇ performed better under all the stages of application.

4.4. Yield and yield components (Table 23a,23b)

Two levels of nitrogen as soil application with or without foliar application of urea were studied in banana cv. Ney Poovan. In each of the above main plot treatments, foliar spray of seven growth regulators in addition to untreated control were tried as sub plots. The effects of these treatments on yield and yield parameters are presented in Tables 23 a and 23 b.

4.4.1. Finger length (cm)

Data on finger length revealed significant differences among main, sub plot and interaction treatments. Finger length ranged from 13.5 cm in M₁ to 14.6 cm in M₃. Both M₃ and M₄ recorded comparable values with 8.1 and 7.4 per cent increased finger length over control. Foliar spray was effective at low nitrogen fertilization of

150 g N plant⁻¹ (M₂) with 5.2 per cent increased value over M₁ (soil application of 150 g N plant⁻¹).

Foliar application of benzyl adenine (S₇) excelled among the growth regulator treatments (15.0 cm) with 11.9 per cent increased fruit length over control. Salicylic acid (S₅) and 2,4-D (S₈) also produced increased fruit lengths by 11.2 and 10.4 per cent respectively over control. All the others except ethrel (S₄) had moderately increased fruit length. The effect of ethrel as was as equal to that of untreated control.

Maximum fruit length of 15.4 cm was recorded in M₄ S₇ followed by both M₂S₅ and M₄S₈ (15.2), which were in par with both M₂S₇ and M₄S₁ (15.1). Incidentally control treatment M₁S₁ recorded the lowest value (12.4).

4.4.2. Fruit girth (cm)

Various treatments exhibited significant differences in finger girth. By increasing nitrogen dose from 150 to 200 g of plant⁻¹, finger girth was increased by 5.52 per cent (from 12.7 in M₁ to 13.4 in M₃). However, giving foliar spray of urea in addition to soil application of N at 150 g plant⁻¹ showed 5.5 per cent increase, and over 200 g plant⁻¹ the foliar spray facilitated 10.2 per cent increase over control.

Benzyl adenine spray (S₇) recorded the maximum finger girths of 14.8 cm (22.3 % increase over control), which was closely followed by S₅ with 14.6 cm (20%) increase. Ethrel produced to the least effect (6.6% increase) among the growth regulators. Benzyl adenine and 2, 4-D showed moderate effects in enhancing fruit girth.

As the higher N dose of 200 g plant⁻¹ plus urea spray had distinctly favoured the fruit girth, growth regulator treatments in combination with high N level produced

elevated stem girth values. Among the interactions, M₄S₅ (15.6 cm) followed by M₄S₇ (15.3 cm) recorded higher fruit girth than others.

4.4.3. Number of hands

The values of number of hands ranged from 8.2 in M₁S₁ to 10.8 both in M₃S₅ and M₄S₇. The differences were significant among growth regulator treatments and interactions. N levels failed to reveal significant differences. But, M₄ recorded 10.2 hands per bunch, while M₁ recording 9.7.

Among the sub plots, number of hands ranged from 9.1 in control to 10.6 in S₅. Other than S₅, S₇ also performed better with 10.5 hands per bunch.

4.4.4. Number of fingers

The data revealed significant differences among M levels, growth regulators and interaction treatments. Maximum number of fingers were observed in M₄ (158.9) followed by M₂ (155.7). Urea were spray over and above soil application of nitrogen, obviously, enhanced the number of fingers, as M₂ and M₄ which received urea spray recorded higher values above their respective dose of nitrogen as soil application (M₁ and M₃).

Number of fingers ranged from 148.5 in S₁ to 161.8 in S₇. Benzyl adenine spray (S₇) increased the number of fingers by 9.0 per cent over that of control. This was followed by S₅ and S₈ with 7.6 and 7.5 per cent increases over control. Though all the growth regulators have performed better than untreated control in terms of finger number, CCC and ethrel treatments showed only negligible increases over control treatment.

Among the interactions, M₄S₇ performed well with maximum finger number of 168.6 followed by M₄S₈ (165.4) and M₄S₅ (165.2). The results indicated that the

growth promoters, namely benzyl adenine and 2, 4-D or salicylic acid in collaboration with higher N dose might increase the finger number favourably.

4.4.5. Finger weight (g)

Significant differences were revealed in all aspects with regard to finger weight. By increasing nitrogen level from 150 g plant⁻¹ to 200 g plant⁻¹, the finger weight was increased from 50.1 to 56.5 g. By giving foliar spray over 150 g plant⁻¹, there was a seven per cent increase in finger weight. But, there was no such increase when foliar spray was given over 200 g plant⁻¹. But, a slight reduction was observed.

Maximum fruit weight of 57.2 g was recorded by S₅ (salicylic acid), which was 9.8 per cent increase over control. The other growth regulators which have favourably increase finger weight are S₇ (benzyl adenine) and S₈ (2, 4-D) with increases of 6.7 and 5.8 per cent respectively over control. Evidently, ethrel spray (S₄) resulted in lower finger weight than untreated control. Mepiquat chloride and nitrobenzene also showed negligible influences on finger weight.

Among the interactions, finger weight ranged from 46.7 in M₁S₂ to 60.5 in M₃S₅. Apart from M₃S₅, the other better performing treatments in terms of finger weight are M₃S₈ (59.5) and M₄S₅ (58.5).

4.4.6. Bunch weight (kg)

Data on bunch weight revealed that the values ranged from 9.85 to 13.65 and the differences among main, sub plots and interactions were significant.

Distinct increase in bunch weight with increase in the dose of nitrogen, applied to banana crop, was exhibited. The bunch weight in M₁ (150 g nitrogen plant⁻¹) was 10.70 kg, whereas, by giving urea spray above this level (M₂), there was 7.6 per cent increase in bunch weight. In M₃ (200 g N plant⁻¹) the bunch weight was 12.20 kg

(14.0% increase), while giving urea spray over this dose resulted in 15.5 per cent increase in bunch weight over control. It is clear from the present study that bunch weight could be increased by increasing the nitrogen dose to 200 g plant⁻¹, and by giving urea spray at two per cent level, additional yield might be attained.

The maximum bunch weight of 12.58 kg was recorded by giving foliar spray of salicylic acid at 100 ppm level, which resulted in 13.9 per cent increase over untreated control. Benzyl adenine treatment also performed better with 12.52 kg bunch weight and 13.4 per cent increase over control. 2, 4-D also revealed its usefulness by enhancing bunch weight upto 8.4 per cent. The other growth regulators revealed very low influence in increasing bunch weight. However, etrel spray adversely affected the bunch yield by reducing the weight by one per cent below that of control.

As higher nitrogen level showed profound influence on bunch weight in the present study, the growth regulator treatments in combination with higher nitrogen levels also performed better. Among the interactions, M₄S₅ recorded the highest bunch weight of 13.65 kg followed by M₄S₇ (13.28 kg) and M₃S₇ (13.16 kg). The results clearly indicated that 200 g N plant⁻¹ as soil application in addition to two per cent urea spray, and foliar spray of either 100 ppm salicylic acid or 20 ppm benzyl adenine might result in increased fruit yield in banana cv. Ney Poovan.

CHAPTER -V

DISCUSSION

The healthy and robust vegetative frame is an essential prerequisite for obtaining high yields in bananas, and for the formation of such a desired vegetative frame, nitrogen plays an important role. Bananas, in general, are responsive to nitrogen in the early vegetative stages of growth, when sufficient pseudostem and leaf growth have to take place to produce a bigger bunch later. The beneficial aspects of increased source development by giving optimum nitrogen dose have to be utilized for better sink production later with the intention of getting an appreciable yield. Growth regulators are being used widely in many crops to manipulate the source-sink relationship for yield advantage.

Two nitrogen levels, namely soil application of 150 and 200 g plant⁻¹ with or without foliar application of urea at two per cent level were the four nitrogen doses, tried to manipulate the source size in banana cv. Ney Poovan. Seven growth regulating chemicals were tried by foliar spray to study their effects in transforming the anticipated advantage in vegetative growth as a result of increasing nitrogen supply towards increasing sink size and activity with the ultimate aim of obtaining a good yield in banana. The results obtained from the present study are discussed hereunder with relevant research works carried out in the related areas.

5.1. Effect of different levels of nitrogen and certain plant growth regulators on growth attributes of banana cv. Ney Poovan

In banana, a good vegetative growth is essential for getting higher yield and robust frame of the plant is decided by the **pseudostem height** and girth. Simmonds (1966) emphasized that the height and girth of pseudostem are important parameters to judge the vigour of banana. In the present investigation, pseudostem height was

consistently increased with increase in nitrogen dose by soil application of nitrogen from 150 g plant⁻¹ to 200 g plant⁻¹ and also by giving foliar spray of urea at two per cent level (Fig.1). The increase in pseudostem height in 200 g N plant⁻¹ in addition to urea spray was as high as about 26 per cent over that of 150 g N plant⁻¹. The findings concurred with that of Jeeva (1987), Thangaselvabai (1989), and Rajan (1994). Enhancement of pseudostem height was facilitated effectively by salicylic acid spray at 100 ppm in this study. Benzyl adenine was also found effective next to salicylic acid. However, reduction in height was distinctly observed in chlormequat chloride (CCC), ethrel and mepiquat chloride treated plants. These treatments recorded reduced pseudostem heights well below that of untreated plants with about 13 per cent decrease. The reduction in height by chlormequat chloride and mepiquat chloride is due to their antigibberellin effect by blocking the conversion of geranyl pyrophosphate in the gibberellic acid biosynthesis pathway (Moore, 1980). Anitha, (2003) recorded similar reductions in banana cv. Grand Nain. The increase in pseudostem height by salicylic acid might be due to its synergistic interaction with available endogenous auxin as reported by Datta and Nanda (1985) in cheena millet, and Zhao and Lin (1993) in soybean. The increase in pseudostem height by salicylic acid spray, in the present study, is in consonance with the findings of Anitha (2003). The combination of soil application of 200 g nitrogen plant⁻¹ with foliar spray of urea and salicylic acid enhanced the pseudostem height to the maximum extent due to complementary effects.

Unlike the generous increase in pseudostem height by nitrogen, the **pseudostem girth** was increased only moderately by about two per cent with the increased dose of nitrogen. An increase in shoot dry weight with increase in nitrogen supply appears to be common in both perennial and annual plant species (Levin *et al.*, 1989; Olsthoorn and Tiktak,1991; Hocking and Meyer, 1991). The promotive effect

of nitrogen in increasing pseudostem girth is in accordance with the results of Chattopadhyay *et al.* (1980), Prabhuram (1992), and Rajan (1994). In the present study, the decrease in plant height was compensated by attendant increase in girth by the growth retardants namely, CCC, mepiquat chloride and etrel (Fig.2). Anitha (2003) observed increased girth in 1000 ppm CCC spray. In cv. Nendren, Vijayalakshmi and Mathan (2000) recorded significant increase in stem girth by spraying cytozyme which is learnt to have cytokinin effect. But benzyl adenine showed only moderate increase in pseudostem girth to the tune of 6 to 8 per cent increase over control. During 5-7 MAP, in the present study, very low pseudostem girth increase was observed in 2,4-D treated plants.

Maintenance of higher **number of functional green leaves** is essential to harness light energy, and in determinate types like banana retaining more green leaves upto harvest may favour current photosynthesis during bunch development (Satheesh kumar, 2002). Enhancement of leaf number in banana by increasing the dose of nitrogen fertilization has been reported by many workers (Jeeva, 1987; Thangaselvabai, 1989; Rajan, 1994). A distinct increase in functional leaf number was observed with the increase in nitrogen dose in the present study (Fig.3), upto 7 MAP. At harvest also, the green leaf number was high, but with reduced difference, in plants that received high nitrogen dose. Foliar spray of urea appeared to set distinct advantage in terms of maintaining increased green leaf number over respective dose of N application in soil. Umadevi (1998) obtained significant increase in leaf number by giving foliar spray with urea. By post-shooting foliar application of urea, Satheesh kumar (2002) recorded more number of green leaves at harvest in cv. Rasthali. Similar results were obtained by Ancy *et al.* (1998) in cv. Nendren. The increase in leaf number, as a result of urea spray, might be due to delayed abscission of leaves (Leece and Kenworthy, 1971).

Data of the present investigation revealed that salicylic acid spray was the most efficient among the chosen growth regulators in maintaining highest green leaf number throughout the ontogeny of the banana crop. Next to salicylic acid, the performance of benzyl adenine was also good. Although all growth regulators including growth retardants had revealed positive influence on leaf number, the effect of ethrel was the least.

Anitha (2003) recorded increased leaf number, consequent to CCC spray. In the present study, CCC did increased the number to the tune of about 11 per cent at harvest, but the increase was not as effective as that of salicylic acid and benzyl adenine treatments.

Being a determinate crop, the total number of leaves produced by a banana pseudostem is almost constant (Simmonds, 1966). But, the **phyllochron** which is the time interval between two successive leaf emergences in any chosen stage becomes important as the early production of leaves may facilitate more efficient light utilization. Even as early as 1960, Murray indicated that the rate of leaf production is under the influence of nutrients. The present study (Fig.4) clearly indicated that the interval between two successive leaf emergence decreased with increasing the dose nitrogen fertilization, and this result is in confirmation with earlier works (Jeeva, 1987; Rajan, 1994). Among the growth regulators, salicylic acid spray at 100 ppm was very effective with about 24 and 31 per cent reduction in phyllochron at 5 and 7 MAP respectively. Benzyl adenine also was found to be useful in quickening the leaf production. Except ethrel, which produced only minimum effect, the other growth regulators had moderate influences in reducing the time interval between two leaves. Anitha (2003) also attained low time interval by spraying 1000 ppm CCC in cv. Grand Nain.

Leaf area being the fundamental determinant of the rate of photosynthesis of any plant, optimum leaf area development aids in effective interception of light energy and facilitates higher dry matter production (Shibles and Webber, 1966). Typical nitrogen induced changes in leaf morphology are increases in length, width and area of leaf blades, but the decrease in thickness, as reported by Yoshida *et al.* (1969). There was attendant increase in leaf area with the increment in nitrogen dose (Fig.5). The increase was conspicuously revealed by urea spray. The leaf spread was more prominent in salicylic acid treatment, which recorded more than 20 per cent increase in leaf area over untreated control at every stage of sampling. The treatment managed to maintain maximum green leaf area at harvest which was as high as about 47 per cent over control. All the chosen growth regulators have positively influenced the leaf area, but salicylic acid and benzyl adenine were found very effective, while others having only moderate influence. Anitha (2003) found increased leaf areas in brassinosteroid, nitrophenol and salicylic acid treated plants. The supreme influence of salicylic acid in increasing leaf area might be due to its effect on enlarging epidermal cells of leaves as stated by Zhang *et al.* (1987). Although the growth retardants showed better leaf area values than untreated plants, the reason for moderate increases by these chemicals might be due to their mode of action in effecting more increase in leaf thickness than in leaf girth.

Leaf area reductions in sunflower due to CCC application (Pando and Srivastava, 1985), and by mepiquat chloride in cotton (Xu and Taylor, 1992) were attributed to reduced cell division and cell enlargement by reducing GA level.

Banana is known to have higher optimum **leaf area index** than many of the cultivated crops (Simmonds, 1966). Both higher nitrogen levels and salicylic acid spray facilitated the banana cultivar cv. Ney Poovan to maintain high LAI at any

chosen stage. Stover (1984) indicated that the critical LAI for optimum utilization of photosynthetically active radiation in banana ranged from 4-4.5. High LAI was maintained in the present study by increased N fertilization and by either salicylic acid or by benzyl adenine treatment. During shooting (7 MAP) and at harvest, LAI values were more than 5.3 and 4.5 respectively in plants receiving 200 g N and urea spray. The effectiveness of urea spray and also increased N fertilization was clearly felt in the present study.

5.2 Effect of different levels of nitrogen and certain plant growth regulators on biochemical attributes of banana cv. Ney Poovan

Both **chlorophyll a** and **b**, and **total chlorophyll** were increased with the increased levels of nitrogen, and the effect of foliar spray of urea had pronounced influence. High nitrogen level appeared to have more impact on chlorophyll b than on chlorophyll a.

Being a constituent of chlorophyll, increased nitrogen supply might have accelerated the synthesis of more chlorophyll pigments (Kohli *et al.*, 1984). Mahadevan (1988) also observed higher chlorophyll content in cv. Nendren with foliar application of urea. Among the growth regulators, salicylic acid and benzyl adenine were more efficient in increasing the contents of chlorophyll a and b. The effects of these treatments were obviously high on chlorophyll a. Increase in chlorophyll content by salicylic acid spray was reported by many early workers in different crops (Setia *et al.*, 1995; Kalpana, 1997; Sivakumar, 2000). The reason adduced for enhanced chlorophyll biosynthesis by phenolic substances was that the phenolics inhibited chlorophyllase enzyme which led to higher accumulation of chlorophyll (Paricha *et al.*, 1977). All the chosen growth regulators in the present study (Fig.6) favoured higher chlorophyll content as compared to untreated control. Among the growth retardants, CCC appeared to have greater effect than others in increasing chlorophyll

content. Anitha (2003) recorded increased chlorophyll content in banana plants treated with CCC at 1000 ppm.

Chlorophyll stability index has been considered as an useful parameter for resisting the degradation of chlorophyll pigments under different stresses (Koleyoreas, 1958; Murty and Majumder, 1962; Sanandachary, 1978). Compared to the effects of growth regulating chemicals, nitrogen levels had low response on chlorophyll stability index (Fig.7). Salicylic acid appeared to effect greater stability to chlorophyll pigments than others, which recorded 21.6 per cent increased chlorophyll stability over untreated plant. Benzyl adenine and 2,4-D also were better. The other growth regulators also performed moderately and better than control. Anitha (2003) showed higher chlorophyll stability index while by applying CCC at 1000 ppm.

The indicated function of **chlorophyll fluorescence** is that fluorescence emission is complementary to alternative pathway of de-excitation, which is primarily related to photochemistry and heat decipation. Fluorescence yield will be high when PS II reaction centre is least damaged by photoinhibition. In green leaves, above 95 per cent of the emitted fluorescence at 658 nm is reabsorbed by chlorophylls of the leaf. F_v/F_m is a useful measurement which is proportional to quantum yield, and shows a high degree of photosynthesis (Gitelson *et al.*, 1998). In the present investigation (Fig.8), nitrogen fertilization showed profound influence on chlorophyll fluorescence as there was concomitant increase in fluorescence value with the increase in nitrogen dose. But, more pronounced effects were observed for various growth regulators, among which, salicylic acid recorded maximum increases ranging from 34 to 36 per cent over control between shooting and harvest. The other better performing growth regulator is benzyl adenine. Anitha (2003) observed that CCC at 1000 ppm registered the highest chlorophyll fluorescence in Grand Nain banana. But

the performance of CCC was not as good as that of salicylic acid and benzyl adenine in the present study.

Soluble protein serves an indicator of photosynthetic rate, since Rubisco forms more than 50 per cent of soluble protein in leaves of many plants (Joseph *et al.*, 1981). Millard (1988) indicated that as nitrogen supply was increased, a higher proportion of assimilated nitrogen was sequestered in storage pools especially in the chloroplast, mainly in the form of Rubisco. This appears to be true as about 28 mg g⁻¹ soluble protein content was recorded at 7 MAP (Fig.9), in plants that received 200 g N plant⁻¹ plus urea spray, while other treatments which received lesser N recorded soluble protein contents below 24.12 mg g⁻¹. The content was maximum, when salicylic acid was sprayed at 100 ppm and increase in content was above 22 per cent at 5 MAP and above 30 per cent both at 7 MAP and harvest over that of untreated plants. The content was also high in benzyl adenine treatment with more than 27 per cent increase after 7 MAP. It is pertinent to note that all the growth regulators studied were found effective in enhancing soluble protein content over that of control. Anitha (2003) recorded more soluble protein content in CCC sprayed plants. El-Tahawi *et al.* (1983) reported increased protein synthesis and aminoacid content in *Phaseolus vulgaris* due to cycocel application.

Nagasubramanium (2003) recorded higher soluble protein content in maize leaves when mepiquat chloride and salicylic acid were sprayed. In rice, Maibangsa *et al.* (1999) revealed that mepiquat chloride and salicylic acid treatments significantly increased soluble protein content which led to increased biomass production.

The role of **nitrate reductase** in the process of nitrate reduction is a primary factor for crop growth. As utilization of N depends upon this enzyme, high activity of

this enzyme was related to yield and protein content of many crops (Mishra *et al.*, 1980).

A definite increase in nitrate reductase activity with the increase in nitrogen level was observed in the present study (Fig.10). However, the effects of many of the chosen growth regulators were more prominent than the nitrogen levels. More than 15 per cent increase in activity was observed at 7 MAP as a result of either salicylic acid spray or benzyl adenine spray. Salicylic acid treatment was particularly efficient among the growth regulators with more than 32 per cent increased activity over control from 5 MAP onwards. Apart from salicylic acid and benzyl adenine, CCC and mepiquat chloride also effected substantial increases in the activity. The effective increase in nitrate reductase activity by salicylic acid was confirmed by many workers (Leslie and Romani, 1988; Jagadish Rane *et al.*, 1995; Kalpana, 1997). Salicylic acid was assumed to increase nitrate reductase activity by protecting the enzyme from inactivation (Gehlot *et al.*, 1998).

Lu *et al.*, (1992) stated that the well known increase in nitrate reductase activity by cytokinin was expressed at the level of nitrate reductase – mRNA, which was increased by cytokinin. This might be the reason for the good performance of benzyl adenine, a synthetic cytokinin, in the present study.

In the present study, **IAA oxidase activity** values, which were the measures of unoxidised auxin contents, indicated that with the increase in nitrogen application, the unoxidised auxin content increased concomitantly and hence, maximum unoxidised auxin was at 200 g plant⁻¹ plus foliar application of urea. Among the growth regulators, salicylic acid treatment was very effective with maximum unoxidised auxin values at every chosen stage of observation, which was followed by benzyl adenine and cycocel. Very poor response was noticed in ethrel treated plants. Sivakumar (2000) revealed that salicylic acid was capable of inhibiting IAA oxidase

activity, and thereby increased the auxin content which was in agreement with the present finding. Jose *et al.* (1991) had confirmed that phenolics had the property to suppress IAA destruction. Salicylic acid, being a phenol, might have reduced the IAA oxidase activity and enhanced unoxidised auxin content.

The inhibitory effect of nitrogen on **total phenolics content** was clearly revealed in the present study, as there was attendant decrease in phenolic content with the increase in nitrogen dose. All the growth regulator treatments also acted against accumulation of phenolic content. Lowest contents were observed in salicylic acid treated plants at different growth stages. The content was also effectively reduced by benzyl adenine treatment. The reduction of phenolic content was at low level in ethrel treatment, and in others the decrease was moderate. Salicylic acid, itself being a phenol, might not have encouraged the synthesis of other phenols.

Relative water content was moderately promoted by nitrogen application. It appeared that under well watered situations, nitrogen application also might help in maintaining better tissue water status. But, Satheesh kumar (2002) obtained decreased RWC values in urea sprayed banana plants and revealed the vulnerable water status of urea sprayed leaves. It is to be noted that increased nitrogen application have facilitated in the increased uptake of potassium from the soil, as the K contents of leaves were high in high nitrogen treatments, as reported elsewhere in this chapter. The increased K content in the leaves would have taken care of the water status of the leaves.

Salicylic acid and benzyl adenine appeared to have good effect in maintaining higher moisture status. Salicylic acid is known to change the membrane organization, thereby increasing the mobility of nutrients (Jain and Srivastava, 1981). Many phenolics also act as chelating agents and help in restricting the movement of nutrients (Marschner,

1995). By retaining nutrients within the cell the osmotic effect will have been created for retaining more cellular water.

The effect of nitrogen application in altering **transpiration** was not noticed significantly (Fig.11). However, all the growth regulators chosen for the present study showed their distinct impacts in lowering transpiration rate. Salicylic acid and mepiquat chloride were very effective in lowering rate of transpiration. The known growth promoters namely nitrobenzene, benzyl adenine and 2,4-D, on the other hand, failed to reveal any tangible effects. The effect of salicylic acid in reducing the rate of transpiration was confirmed in previous works (Saavedra, 1978).

Nitrogen produced only negligible effect on **leaf temperature** changes in banana. Salicylic acid, mepiquat chloride and cycocel were effective in reducing leaf temperature below that of control. On the other hand, nitrobenzene, benzyl adenine and 2,4-D had higher leaf temperature values. The reduced leaf temperature values in certain growth regulator treatments might be attributed to the maintenance of better water status in leaf tissues.

By increasing nitrogen dose or by giving urea spray, **stomatal resistance** was found to decrease (Fig.12). Among the growth regulators, salicylic acid was found more effective in increasing stomatal resistance, while benzyl adenine performed poorly with low values. Apart from benzyl adenine, nitrobenzene and 2,4-D also showed low stomatal resistance. As stomatal resistance is an useful parameter in identifying drought resistant character, salicylic acid appears to be an useful tool for inducing resistance to drought. Eris (1983) observed significant increase in stomatal resistance in pepper with salicylic acid treatment. Anitha (2003) reported promotory effect of cycocel treatment on stomatal resistance in banana leaves, which is in

conformity with the present findings as all growth retarding chemicals including CCC (cycocel) maintained positive influence on stomatal resistance.

5.3 Effects of different levels of nitrogen and certain plant growth regulators on leaf nutrient status of banana cv. Ney Poovan

Depending on the development stage and organ, the leaf **nitrogen content** required for optimal growth varies between two and five per cent of the plant dry weight (Marschner, 1995). Leaf N content, in the present study (Fig.13), ranged from 1.73 to 3.02 per cent and the content increased upto shooting (7 MAP), which later started declining. As expected, leaf nitrogen content increased with the increasing N supply at 7 MAP and 8.6 per cent increase was observed in 200 g N plant⁻¹ plus to urea spray, whereas the increase was only 4.3 per cent in the same level without urea spray. This indicated the effective intake of N by banana leaves from the foliar applied urea. Nagasubramaniam (2003) observed similar increase in babycorn leaves sprayed with urea. Kalarani (1991) and Kalpana (1997) also reported such increases in leaf N content with urea spray in soybean and rice respectively.

All the growth regulator treatments showed significant increases in leaf N content over that of untreated plant. The increases ranged from 19 to 40 per cent at 5 MAP, from 10 to 29 per cent at 7 MAP, and from 18 to 29 per cent at harvest. Salicylic acid spray appeared to be more effective in increasing leaf N content at every stage of sampling, and the least effect was with ethrel treatment. In cv. Grand Nain, Anitha (2003) observed similar increases for salicylic acid, brassinolide and mepiquat chloride treatments. The increased uptake of nitrogen in salicylic acid treated plants which was explicitly revealed in terms of leaf nitrogen content, might be due to the direct role of salicylic acid in altering root physiology, growth and root hair production, and thus affecting soil processes related to nutrient availability (Jose *et al.*, 1991).

Both nitrogen doses and growth regulator treatments appeared to have positive role's in increasing P uptake and maintaining high **leaf P content** in leaves of banana in all the growth stages (Fig.14) . The demand, created in energy supply for reducing more nitrogen, might have influenced the increased uptake of P, as nitrogen reduction is an energy dependent process. Salicylic acid and benzyl adenine treatments helped in accumulating more P contents in leaves than other growth regulators. The increased uptake of P due to salicylic acid spray might be due to its role in altering root physiology as stated in the previous para. Anitha (2003) found similar increase in P content with salicylic acid spray. Frang *et al*, (1983) and Jawahararaj and Sivaprakasam, (1994) reported the influences of growth regulators on leaf P content. The beneficial effects of cycocel spray in increasing P status of leaf were reported in soybean (Harshan Singh *et al.*, 1987), and in wheat (Bhati and Rathore, 1988).

Leaf potassium content in banana appeared to be favourably influenced by nitrogen application, as the leaf K content showed increments with increase in N dose (Fig.15). It is also noted that urea spray showed positive impact on leaf K content. Kalarani (1991) and Sivakumar (2000) observed similar results. But, Rajan (1994) recorded reciprocal association between leaf nitrogen and leaf potassium contents. The reason for decreased potassium content in leaves was attributed to efficient K utilization when the plant growth was enhanced by increased nitrogen levels. Benzyl adenine was more effective in increasing K content of banana leaf. CCC, salicylic acid and mepiquat chloride also were favourable in increasing K content. The reason for maintaining higher tissue water status by these growth regulators might be due to the elevated K contents of leaves in these treatments, as K is considered as the best compatible osmolyte among the nutrient elements (Lahav, 1973).

5.4. Effect of different levels of nitrogen and certain plant growth regulators on yield and yield components of banana cv. Neypoovan

The ultimate aim of any farmer will be to get maximum fruit yield with quality. If all the growth and physiological parameters are favourably settled, then the cumulative response could be manifested in terms of high fruit yield.

Increase in **finger length** was favoured by higher dose of nitrogen but giving urea spray over and above 200 g N plant⁻¹ as soil application showed only negative influence on finger length. On the other hand, **finger girth** was substantially increased by urea spray in addition to soil application of N. Satheeshkumar (2002) also stated that urea spray tended to influence fruit circumference as compared to fruit length. Salicylic acid and benzyl adenine, which influenced many of the parameters in the present study, also revealed greater influence on finger girth than on finger length. Except ethrel, the other growth regulators tended to increase both finger length and finger girth. But, ethrel failed to show any influence on finger length, but had a moderate influence in increasing finger girth only.

Nitrogen levels showed only negligible influence on **number of hands per bunch**. But, the number was found high in higher dose of nitrogen. Ashok kumar and Shanmugavelu (1978), and Ramaswamy and Muthukrishnan (1974) obtained significant increases in number of hands by increasing N levels either by foliar application of urea or by soil application. Salicylic acid and benzyl adenine revealed greater influences in increasing the number of hands per bunch. Ethrel spray appeared to have a better influence on number of hands, while the treatment failed to show any positive effect on other yield components.

Number of fingers per bunch and **finger weight** decide the bunch weight and hence, are very valuable yield components in banana. The influence of nitrogen levels was more on finger weight than on finger number. However, maximum values in both

the parameters were with high nitrogen dose. Giving urea spray, in addition to soil application, showed beneficial effect on these characters explicitly. Ramaswamy and Muthukrishnan (1974) observed significant correlation between leaf nitrogen and number of fingers. Chattopadhyay *et al*, (1980) also reported that number of fingers were increased significantly with N application. Among the growth regulators, the effect of benzyl adenine was in promoting finger number, while salicylic acid tended to increase finger weight. Ethrel which had very negligible influence on these two parameters. The regulators had varying degrees of positive influences on these traits. Anitha (2003) recorded increased fruit weight in cycocel and mepiquat chloride treated trees. Chattopadhyay *et al*. (1980) attributed increased fruit weight due to high N dose for obtaining greater bunch weights.

There was concomitant increase in **bunch weight** with increase in nitrogen dose. The results revealed the benefit of giving urea spray in addition to soil application, as was seen in bunch weight (Fig.16). Srikul and Turner (1995) observed increased fruit growth rate in banana with the increase in nitrogen dose. Several workers have reported increased bunch yield with high N levels at 200 g N plant⁻¹ or nearer to this dose (Ramaswamy and Muthukrishnan, 1974; Chattopadhyay *et al*, 1980; Nalina, 2002). As a culmination of favourable effects of major yield components, namely number of hands, number of fingers and finger weight, obtained by salicylic acid treatment, the maximum bunch weight of 12.58 kg was recorded in this treatment. However, Anitha (2003) reported higher bunch weight in CCC treated plants than in salicylic acid treatment. CCC treatment also increased the bunch weight by 3.8 per cent over that of control treatment, but the increase was not as high as that of salicylic acid or benzyl adenine, which are the better performing growth regulators as far as the present investigation is concerned.

5.5. Correlation studies

The relationships of various parameters with final fruit yield are furnished in Table 24. Among the growth characters, number of green leaves retained at the time of shooting had greater influence ($r = 0.904$) than others. At harvest also, the green leaf number had a better relationship ($r = 0.835$) with yield. Pseudostem height appear to influence the fruit yield ($r = 0.670$), while pseudostem girth did not reveal any response. Leaf area at harvest appears to be relatively more important ($r = 0.751$) than leaf area at shooting. So also, the total chlorophyll content at harvest revealed a strong relationship with yield. But, chlorophyll fluorescence at shooting alone showed a good relationship with yield, rather than at harvest.

Soluble protein and unoxidised IAA content at shooting were found to be closely related to final fruit yield. Phyllochron and total phenolics showed significant negative relationship with yield. Both high leaf N and K contents at shooting are important for increased fruit yield, whereas, leaf P content has to be high at harvest. Salicylic acid and benzyl adenine treatments had influenced many of these favourable traits. These treatments ultimately brought out enhanced fruit yields in banana cv. Neypoovan in association with high N level at $200 \text{ g N plant}^{-1}$ along with urea spray.

The present investigation brought out that for the banana cultivar Ney Poovan, the nitrogen dose as soil application can be enhanced to the level of $200 \text{ g N plant}^{-1}$ for getting higher fruit yield, and giving urea spray at two per cent concentration during 3rd, 5th and 7th month after planting might enhance the fruit yield further. Among the growth regulators, good response in terms of increased fruit yield could be realized by spraying either salicylic acid at 100 ppm or benzyl adenine at 20 ppm during 3rd, 5th and 7th month after planting.

CHAPTER - VI

SUMMARY

The results of the investigation are summarized below

1. Application of nitrogen at 200 g plant^{-1} as soil application and two per cent urea foliar spray combined with salicylic acid treatment recorded maximum pseudostem height and girth at 7 MAP.
2. Application of nitrogen 200 g plant^{-1} and salicylic acid 100 ppm maintained more number of leaves and leaf area on 7 MAP. But a steep reduction in number of leaves and leaf area was noticed in the plants treated with ethrel. Leaf area at shooting and harvest stage revealed good relationship with bunch weight. Superiority of salicylic acid in production of leaves in quick succession was observed.
3. Total chlorophyll and its fractions, such as, chlorophyll a and b in leaf were high in salicylic acid treated plants followed by benzyl adenine sprayed plants. Decreased chlorophyll degradation and increased chlorophyll synthesis through the inhibition of chlorophyllase enzyme activity and higher translocation of photoassimilates of fruits might have caused increased chlorophyll content.
4. Soluble protein in leaf, an index of photosynthetic efficiency increased in salicylic acid followed by benzyl adenine treated plants due to enhanced activation of Rubisco enzyme.
5. Increased nitrate reductase activity was recorded in the plants supplied with $200 \text{ g nitrogen plant}^{-1}$ with urea foliar spray plus salicylic acid at 100 ppm. The activity at shooting stage showed significant positive relationship with bunch yield.
6. Increase in IAA oxidase activity at shooting adversely affected bunch yield. It showed negative relationship with NRase. IAA oxidase activity was low

when the plants are supplied with 200 g nitrogen plant⁻¹ with urea spray. Salicylic acid at 100 ppm was found capable of reducing IAA oxidase activity.

7. Net photosynthesis and stomatal conductance revealed very high positive relationship with bunch yield, which were showing high rates at shooting stage in plants receiving nitrogen 200 g plant⁻¹ with urea two per cent foliar spray and salicylic acid 100 ppm as combined spray.
8. Nitrogen accumulation was high in leaves of both salicylic acid and benzyl adenine sprayed plants. Nitrogen application at the rate of 200 g plant⁻¹ along with two per cent urea spray showed more leaf nitrogen content. Phosphorus accumulation in leaves was also more in the plants receiving nitrogen at 200 g plant⁻¹ with foliar spray of urea. Salicylic acid recorded higher leaf P than other growth regulators. Both N and P accumulations exhibited highly positive relationship with bunch yield.
9. Potassium accumulation in leaves was high in salicylic acid treatment which might be attributed to altering the root physiology, growth rate and root hair formation, thus affecting soil processes related to the nutrient availability by salicylic acid.
10. The yield and yield components were enhanced by high nitrogen fertilization of 200 g N plant⁻¹ and foliar spray of urea. Salicylic acid and benzyl adenine spray produced further improvement in fruit yield. The enhancement in fruit yield by these treatments was by increasing finger number per bunch and finger weight.
11. The results indicated that soil application of 200 g N plant⁻¹ in three splits along with urea spray at two per cent concentration during third, fifth and seventh month after planting might be advocated for getting high fruit yield in banana cv. Ney Poovan. Additionally, by giving either salicylic acid spray at 100 ppm or benzyl adenine spray at 20ppm could further increase the yielding ability of the cultivar.

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Table 1a. Effect of different levels of nitrogen and plant growth regulators on pseudostem height (cm) at different growth stages of banana cv. Ney Poovan (Main effect)

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|---------|--------------|
| Main Plot | | | | | | | |
| M₁ | 50.5 | (0.0) | 130.3 | (0.0) | 173.6 | (0.0) | 118.1 |
| M₂ | 50.3 | (-0.4) | 135.7 | (4.1) | 174.4 | (0.5) | 120.1 |
| M₃ | 50.5 | (0.0) | 160.9 | (23.5) | 183.3 | (5.6) | 131.5 |
| M₄ | 50.2 | (-0.6) | 163.7 | (25.6) | 188.1 | (8.4) | 134.0 |
| Mean | 50.4 | | 147.6 | | 179.8 | | 125.9 |
| CD (p=0.05) | NS | | 0.621 | | 0.793 | | |
| Sub Plot | | | | | | | |
| S₁ | 50.5 | (0.0) | 146.0 | (0.0) | 182.5 | (0.0) | 126.3 |
| S₂ | 49.9 | (-1.2) | 136.7 | (-6.4) | 158.3 | (-13.3) | 115.0 |
| S₃ | 50.4 | (-0.2) | 137.8 | (-5.6) | 160.1 | (-12.3) | 116.1 |
| S₄ | 50.7 | (0.4) | 136.4 | (-6.6) | 158.5 | (-13.2) | 115.2 |
| S₅ | 50.4 | (-0.2) | 162.4 | (11.2) | 199.9 | (9.5) | 137.6 |
| S₆ | 50.2 | (-0.6) | 152.2 | (4.2) | 189.4 | (3.8) | 130.6 |
| S₇ | 50.8 | (0.6) | 158.4 | (8.5) | 198.4 | (8.7) | 135.9 |
| S₈ | 50.2 | (-0.6) | 151.3 | (3.6) | 191.5 | (4.9) | 131.0 |
| Mean | 50.4 | | 147.6 | | 179.8 | | 126.0 |
| CD (p=0.05) | NS | | 1.337 | | 1.623 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 1b. Effect of different levels of nitrogen and plant growth regulators on pseudostem height (cm) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Mean |
|-----------------------------------|--------------|--------------|--------------|--------------|
| Interaction effect | | | | |
| M₁S₁ | 50.9 | 129.5 | 176.4 | 118.9 |
| M₁S₂ | 49.3 | 125.8 | 156.3 | 110.5 |
| M₁S₃ | 51.1 | 126.9 | 158.8 | 112.3 |
| M₁S₄ | 49.9 | 127.5 | 156.9 | 111.4 |
| M₁S₅ | 51.3 | 136.4 | 189.9 | 125.9 |
| M₁S₆ | 50.3 | 130.8 | 183.2 | 121.4 |
| M₁S₇ | 51.4 | 134.5 | 187.2 | 124.3 |
| M₁S₈ | 49.8 | 131.8 | 182.9 | 121.5 |
| M₂S₁ | 49.2 | 132.4 | 178.8 | 120.1 |
| M₂S₂ | 49.7 | 126.8 | 159.2 | 111.9 |
| M₂S₃ | 50.0 | 127.8 | 159.3 | 112.4 |
| M₂S₄ | 51.1 | 127.3 | 157.5 | 111.9 |
| M₂S₅ | 50.4 | 147.2 | 189.9 | 129.1 |
| M₂S₆ | 50.1 | 138.8 | 180.1 | 123.0 |
| M₂S₇ | 51.3 | 146.0 | 189.6 | 129.0 |
| M₂S₈ | 50.9 | 141.7 | 183.4 | 125.3 |
| M₃S₁ | 51.5 | 153.9 | 187.0 | 130.8 |
| M₃S₂ | 51.1 | 146.5 | 159.2 | 118.9 |
| M₃S₃ | 49.5 | 146.9 | 160.9 | 119.1 |
| M₃S₄ | 50.5 | 144.4 | 159.4 | 118.1 |
| M₃S₅ | 51.1 | 189.5 | 202.4 | 147.7 |
| M₃S₆ | 49.5 | 166.0 | 195.4 | 137.0 |
| M₃S₇ | 51.0 | 178.2 | 203.4 | 144.2 |
| M₃S₈ | 49.8 | 162.1 | 198.9 | 136.9 |
| M₄S₁ | 50.2 | 168.2 | 188.0 | 135.5 |
| M₄S₂ | 49.4 | 149.0 | 160.2 | 119.5 |
| M₄S₃ | 51.1 | 149.4 | 161.3 | 120.6 |
| M₄S₄ | 51.5 | 146.8 | 160.5 | 119.6 |
| M₄S₅ | 49.0 | 178.0 | 219.3 | 148.8 |
| M₄S₆ | 50.9 | 172.2 | 200.1 | 141.1 |
| M₄S₇ | 49.3 | 176.0 | 214.9 | 146.7 |
| M₄S₈ | 50.4 | 170.1 | 201.0 | 140.5 |
| Mean | 50.4 | 147.8 | 180.0 | 126.1 |
| CD (p=0.05) | | | | |
| M at S | NS | 2.574 | 3.135 | |
| S at M | NS | 2.673 | 3.246 | |

Table 2a. Effect of different levels of nitrogen and plant growth regulators on pseudostem girth (cm) at different growth stages of banana cv. Ney poovan (Main effect)

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Mean |
|----------------------|--------------|-------|--------------|--------|--------------|--------|--------------|
| Main Plot | | | | | | | |
| M₁ | 28.79 | (0.0) | 54.63 | (0.0) | 56.38 | (0.0) | 46.62 |
| M₂ | 28.90 | (0.4) | 54.87 | (0.4) | 56.93 | (1.0) | 46.95 |
| M₃ | 29.11 | (1.1) | 55.41 | (1.4) | 57.44 | (1.9) | 47.37 |
| M₄ | 29.20 | (1.4) | 55.67 | (1.9) | 57.93 | (2.7) | 47.60 |
| Mean | 29.00 | | 55.15 | | 57.17 | | 47.16 |
| CD (p=0.05) | NS | | 0.248 | | 0.256 | | |
| Sub Plot | | | | | | | |
| S₁ | 28.05 | (0.0) | 51.15 | (0.0) | 53.62 | (0.0) | 44.34 |
| S₂ | 28.20 | (0.5) | 58.17 | (13.7) | 60.54 | (12.9) | 49.04 |
| S₃ | 28.01 | (0.2) | 57.94 | (13.3) | 60.52 | (12.9) | 48.89 |
| S₄ | 28.78 | (2.6) | 57.40 | (12.2) | 59.51 | (10.9) | 48.66 |
| S₅ | 28.43 | (1.4) | 55.37 | (3.3) | 57.02 | (6.3) | 46.91 |
| S₆ | 29.01 | (3.4) | 52.87 | (3.4) | 55.20 | (2.9) | 45.76 |
| S₇ | 28.35 | (1.1) | 55.22 | (7.9) | 56.65 | (5.7) | 46.70 |
| S₈ | 28.16 | (0.4) | 53.04 | (3.7) | 54.30 | (1.3) | 45.27 |
| Mean | 28.31 | | 55.15 | | 57.17 | | 46.96 |
| CD (p=0.05) | NS | | 0.491 | | 0.524 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 2b. Effect of different levels of nitrogen and plant growth regulators on pseudostem girth (cm) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Mean |
|-----------------------------------|--------------|--------------|--------------|--------------|
| Interaction effect | | | | |
| M₁S₁ | 28.50 | 50.26 | 53.00 | 43.92 |
| M₁S₂ | 28.40 | 57.80 | 60.00 | 48.73 |
| M₁S₃ | 28.30 | 57.27 | 59.50 | 48.36 |
| M₁S₄ | 28.60 | 57.00 | 58.90 | 48.17 |
| M₁S₅ | 28.70 | 55.10 | 56.10 | 49.97 |
| M₁S₆ | 28.80 | 52.25 | 54.00 | 45.02 |
| M₁S₇ | 28.90 | 54.90 | 56.00 | 46.60 |
| M₁S₈ | 28.60 | 52.75 | 53.80 | 45.05 |
| M₂S₁ | 28.20 | 50.58 | 53.50 | 44.09 |
| M₂S₂ | 28.00 | 58.00 | 60.80 | 48.93 |
| M₂S₃ | 28.10 | 57.90 | 60.00 | 48.67 |
| M₂S₄ | 28.30 | 57.10 | 59.50 | 48.30 |
| M₂S₅ | 28.40 | 55.30 | 57.00 | 46.90 |
| M₂S₆ | 28.35 | 52.75 | 55.00 | 45.37 |
| M₂S₇ | 28.45 | 55.10 | 56.80 | 46.78 |
| M₂S₈ | 28.20 | 53.00 | 54.00 | 45.07 |
| M₃S₁ | 29.00 | 51.78 | 53.90 | 44.89 |
| M₃S₂ | 28.70 | 58.50 | 61.00 | 49.40 |
| M₃S₃ | 28.60 | 58.00 | 60.50 | 49.03 |
| M₃S₄ | 29.10 | 57.80 | 59.80 | 48.90 |
| M₃S₅ | 29.40 | 55.70 | 57.50 | 47.53 |
| M₃S₆ | 29.15 | 53.00 | 55.50 | 45.88 |
| M₃S₇ | 29.45 | 55.60 | 57.00 | 47.35 |
| M₃S₈ | 29.20 | 53.10 | 54.50 | 45.60 |
| M₄S₁ | 28.60 | 52.00 | 54.10 | 44.90 |
| M₄S₂ | 28.40 | 59.00 | 62.00 | 49.47 |
| M₄S₃ | 28.20 | 58.50 | 61.00 | 49.57 |
| M₄S₄ | 28.70 | 57.85 | 60.00 | 48.85 |
| M₄S₅ | 29.00 | 55.90 | 58.00 | 47.63 |
| M₄S₆ | 28.70 | 53.20 | 56.00 | 45.97 |
| M₄S₇ | 29.10 | 55.70 | 57.50 | 47.43 |
| M₄S₈ | 28.80 | 53.40 | 55.00 | 45.73 |
| Mean | 28.65 | 55.19 | 57.54 | 47.13 |
| CD (p=0.05) | | | | |
| M at S | NS | 0.949 | 0.983 | |
| S at M | NS | NS | NS | |

Table 3a. Effect of different levels of nitrogen and plant growth regulators on number of functional leaves plant⁻¹ at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 10.12 | (0.0) | 13.06 | (0.0) | 13.12 | (0.0) | 8.79 | (0.0) | 11.30 |
| M₂ | 10.21 | (0.9) | 13.23 | (1.3) | 14.29 | (8.9) | 8.87 | (0.9) | 11.65 |
| M₃ | 10.69 | (5.6) | 14.14 | (1.3) | 16.31 | (24.3) | 9.04 | (2.8) | 12.54 |
| M₄ | 10.13 | (0.1) | 14.71 | (12.6) | 16.87 | (28.6) | 9.18 | (4.4) | 12.97 |
| Mean | 10.50 | | 13.78 | | 15.14 | | 8.97 | | 12.10 |
| CD (p=0.05) | NS | | 0.059 | | 0.059 | | 0.039 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 9.19 | (0.0) | 12.31 | (0.0) | 13.99 | (0.0) | 7.92 | (0.0) | 10.85 |
| S₂ | 9.35 | (1.7) | 14.01 | (13.8) | 15.34 | (9.6) | 8.81 | (11.2) | 12.17 |
| S₃ | 9.30 | (1.2) | 14.04 | (14.1) | 15.01 | (7.3) | 8.79 | (11.0) | 12.05 |
| S₄ | 9.20 | (0.1) | 13.47 | (9.4) | 14.55 | (4.0) | 8.07 | (1.9) | 11.50 |
| S₅ | 9.75 | (6.1) | 14.52 | (18.0) | 16.34 | (16.8) | 10.36 | (30.8) | 13.39 |
| S₆ | 9.25 | (0.7) | 13.64 | (10.8) | 15.02 | (7.4) | 8.88 | (12.1) | 11.69 |
| S₇ | 9.65 | (5.0) | 14.44 | (17.3) | 15.91 | (13.7) | 9.92 | (25.3) | 12.96 |
| S₈ | 9.28 | (1.0) | 13.85 | (12.5) | 14.99 | (7.1) | 9.01 | (13.8) | 11.88 |
| Mean | 9.45 | | 13.79 | | 15.19 | | 8.97 | | 12.04 |
| CD (p=0.05) | NS | | 0.123 | | 0.138 | | 0.081 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 3b. Effect of different levels of nitrogen and plant growth regulators on number of functional leaves plant⁻¹ at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 10.00 | 12.00 | 12.50 | 7.74 | 9.69 |
| M₁S₂ | 10.30 | 13.22 | 12.75 | 8.52 | 10.87 |
| M₁S₃ | 10.33 | 13.42 | 12.25 | 8.63 | 10.66 |
| M₁S₄ | 10.10 | 12.77 | 12.12 | 7.99 | 10.47 |
| M₁S₅ | 10.70 | 13.93 | 15.00 | 10.10 | 12.76 |
| M₁S₆ | 10.15 | 12.45 | 13.50 | 8.56 | 10.63 |
| M₁S₇ | 10.65 | 13.76 | 14.25 | 9.87 | 12.22 |
| M₁S₈ | 10.20 | 13.00 | 13.25 | 8.98 | 10.98 |
| M₂S₁ | 10.00 | 12.04 | 13.00 | 7.82 | 10.47 |
| M₂S₂ | 10.27 | 13.44 | 14.75 | 8.78 | 11.91 |
| M₂S₃ | 10.20 | 13.46 | 14.50 | 8.72 | 11.67 |
| M₂S₄ | 10.13 | 12.98 | 13.50 | 8.01 | 11.21 |
| M₂S₅ | 10.57 | 13.99 | 15.50 | 10.23 | 12.99 |
| M₂S₆ | 10.17 | 13.00 | 14.00 | 8.63 | 11.33 |
| M₂S₇ | 10.48 | 13.97 | 15.00 | 9.88 | 12.71 |
| M₂S₈ | 10.20 | 13.12 | 14.25 | 8.99 | 11.32 |
| M₃S₁ | 10.10 | 12.19 | 15.00 | 7.48 | 10.97 |
| M₃S₂ | 10.30 | 14.57 | 16.75 | 8.92 | 12.81 |
| M₃S₃ | 10.25 | 14.52 | 16.25 | 8.72 | 12.71 |
| M₃S₄ | 10.17 | 13.75 | 16.00 | 8.11 | 11.97 |
| M₃S₅ | 10.75 | 14.95 | 17.25 | 10.52 | 13.81 |
| M₃S₆ | 10.20 | 14.01 | 16.00 | 9.12 | 12.22 |
| M₃S₇ | 10.68 | 14.89 | 17.00 | 9.99 | 13.35 |
| M₃S₈ | 10.23 | 14.30 | 16.25 | 9.00 | 12.26 |
| M₄S₁ | 10.00 | 13.00 | 16.00 | 8.12 | 11.86 |
| M₄S₂ | 10.21 | 14.97 | 17.25 | 9.11 | 13.21 |
| M₄S₃ | 10.20 | 14.74 | 17.00 | 9.07 | 13.14 |
| M₄S₄ | 10.10 | 14.40 | 16.75 | 8.21 | 12.53 |
| M₄S₅ | 10.65 | 15.34 | 17.75 | 10.67 | 14.13 |
| M₄S₆ | 10.15 | 15.02 | 16.50 | 9.18 | 12.78 |
| M₄S₇ | 10.55 | 15.25 | 17.50 | 10.01 | 13.69 |
| M₄S₈ | 10.20 | 15.01 | 16.25 | 9.10 | 12.72 |
| Mean | 10.33 | 13.80 | 15.16 | 8.96 | 12.06 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.265 | 0.239 | 0.156 | |
| S at M | NS | 0.276 | 0.247 | 0.162 | |

Table 4a. Effect of different levels of nitrogen and plant growth regulators on phyllochron (days leaf⁻¹) at different growth stages of banana cv. Ney Poovan (Main effect)

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Mean |
|----------------------|--------------|--------|--------------|---------|--------------|---------|-------------|
| Main Plot | | | | | | | |
| M₁ | 8.71 | (0.0) | 8.06 | (0.0) | 9.68 | (0.0) | 8.81 |
| M₂ | 9.05 | (3.9) | 7.81 | (-3.1) | 8.97 | (-7.3) | 8.62 |
| M₃ | 8.87 | (1.8) | 7.62 | (-5.5) | 8.75 | (-9.6) | 8.40 |
| M₄ | 8.05 | (-7.6) | 7.36 | (-8.7) | 8.33 | (-13.9) | 7.92 |
| Mean | 8.72 | | 7.71 | | 8.93 | | 8.43 |
| CD (p=0.05) | NS | | 0.038 | | 0.048 | | |
| Sub Plot | | | | | | | |
| S₁ | 9.00 | (0.0) | 8.69 | (0.0) | 10.19 | (0.0) | 9.31 |
| S₂ | 8.89 | (-1.2) | 7.64 | (-12.1) | 9.10 | (-10.7) | 8.52 |
| S₃ | 8.69 | (-3.4) | 7.89 | (-9.2) | 8.88 | (-12.9) | 8.51 |
| S₄ | 8.50 | (-5.6) | 8.37 | (-3.7) | 9.87 | (-3.1) | 8.90 |
| S₅ | 8.46 | (-6.0) | 6.61 | (-23.9) | 6.99 | (-31.4) | 7.40 |
| S₆ | 8.43 | (-6.3) | 7.70 | (-11.4) | 9.79 | (-3.9) | 8.62 |
| S₇ | 8.73 | (-3.0) | 6.92 | (-20.4) | 7.30 | (-28.4) | 7.71 |
| S₈ | 8.69 | (-3.4) | 7.87 | (-9.4) | 9.33 | (-8.4) | 8.63 |
| Mean | 8.70 | | 7.71 | | 8.92 | | 8.41 |
| CD (p=0.05) | NS | | 0.070 | | 0.080 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 4b. Effect of different levels of nitrogen and plant growth regulators on phyllochron (days leaf⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Mean |
|-----------------------------------|--------------|--------------|--------------|--------------|
| Interaction effects | | | | |
| M₁S₁ | 8.50 | 9.00 | 10.90 | 10.13 |
| M₁S₂ | 8.00 | 8.00 | 9.80 | 9.27 |
| M₁S₃ | 8.50 | 8.25 | 9.50 | 9.08 |
| M₁S₄ | 8.00 | 8.75 | 10.50 | 9.75 |
| M₁S₅ | 8.25 | 7.00 | 8.00 | 8.08 |
| M₁S₆ | 8.75 | 8.00 | 10.40 | 9.38 |
| M₁S₇ | 8.25 | 7.25 | 8.25 | 8.25 |
| M₁S₈ | 8.50 | 8.25 | 10.10 | 9.28 |
| M₂S₁ | 9.75 | 8.75 | 10.10 | 9.53 |
| M₂S₂ | 9.20 | 7.75 | 9.20 | 8.72 |
| M₂S₃ | 9.20 | 8.00 | 9.00 | 8.73 |
| M₂S₄ | 9.65 | 8.50 | 10.00 | 9.38 |
| M₂S₅ | 9.00 | 6.75 | 7.00 | 7.25 |
| M₂S₆ | 9.50 | 7.85 | 9.80 | 9.05 |
| M₂S₇ | 9.25 | 7.00 | 7.25 | 7.50 |
| M₂S₈ | 9.45 | 8.00 | 9.50 | 8.98 |
| M₃S₁ | 9.75 | 8.60 | 10.00 | 9.12 |
| M₃S₂ | 7.00 | 7.60 | 9.00 | 8.20 |
| M₃S₃ | 7.75 | 7.80 | 8.75 | 8.10 |
| M₃S₄ | 7.50 | 8.25 | 9.80 | 8.85 |
| M₃S₅ | 7.00 | 6.50 | 6.75 | 6.75 |
| M₃S₆ | 7.20 | 7.60 | 9.70 | 8.50 |
| M₃S₇ | 7.75 | 6.85 | 7.00 | 6.87 |
| M₃S₈ | 8.00 | 7.75 | 9.00 | 8.25 |
| M₄S₁ | 8.75 | 8.40 | 9.75 | 8.63 |
| M₄S₂ | 8.25 | 7.30 | 8.50 | 7.68 |
| M₄S₃ | 8.00 | 7.50 | 8.25 | 7.58 |
| M₄S₄ | 8.50 | 8.00 | 9.20 | 8.23 |
| M₄S₅ | 8.00 | 6.25 | 6.50 | 6.17 |
| M₄S₆ | 8.40 | 7.30 | 9.20 | 7.97 |
| M₄S₇ | 8.25 | 6.65 | 6.75 | 6.55 |
| M₄S₈ | 8.25 | 7.50 | 8.75 | 7.83 |
| Mean | 8.44 | 7.72 | 8.94 | 8.36 |
| CD (p=0.05) | | | | |
| M at S | NS | 0.131 | 0.151 | |
| S at M | NS | NS | 0.160 | |

Table 5a. Effect of different levels of nitrogen and plant growth regulators on leaf area (m² plant⁻¹) at different growth stages of banana cv. Ney Poovan (Main effect)

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 3.49 | (0.0) | 8.73 | (0.0) | 16.85 | (0.0) | 12.83 | (0.0) | 10.55 |
| M₂ | 3.88 | (11.2) | 8.82 | (1.0) | 17.07 | (1.3) | 13.09 | (2.0) | 10.71 |
| M₃ | 3.91 | (12.0) | 8.90 | (1.9) | 17.29 | (2.6) | 13.37 | (4.2) | 10.96 |
| M₄ | 4.06 | (16.3) | 8.98 | (2.9) | 17.38 | (3.1) | 13.49 | (5.1) | 11.07 |
| Mean | 3.85 | | 8.85 | | 17.14 | | 13.19 | | 10.87 |
| CD (p=0.05) | NS | | 0.038 | | 0.076 | | 0.058 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 3.14 | (0.0) | 8.25 | (0.0) | 15.09 | (0.0) | 10.63 | (0.0) | 9.37 |
| S₂ | 3.48 | (10.8) | 8.88 | (7.6) | 17.56 | (16.4) | 13.73 | (29.2) | 11.03 |
| S₃ | 3.39 | (8.0) | 8.74 | (5.9) | 17.45 | (15.6) | 13.38 | (25.9) | 10.89 |
| S₄ | 3.20 | (1.9) | 8.47 | (2.7) | 16.59 | (9.9) | 12.21 | (14.9) | 10.22 |
| S₅ | 3.78 | (20.4) | 9.92 | (20.2) | 18.65 | (23.6) | 15.61 | (46.8) | 12.13 |
| S₆ | 3.23 | (2.9) | 8.57 | (3.9) | 16.82 | (11.5) | 12.34 | (16.1) | 10.38 |
| S₇ | 3.68 | (17.2) | 9.52 | (15.4) | 18.30 | (21.3) | 14.99 | (41.0) | 11.74 |
| S₈ | 3.27 | (14.1) | 8.52 | (3.3) | 16.72 | (10.8) | 12.64 | (18.9) | 10.43 |
| Mean | 3.43 | | 8.85 | | 17.14 | | 13.19 | | 10.77 |
| CD (p=0.05) | NS | | 0.079 | | 0.154 | | 0.119 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 5b. Effect of different levels of nitrogen and plant growth regulators on leaf area ($\text{m}^2 \text{ plant}^{-1}$) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 3.42 | 8.01 | 15.00 | 10.50 | 9.13 |
| M₁S₂ | 3.81 | 8.82 | 17.26 | 13.50 | 10.77 |
| M₁S₃ | 3.79 | 8.63 | 17.11 | 13.02 | 10.56 |
| M₁S₄ | 3.51 | 8.47 | 16.26 | 11.60 | 9.86 |
| M₁S₅ | 4.11 | 9.88 | 18.40 | 15.25 | 11.83 |
| M₁S₆ | 3.54 | 8.49 | 16.41 | 12.11 | 10.06 |
| M₁S₇ | 3.94 | 9.21 | 18.02 | 14.20 | 11.26 |
| M₁S₈ | 3.63 | 8.47 | 16.42 | 12.51 | 10.18 |
| M₂S₁ | 3.54 | 8.22 | 15.06 | 10.57 | 9.27 |
| M₂S₂ | 3.97 | 8.87 | 17.65 | 13.75 | 10.98 |
| M₂S₃ | 3.82 | 8.72 | 17.26 | 13.37 | 10.71 |
| M₂S₄ | 3.51 | 8.51 | 16.60 | 11.66 | 9.968 |
| M₂S₅ | 4.18 | 9.91 | 18.56 | 15.65 | 12.00 |
| M₂S₆ | 3.64 | 8.55 | 16.50 | 12.31 | 10.17 |
| M₂S₇ | 4.04 | 9.56 | 18.22 | 15.00 | 11.63 |
| M₂S₈ | 3.71 | 8.48 | 16.98 | 12.61 | 10.37 |
| M₃S₁ | 3.28 | 8.35 | 15.11 | 10.72 | 9.49 |
| M₃S₂ | 3.81 | 8.92 | 17.70 | 13.90 | 11.20 |
| M₃S₃ | 3.95 | 8.77 | 17.68 | 13.50 | 11.10 |
| M₃S₄ | 3.60 | 8.55 | 16.72 | 12.75 | 10.53 |
| M₃S₅ | 4.32 | 9.98 | 18.80 | 15.81 | 12.35 |
| M₃S₆ | 3.72 | 8.58 | 17.11 | 12.34 | 10.56 |
| M₃S₇ | 4.08 | 9.57 | 18.51 | 15.31 | 11.99 |
| M₃S₈ | 3.70 | 8.54 | 16.75 | 12.70 | 10.54 |
| M₄S₁ | 3.74 | 8.41 | 15.21 | 10.75 | 9.62 |
| M₄S₂ | 4.04 | 9.01 | 17.82 | 13.93 | 11.30 |
| M₄S₃ | 4.09 | 8.82 | 17.71 | 13.63 | 11.16 |
| M₄S₄ | 3.82 | 8.59 | 16.82 | 12.88 | 10.62 |
| M₄S₅ | 4.52 | 10.01 | 19.01 | 15.88 | 12.46 |
| M₄S₆ | 3.92 | 8.62 | 17.18 | 12.55 | 10.66 |
| M₄S₇ | 4.29 | 9.82 | 18.60 | 15.56 | 12.16 |
| M₄S₈ | 4.29 | 8.59 | 16.78 | 12.76 | 10.70 |
| Mean | 3.85 | 8.87 | 17.16 | 13.20 | 10.79 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.152 | 0.297 | 0.231 | |
| S at M | NS | 0.158 | 0.308 | 0.239 | |

Table 6a. Effect of different levels of nitrogen and plant growth regulators on leaf area index at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 1.08 | (0.0) | 2.69 | (0.0) | 5.20 | (0.0) | 3.96 | (0.0) | 3.22 |
| M₂ | 1.20 | (11.1) | 2.72 | (1.1) | 5.27 | (1.3) | 4.04 | (2.0) | 3.35 |
| M₃ | 1.21 | (12.0) | 2.75 | (2.2) | 5.34 | (2.7) | 4.13 | (4.3) | 3.44 |
| M₄ | 1.25 | (15.7) | 2.77 | (3.0) | 5.36 | (3.1) | 4.16 | (5.1) | 3.43 |
| Mean | 1.22 | | 2.73 | | 5.34 | | 4.15 | | 3.31 |
| CD (p=0.05) | NS | | 0.009 | | 0.017 | | 0.012 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.97 | (0.0) | 2.55 | (0.0) | 4.66 | (0.0) | 3.28 | (0.0) | 2.92 |
| S₂ | 1.07 | (10.3) | 2.74 | (7.5) | 5.42 | (16.3) | 4.24 | (29.3) | 3.41 |
| S₃ | 1.05 | (8.2) | 2.70 | (5.9) | 5.39 | (15.7) | 4.13 | (25.9) | 3.34 |
| S₄ | 0.99 | (2.1) | 2.61 | (2.4) | 5.12 | (9.9) | 3.77 | (14.9) | 3.15 |
| S₅ | 1.17 | (20.6) | 3.06 | (20.0) | 5.76 | (23.6) | 4.82 | (47.0) | 3.77 |
| S₆ | 1.00 | (3.1) | 2.65 | (3.9) | 5.19 | (11.4) | 3.81 | (16.2) | 3.23 |
| S₇ | 1.14 | (17.5) | 2.94 | (15.3) | 5.65 | (21.2) | 4.63 | (41.1) | 3.68 |
| S₈ | 1.01 | (4.1) | 2.63 | (3.1) | 5.16 | (10.7) | 3.90 | (18.9) | 3.21 |
| Mean | 1.05 | | 2.73 | | 5.29 | | 4.07 | | 3.39 |
| CD (p=0.05) | NS | | 0.019 | | 0.030 | | 0.024 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 6b. Effect of different levels of nitrogen and plant growth regulators on leaf area index at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 1.06 | 2.47 | 4.63 | 3.24 | 2.85 |
| M₁S₂ | 1.18 | 2.72 | 5.33 | 4.17 | 3.35 |
| M₁S₃ | 1.17 | 2.66 | 5.28 | 4.02 | 3.28 |
| M₁S₄ | 1.08 | 2.61 | 5.02 | 3.58 | 3.07 |
| M₁S₅ | 1.27 | 3.05 | 5.68 | 4.71 | 3.68 |
| M₁S₆ | 1.09 | 2.62 | 5.06 | 3.74 | 3.13 |
| M₁S₇ | 1.22 | 2.84 | 5.56 | 4.38 | 3.50 |
| M₁S₈ | 1.12 | 2.61 | 5.07 | 3.86 | 3.17 |
| M₂S₁ | 1.09 | 2.54 | 4.65 | 3.26 | 2.89 |
| M₂S₂ | 1.23 | 2.74 | 5.45 | 4.24 | 3.41 |
| M₂S₃ | 1.18 | 2.69 | 5.33 | 4.13 | 3.33 |
| M₂S₄ | 1.08 | 2.63 | 5.12 | 3.60 | 3.11 |
| M₂S₅ | 1.29 | 3.06 | 5.73 | 4.83 | 3.73 |
| M₂S₆ | 1.12 | 2.64 | 5.09 | 3.80 | 3.16 |
| M₂S₇ | 1.25 | 2.95 | 5.62 | 4.63 | 3.61 |
| M₂S₈ | 1.15 | 2.62 | 5.24 | 3.89 | 3.22 |
| M₃S₁ | 1.01 | 2.58 | 4.66 | 3.31 | 2.89 |
| M₃S₂ | 1.18 | 2.75 | 5.46 | 4.29 | 3.42 |
| M₃S₃ | 1.22 | 2.71 | 5.46 | 4.17 | 3.39 |
| M₃S₄ | 1.11 | 2.64 | 5.16 | 3.94 | 3.21 |
| M₃S₅ | 1.33 | 3.08 | 5.80 | 4.88 | 3.77 |
| M₃S₆ | 1.15 | 2.65 | 5.28 | 3.81 | 3.22 |
| M₃S₇ | 1.26 | 2.95 | 5.71 | 4.73 | 3.66 |
| M₃S₈ | 1.14 | 2.64 | 5.17 | 3.92 | 3.22 |
| M₄S₁ | 1.15 | 2.60 | 4.69 | 3.32 | 2.94 |
| M₄S₂ | 1.25 | 2.78 | 5.50 | 4.30 | 3.46 |
| M₄S₃ | 1.26 | 2.72 | 5.47 | 4.21 | 3.41 |
| M₄S₄ | 1.18 | 2.65 | 5.19 | 3.98 | 3.25 |
| M₄S₅ | 1.40 | 3.09 | 5.87 | 4.90 | 3.81 |
| M₄S₆ | 1.21 | 2.66 | 5.30 | 3.87 | 3.26 |
| M₄S₇ | 1.32 | 3.03 | 5.74 | 4.80 | 3.72 |
| M₄S₈ | 1.32 | 2.65 | 5.18 | 3.94 | 3.27 |
| Mean | 1.19 | 2.74 | 5.30 | 4.08 | 3.33 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.037 | 0.067 | 0.046 | |
| S at M | NS | 0.039 | 0.069 | 0.048 | |

Table 7a. Effect of different levels of nitrogen and plant growth regulators on chlorophyll *a* content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 0.62 | (0.0) | 0.76 | (0.0) | 0.87 | (0.0) | 0.82 | (0.0) | 0.76 |
| M₂ | 0.63 | (1.6) | 0.79 | (3.9) | 0.89 | (2.3) | 0.83 | (1.2) | 0.78 |
| M₃ | 0.66 | (6.5) | 0.84 | (10.5) | 0.91 | (4.6) | 0.85 | (3.7) | 0.81 |
| M₄ | 0.68 | (9.7) | 0.86 | (13.2) | 0.93 | (6.9) | 0.86 | (4.9) | 0.83 |
| Mean | 0.65 | | 0.81 | | 0.89 | | 0.84 | | 0.80 |
| CD (p=0.05) | NS | | 0.003 | | 0.004 | | 0.004 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.60 | (0.0) | 0.77 | (0.0) | 0.81 | (0.0) | 0.74 | (0.0) | 0.72 |
| S₂ | 0.67 | (11.7) | 0.82 | (6.5) | 0.92 | (13.6) | 0.87 | (17.6) | 0.81 |
| S₃ | 0.65 | (8.3) | 0.84 | (9.1) | 0.91 | (12.3) | 0.84 | (13.5) | 0.80 |
| S₄ | 0.64 | (6.7) | 0.78 | (1.3) | 0.87 | (7.4) | 0.82 | (10.8) | 0.77 |
| S₅ | 0.69 | (15.0) | 0.87 | (13.0) | 0.96 | (18.5) | 0.90 | (21.6) | 0.85 |
| S₆ | 0.62 | (3.3) | 0.79 | (2.6) | 0.89 | (9.9) | 0.84 | (13.5) | 0.78 |
| S₇ | 0.68 | (13.3) | 0.85 | (10.4) | 0.94 | (16.0) | 0.89 | (20.3) | 0.84 |
| S₈ | 0.62 | (3.3) | 0.79 | (2.6) | 0.90 | (11.1) | 0.83 | (12.2) | 0.78 |
| Mean | 0.65 | | 0.81 | | 0.89 | | 0.84 | | 0.80 |
| CD (p=0.05) | 0.050 | | 0.007 | | 0.008 | | 0.008 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 7b. Effect of different levels of nitrogen and plant growth regulators on chlorophyll *a* content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.56 | 0.71 | 0.77 | 0.72 | 0.69 |
| M₁S₂ | 0.64 | 0.77 | 0.89 | 0.85 | 0.78 |
| M₁S₃ | 0.62 | 0.78 | 0.87 | 0.81 | 0.77 |
| M₁S₄ | 0.60 | 0.73 | 0.85 | 0.79 | 0.74 |
| M₁S₅ | 0.66 | 0.82 | 0.92 | 0.88 | 0.82 |
| M₁S₆ | 0.61 | 0.75 | 0.86 | 0.80 | 0.75 |
| M₁S₇ | 0.65 | 0.80 | 0.90 | 0.87 | 0.80 |
| M₁S₈ | 0.61 | 0.74 | 0.87 | 0.81 | 0.75 |
| M₂S₁ | 0.58 | 0.76 | 0.78 | 0.74 | 0.71 |
| M₂S₂ | 0.66 | 0.82 | 0.91 | 0.87 | 0.81 |
| M₂S₃ | 0.64 | 0.83 | 0.90 | 0.82 | 0.79 |
| M₂S₄ | 0.61 | 0.75 | 0.86 | 0.80 | 0.75 |
| M₂S₅ | 0.68 | 0.85 | 0.95 | 0.90 | 0.84 |
| M₂S₆ | 0.62 | 0.76 | 0.88 | 0.84 | 0.77 |
| M₂S₇ | 0.67 | 0.83 | 0.94 | 0.88 | 0.83 |
| M₂S₈ | 0.62 | 0.76 | 0.88 | 0.83 | 0.77 |
| M₃S₁ | 0.61 | 0.79 | 0.83 | 0.75 | 0.74 |
| M₃S₂ | 0.67 | 0.85 | 0.93 | 0.88 | 0.83 |
| M₃S₃ | 0.66 | 0.86 | 0.92 | 0.86 | 0.82 |
| M₃S₄ | 0.62 | 0.80 | 0.87 | 0.84 | 0.78 |
| M₃S₅ | 0.72 | 0.88 | 0.97 | 0.91 | 0.87 |
| M₃S₆ | 0.63 | 0.82 | 0.90 | 0.86 | 0.80 |
| M₃S₇ | 0.70 | 0.87 | 0.96 | 0.90 | 0.85 |
| M₃S₈ | 0.63 | 0.81 | 0.91 | 0.84 | 0.79 |
| M₄S₁ | 0.63 | 0.82 | 0.86 | 0.76 | 0.76 |
| M₄S₂ | 0.70 | 0.86 | 0.95 | 0.89 | 0.85 |
| M₄S₃ | 0.69 | 0.87 | 0.94 | 0.87 | 0.84 |
| M₄S₄ | 0.64 | 0.83 | 0.90 | 0.85 | 0.80 |
| M₄S₅ | 0.74 | 0.93 | 0.99 | 0.92 | 0.89 |
| M₄S₆ | 0.65 | 0.84 | 0.91 | 0.86 | 0.81 |
| M₄S₇ | 0.71 | 0.91 | 0.97 | 0.91 | 0.87 |
| M₄S₈ | 0.64 | 0.84 | 0.92 | 0.85 | 0.81 |
| Mean | 0.64 | 0.81 | 0.89 | 0.84 | 0.80 |
| CD (p=0.05) | | | | | |
| M at S | 0.011 | 0.014 | 0.016 | 0.015 | |
| S at M | 0.012 | 0.015 | 0.016 | 0.015 | |

Table 8a. Effect of different levels of nitrogen and plant growth regulators on chlorophyll *b* content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 0.50 | (0.0) | 0.56 | (0.0) | 0.62 | (0.0) | 0.54 | (0.0) | 0.55 |
| M₂ | 0.53 | (6.0) | 0.55 | (-1.8) | 0.64 | (3.2) | 0.55 | (1.9) | 0.57 |
| M₃ | 0.54 | (8.0) | 0.60 | (7.1) | 0.65 | (4.8) | 0.63 | (16.7) | 0.61 |
| M₄ | 0.56 | (12.0) | 0.64 | (14.3) | 0.67 | (8.1) | 0.64 | (18.5) | 0.62 |
| Mean | 0.53 | | 0.59 | | 0.64 | | 0.59 | | 0.59 |
| CD (p=0.05) | NS | | 0.003 | | 0.003 | | 0.002 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.49 | (0.0) | 0.53 | (0.0) | 0.54 | (0.0) | 0.55 | (0.0) | 0.53 |
| S₂ | 0.53 | (8.2) | 0.58 | (9.4) | 0.67 | (24.1) | 0.58 | (5.5) | 0.59 |
| S₃ | 0.55 | (12.2) | 0.60 | (13.2) | 0.65 | (20.4) | 0.61 | (10.9) | 0.60 |
| S₄ | 0.51 | (4.1) | 0.56 | (5.7) | 0.61 | (13.0) | 0.57 | (3.6) | 0.56 |
| S₅ | 0.58 | (18.4) | 0.65 | (22.6) | 0.72 | (33.3) | 0.64 | (16.4) | 0.65 |
| S₆ | 0.52 | (6.1) | 0.59 | (11.3) | 0.63 | (16.7) | 0.57 | (3.6) | 0.58 |
| S₇ | 0.57 | (16.3) | 0.63 | (18.9) | 0.70 | (29.6) | 0.63 | (14.5) | 0.63 |
| S₈ | 0.52 | (6.1) | 0.57 | (7.5) | 0.64 | (18.5) | 0.57 | (3.6) | 0.57 |
| Mean | 0.53 | | 0.59 | | 0.64 | | 0.59 | | 0.59 |
| CD (p=0.05) | 0.005 | | 0.005 | | 0.006 | | 0.005 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 8b. Effect of different levels of nitrogen and plant growth regulators on chlorophyll *b* content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.47 | 0.51 | 0.52 | 0.50 | 0.50 |
| M₁S₂ | 0.51 | 0.54 | 0.65 | 0.52 | 0.56 |
| M₁S₃ | 0.52 | 0.56 | 0.62 | 0.57 | 0.57 |
| M₁S₄ | 0.49 | 0.52 | 0.60 | 0.51 | 0.53 |
| M₁S₅ | 0.55 | 0.59 | 0.69 | 0.60 | 0.61 |
| M₁S₆ | 0.50 | 0.53 | 0.61 | 0.52 | 0.54 |
| M₁S₇ | 0.53 | 0.58 | 0.68 | 0.59 | 0.60 |
| M₁S₈ | 0.50 | 0.53 | 0.61 | 0.51 | 0.54 |
| M₂S₁ | 0.49 | 0.50 | 0.54 | 0.51 | 0.51 |
| M₂S₂ | 0.53 | 0.55 | 0.66 | 0.54 | 0.57 |
| M₂S₃ | 0.55 | 0.57 | 0.64 | 0.58 | 0.59 |
| M₂S₄ | 0.50 | 0.53 | 0.60 | 0.52 | 0.54 |
| M₂S₅ | 0.57 | 0.60 | 0.71 | 0.61 | 0.62 |
| M₂S₆ | 0.52 | 0.54 | 0.62 | 0.53 | 0.55 |
| M₂S₇ | 0.56 | 0.59 | 0.70 | 0.60 | 0.61 |
| M₂S₈ | 0.51 | 0.54 | 0.63 | 0.53 | 0.55 |
| M₃S₁ | 0.50 | 0.53 | 0.55 | 0.59 | 0.54 |
| M₃S₂ | 0.54 | 0.61 | 0.67 | 0.62 | 0.61 |
| M₃S₃ | 0.56 | 0.63 | 0.66 | 0.64 | 0.62 |
| M₃S₄ | 0.51 | 0.57 | 0.61 | 0.61 | 0.58 |
| M₃S₅ | 0.60 | 0.67 | 0.73 | 0.68 | 0.67 |
| M₃S₆ | 0.53 | 0.58 | 0.63 | 0.61 | 0.59 |
| M₃S₇ | 0.58 | 0.65 | 0.71 | 0.66 | 0.65 |
| M₃S₈ | 0.53 | 0.59 | 0.64 | 0.61 | 0.59 |
| M₄S₁ | 0.51 | 0.59 | 0.56 | 0.60 | 0.57 |
| M₄S₂ | 0.56 | 0.62 | 0.69 | 0.63 | 0.63 |
| M₄S₃ | 0.56 | 0.64 | 0.68 | 0.65 | 0.63 |
| M₄S₄ | 0.52 | 0.60 | 0.63 | 0.62 | 0.59 |
| M₄S₅ | 0.62 | 0.73 | 0.75 | 0.69 | 0.70 |
| M₄S₆ | 0.54 | 0.61 | 0.65 | 0.62 | 0.61 |
| M₄S₇ | 0.60 | 0.69 | 0.73 | 0.67 | 0.67 |
| M₄S₈ | 0.55 | 0.61 | 0.66 | 0.61 | 0.61 |
| Mean | 0.53 | 0.58 | 0.64 | 0.59 | 0.59 |
| CD (p=0.05) | | | | | |
| M at S | 0.009 | 0.010 | 0.011 | 0.010 | |
| S at M | 0.009 | 0.011 | 0.012 | 0.011 | |

Table 9a. Effect of different levels of nitrogen and plant growth regulators on total chlorophyll (mg g^{-1}) content at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|---------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 1.04 | (0.0) | 1.27 | (0.0) | 1.37 | (0.0) | 1.25 | (0.0) | 1.23 |
| M₂ | 1.06 | (1.9) | 1.35 | (6.3) | 1.36 | (-0.7) | 1.27 | (1.6) | 1.26 |
| M₃ | 1.10 | (5.8) | 1.37 | (7.9) | 1.42 | (3.6) | 1.29 | (3.2) | 1.30 |
| M₄ | 1.12 | (7.7) | 1.38 | (8.7) | 1.48 | (8.1) | 1.31 | (4.8) | 1.32 |
| Mean | 1.08 | | 1.34 | | 1.41 | | 1.28 | | 1.28 |
| CD (p=0.05) | NS | | 0.007 | | 0.008 | | 0.005 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.98 | (0.0) | 1.25 | (0.0) | 1.41 | (0.0) | 1.21 | (0.0) | 1.21 |
| S₂ | 1.10 | (12.2) | 1.31 | (4.8) | 1.37 | (-2.8) | 1.30 | (7.4) | 1.27 |
| S₃ | 1.08 | (10.2) | 1.32 | (5.6) | 1.37 | (-2.8) | 1.31 | (8.3) | 1.27 |
| S₄ | 1.05 | (7.1) | 1.35 | (8.0) | 1.37 | (-2.8) | 1.23 | (1.7) | 1.25 |
| S₅ | 1.18 | (20.4) | 1.45 | (16.0) | 1.48 | (5.0) | 1.36 | (12.4) | 1.37 |
| S₆ | 1.04 | (6.1) | 1.32 | (5.6) | 1.38 | (-2.1) | 1.24 | (2.5) | 1.24 |
| S₇ | 1.17 | (19.4) | 1.43 | (14.4) | 1.44 | (2.1) | 1.35 | (11.6) | 1.35 |
| S₈ | 1.07 | (9.2) | 1.33 | (6.4) | 1.14 | (-19.1) | 1.26 | (4.1) | 1.20 |
| Mean | 1.08 | | 1.34 | | 1.38 | | 1.28 | | 1.27 |
| CD (p=0.05) | 0.009 | | 0.011 | | 0.012 | | 0.011 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 9b. Effect of different levels of nitrogen and plant growth regulators on total chlorophyll content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect)

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.94 | 1.21 | 1.35 | 1.20 | 1.18 |
| M₁S₂ | 1.06 | 1.26 | 1.32 | 1.26 | 1.22 |
| M₁S₃ | 1.03 | 1.23 | 1.34 | 1.28 | 1.22 |
| M₁S₄ | 1.02 | 1.26 | 1.30 | 1.21 | 1.20 |
| M₁S₅ | 1.15 | 1.36 | 1.42 | 1.32 | 1.31 |
| M₁S₆ | 0.96 | 1.27 | 1.36 | 1.21 | 1.20 |
| M₁S₇ | 1.12 | 1.37 | 1.43 | 1.31 | 1.31 |
| M₁S₈ | 1.05 | 1.23 | 1.41 | 1.22 | 1.23 |
| M₂S₁ | 0.98 | 1.22 | 1.37 | 1.21 | 1.20 |
| M₂S₂ | 1.08 | 1.31 | 1.31 | 1.29 | 1.25 |
| M₂S₃ | 1.05 | 1.37 | 1.34 | 1.31 | 1.27 |
| M₂S₄ | 1.03 | 1.34 | 1.33 | 1.21 | 1.23 |
| M₂S₅ | 1.17 | 1.45 | 1.46 | 1.34 | 1.36 |
| M₂S₆ | 0.98 | 1.34 | 1.36 | 1.22 | 1.23 |
| M₂S₇ | 1.16 | 1.46 | 1.46 | 1.33 | 1.35 |
| M₂S₈ | 1.06 | 1.33 | 1.32 | 1.22 | 1.23 |
| M₃S₁ | 0.99 | 1.28 | 1.42 | 1.21 | 1.23 |
| M₃S₂ | 1.11 | 1.34 | 1.39 | 1.31 | 1.29 |
| M₃S₃ | 1.10 | 1.31 | 1.38 | 1.32 | 1.28 |
| M₃S₄ | 1.07 | 1.39 | 1.39 | 1.24 | 1.27 |
| M₃S₅ | 1.20 | 1.53 | 1.49 | 1.39 | 1.40 |
| M₃S₆ | 1.10 | 1.32 | 1.41 | 1.23 | 1.27 |
| M₃S₇ | 1.19 | 1.47 | 1.50 | 1.36 | 1.38 |
| M₃S₈ | 1.08 | 1.31 | 1.42 | 1.28 | 1.27 |
| M₄S₁ | 1.00 | 1.28 | 1.51 | 1.22 | 1.25 |
| M₄S₂ | 1.15 | 1.34 | 1.46 | 1.32 | 1.32 |
| M₄S₃ | 1.14 | 1.37 | 1.42 | 1.32 | 1.31 |
| M₄S₄ | 1.09 | 1.39 | 1.45 | 1.27 | 1.30 |
| M₄S₅ | 1.20 | 1.47 | 1.55 | 1.40 | 1.40 |
| M₄S₆ | 1.12 | 1.36 | 1.41 | 1.29 | 1.30 |
| M₄S₇ | 1.20 | 1.41 | 1.53 | 1.39 | 1.38 |
| M₄S₈ | 1.09 | 1.37 | 1.50 | 1.30 | 1.31 |
| Mean | 1.08 | 1.34 | 1.41 | 1.28 | 1.28 |
| CD (p=0.05) | | | | | |
| M at S | 0.188 | 0.023 | 0.024 | 0.022 | |
| S at M | 0.195 | 0.023 | 0.023 | 0.022 | |

Table 10a. Effect of different levels of nitrogen and plant growth regulators on chlorophyll stability index at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|-------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 61.99 | (0.0) | 68.55 | (0.0) | 79.74 | (0.0) | 64.42 | (0.0) | 68.67 |
| M₂ | 62.24 | (0.4) | 69.04 | (0.7) | 80.02 | (0.4) | 64.42 | (0.0) | 68.93 |
| M₃ | 62.15 | (0.3) | 69.27 | (1.1) | 80.61 | (1.1) | 64.63 | (0.3) | 69.16 |
| M₄ | 62.48 | (0.8) | 69.71 | (1.7) | 80.73 | (1.2) | 64.73 | (0.5) | 69.41 |
| Mean | 62.22 | | 69.14 | | 80.27 | | 64.55 | | 69.05 |
| CD (p=0.05) | NS | | 0.550 | | 0.640 | | 0.340 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 60.93 | (0.0) | 67.34 | (0.0) | 69.06 | (0.0) | 60.03 | (0.0) | 64.34 |
| S₂ | 44.54 | (5.9) | 69.36 | (3.0) | 81.66 | (18.2) | 65.20 | (8.6) | 65.04 |
| S₃ | 62.45 | (2.5) | 69.03 | (2.5) | 81.54 | (18.1) | 65.16 | (8.5) | 69.55 |
| S₄ | 61.72 | (1.3) | 68.41 | (1.6) | 79.60 | (15.3) | 64.74 | (7.8) | 68.62 |
| S₅ | 63.63 | (4.4) | 71.04 | (5.5) | 83.95 | (21.6) | 67.14 | (11.8) | 71.15 |
| S₆ | 62.21 | (2.1) | 68.06 | (1.1) | 79.55 | (15.2) | 65.07 | (8.4) | 68.72 |
| S₇ | 63.30 | (3.9) | 70.83 | (5.2) | 83.64 | (21.1) | 66.85 | (11.4) | 71.44 |
| S₈ | 61.63 | (1.1) | 71.00 | (5.4) | 82.95 | (20.1) | 61.61 | (2.6) | 69.56 |
| Mean | 60.20 | | 69.43 | | 80.58 | | 64.55 | | 68.89 |
| CD (p=0.05) | 0.520 | | 0.600 | | 0.710 | | 0.560 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 10b. Effect of different levels of nitrogen and plant growth regulators on chlorophyll stability index at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 60.70 | 67.21 | 68.65 | 59.75 | 64.08 |
| M₁S₂ | 62.66 | 68.52 | 81.40 | 65.12 | 69.43 |
| M₁S₃ | 62.15 | 68.12 | 81.44 | 65.02 | 69.18 |
| M₁S₄ | 61.21 | 68.06 | 79.16 | 64.56 | 68.25 |
| M₁S₅ | 63.02 | 69.91 | 83.15 | 66.78 | 70.68 |
| M₁S₆ | 62.13 | 68.00 | 79.16 | 65.00 | 68.57 |
| M₁S₇ | 63.15 | 69.46 | 83.20 | 66.92 | 70.72 |
| M₁S₈ | 61.27 | 68.10 | 80.01 | 61.68 | 67.77 |
| M₂S₁ | 61.01 | 67.98 | 68.20 | 59.97 | 64.29 |
| M₂S₂ | 62.72 | 69.24 | 81.46 | 65.24 | 69.67 |
| M₂S₃ | 62.66 | 69.13 | 81.25 | 65.21 | 69.56 |
| M₂S₄ | 61.82 | 68.01 | 79.24 | 64.72 | 68.45 |
| M₂S₅ | 63.11 | 69.85 | 83.20 | 66.83 | 71.06 |
| M₂S₆ | 62.23 | 68.20 | 79.95 | 65.07 | 68.86 |
| M₂S₇ | 63.64 | 70.43 | 83.48 | 67.15 | 70.89 |
| M₂S₈ | 61.42 | 68.98 | 81.12 | 61.46 | 68.21 |
| M₃S₁ | 60.98 | 67.00 | 69.65 | 60.15 | 64.45 |
| M₃S₂ | 62.58 | 69.46 | 82.00 | 65.36 | 69.85 |
| M₃S₃ | 62.47 | 69.15 | 81.58 | 65.32 | 69.63 |
| M₃S₄ | 61.75 | 68.72 | 79.58 | 64.68 | 68.68 |
| M₃S₅ | 63.22 | 72.10 | 84.10 | 66.94 | 71.98 |
| M₃S₆ | 62.12 | 68.12 | 79.75 | 65.13 | 68.78 |
| M₃S₇ | 63.75 | 71.21 | 84.70 | 67.25 | 71.34 |
| M₃S₈ | 61.33 | 68.31 | 81.58 | 61.75 | 68.24 |
| M₄S₁ | 61.11 | 67.26 | 69.86 | 60.23 | 64.62 |
| M₄S₂ | 63.00 | 70.58 | 82.21 | 65.47 | 70.32 |
| M₄S₃ | 62.88 | 70.15 | 82.40 | 65.41 | 70.21 |
| M₄S₄ | 62.07 | 68.81 | 80.40 | 64.92 | 69.05 |
| M₄S₅ | 64.07 | 73.12 | 84.40 | 67.45 | 72.58 |
| M₄S₆ | 62.89 | 68.51 | 80.05 | 65.19 | 69.16 |
| M₄S₇ | 64.56 | 72.14 | 85.15 | 67.11 | 71.93 |
| M₄S₈ | 62.58 | 68.64 | 82.32 | 61.88 | 68.86 |
| Mean | 62.34 | 69.28 | 80.44 | 64.61 | 69.17 |
| CD (p=0.05) | | | | | |
| M at S | 1.090 | 1.260 | 1.470 | 1.111 | |
| S at M | 1.051 | 1.212 | 1.411 | 1.123 | |

Table 11a. Effect of different levels of nitrogen and plant growth regulators on chlorophyll fluorescence (Fv/Fm) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|---------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 0.661 | (0.0) | 0.792 | (0.0) | 0.710 | (0.0) | 0.614 | (0.0) | 0.701 |
| M₂ | 0.593 | (-10.3) | 0.817 | (3.2) | 0.738 | (1.2) | 0.637 | (3.7) | 0.703 |
| M₃ | 0.674 | (2.0) | 0.821 | (3.7) | 0.767 | (5.9) | 0.656 | (6.8) | 0.704 |
| M₄ | 0.602 | (-8.9) | 0.834 | (5.3) | 0.785 | (8.4) | 0.684 | (11.4) | 0.707 |
| Mean | 0.636 | | 0.718 | | 0.750 | | 0.646 | | 0.683 |
| CD (p=0.05) | NS | | 0.004 | | 0.004 | | 0.003 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.601 | (0.0) | 0.692 | (0.0) | 0.632 | (0.0) | 0.524 | (0.0) | 0.611 |
| S₂ | 0.643 | (7.0) | 0.793 | (14.6) | 0.767 | (16.5) | 0.652 | (24.4) | 0.704 |
| S₃ | 0.642 | (6.8) | 0.794 | (14.7) | 0.705 | (21.1) | 0.687 | (31.1) | 0.706 |
| S₄ | 0.636 | (5.8) | 0.835 | (20.7) | 0.739 | (12.0) | 0.666 | (27.1) | 0.701 |
| S₅ | 0.684 | (13.8) | 0.814 | (17.6) | 0.849 | (18.7) | 0.622 | (18.7) | 0.705 |
| S₆ | 0.625 | (4.0) | 0.858 | (24.0) | 0.787 | (34.2) | 0.713 | (36.1) | 0.800 |
| S₇ | 0.637 | (6.0) | 0.813 | (17.5) | 0.816 | (23.9) | 0.641 | (22.3) | 0.711 |
| S₈ | 0.632 | (5.2) | 0.781 | (12.9) | 0.710 | (13.3) | 0.614 | (17.2) | 0.702 |
| Mean | 0.636 | | 0.718 | | 0.750 | | 0.646 | | 0.683 |
| CD (p=0.05) | NS | | 0.006 | | 0.006 | | 0.006 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 11b. Effect of different levels of nitrogen and plant growth regulators on chlorophyll fluorescence (Fv/Fm) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.661 | 0.691 | 0.595 | 0.581 | 0.635 |
| M₁S₂ | 0.670 | 0.645 | 0.734 | 0.652 | 0.674 |
| M₁S₃ | 0.782 | 0.768 | 0.685 | 0.623 | 0.716 |
| M₁S₄ | 0.780 | 0.676 | 0.691 | 0.596 | 0.687 |
| M₁S₅ | 0.791 | 0.854 | 0.803 | 0.684 | 0.688 |
| M₁S₆ | 0.781 | 0.737 | 0.731 | 0.605 | 0.742 |
| M₁S₇ | 0.723 | 0.692 | 0.782 | 0.642 | 0.718 |
| M₁S₈ | 0.675 | 0.793 | 0.662 | 0.581 | 0.649 |
| M₂S₁ | 0.454 | 0.694 | 0.631 | 0.513 | 0.607 |
| M₂S₂ | 0.511 | 0.735 | 0.751 | 0.671 | 0.658 |
| M₂S₃ | 0.766 | 0.733 | 0.691 | 0.642 | 0.713 |
| M₂S₄ | 0.693 | 0.711 | 0.741 | 0.613 | 0.684 |
| M₂S₅ | 0.784 | 0.741 | 0.824 | 0.693 | 0.746 |
| M₂S₆ | 0.535 | 0.731 | 0.785 | 0.633 | 0.677 |
| M₂S₇ | 0.733 | 0.710 | 0.811 | 0.661 | 0.725 |
| M₂S₈ | 0.711 | 0.724 | 0.672 | 0.602 | 0.613 |
| M₃S₁ | 0.532 | 0.722 | 0.643 | 0.543 | 0.658 |
| M₃S₂ | 0.681 | 0.695 | 0.784 | 0.694 | 0.715 |
| M₃S₃ | 0.671 | 0.633 | 0.714 | 0.672 | 0.657 |
| M₃S₄ | 0.713 | 0.693 | 0.752 | 0.641 | 0.636 |
| M₃S₅ | 0.771 | 0.722 | 0.863 | 0.732 | 0.751 |
| M₃S₆ | 0.633 | 0.642 | 0.811 | 0.654 | 0.717 |
| M₃S₇ | 0.752 | 0.662 | 0.831 | 0.681 | 0.708 |
| M₃S₈ | 0.742 | 0.761 | 0.730 | 0.623 | 0.712 |
| M₄S₁ | 0.691 | 0.613 | 0.662 | 0.502 | 0.635 |
| M₄S₂ | 0.743 | 0.703 | 0.800 | 0.710 | 0.763 |
| M₄S₃ | 0.762 | 0.713 | 0.731 | 0.701 | 0.734 |
| M₄S₄ | 0.751 | 0.651 | 0.773 | 0.660 | 0.755 |
| M₄S₅ | 0.793 | 0.775 | 0.870 | 0.750 | 0.686 |
| M₄S₆ | 0.761 | 0.692 | 0.820 | 0.685 | 0.655 |
| M₄S₇ | 0.782 | 0.761 | 0.840 | 0.722 | 0.674 |
| M₄S₈ | 0.742 | 0.703 | 0.775 | 0.633 | 0.692 |
| Mean | 0.648 | 0.718 | 0.750 | 0.649 | 0.683 |
| CD (p=0.05) | | | | | |
| M at S | 0.011 | 0.012 | 0.013 | 0.012 | |
| S at M | 0.011 | 0.012 | 0.013 | 0.012 | |

Table 12a. Effect of different levels of nitrogen and plant growth regulators on soluble protein (mg g^{-1}) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 9.46 | (0.0) | 16.92 | (0.0) | 22.36 | (0.0) | 16.69 | (0.0) | 16.36 |
| M₂ | 9.41 | (-0.5) | 16.94 | (0.1) | 23.26 | (4.0) | 16.84 | (0.9) | 16.61 |
| M₃ | 9.50 | (0.4) | 17.14 | (1.3) | 24.12 | (7.9) | 16.95 | (1.6) | 16.93 |
| M₄ | 9.47 | (0.1) | 17.06 | (0.8) | 27.75 | (24.1) | 17.06 | (2.2) | 17.84 |
| Mean | 9.46 | | 17.01 | | 24.37 | | 16.89 | | 16.93 |
| CD (p=0.05) | NS | | 0.092 | | 0.391 | | 0.090 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 8.74 | (0.0) | 15.42 | (0.0) | 20.56 | (0.0) | 14.23 | (0.0) | 14.74 |
| S₂ | 9.66 | (10.5) | 16.70 | (8.3) | 23.92 | (16.3) | 17.75 | (24.7) | 17.01 |
| S₃ | 9.59 | (9.7) | 16.57 | (7.5) | 24.64 | (19.8) | 17.38 | (22.1) | 17.05 |
| S₄ | 8.55 | (-2.2) | 16.79 | (8.9) | 23.49 | (14.1) | 16.69 | (17.3) | 16.38 |
| S₅ | 10.84 | (24.0) | 18.88 | (22.4) | 26.85 | (30.6) | 18.59 | (30.6) | 18.79 |
| S₆ | 8.69 | (-0.6) | 16.69 | (8.2) | 24.97 | (21.4) | 16.25 | (14.2) | 16.65 |
| S₇ | 10.66 | (22.0) | 18.47 | (19.8) | 26.18 | (27.3) | 18.42 | (29.4) | 18.43 |
| S₈ | 9.73 | (11.3) | 16.90 | (9.6) | 24.37 | (18.5) | 16.25 | (14.2) | 16.81 |
| Mean | 9.46 | | 17.01 | | 24.37 | | 16.89 | | 16.93 |
| CD (p=0.05) | 0.081 | | 0.140 | | 0.622 | | 0.151 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 12b. Effect of different levels of nitrogen and plant growth regulators on soluble protein (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 8.70 | 15.50 | 19.91 | 14.11 | 14.56 |
| M₁S₂ | 9.70 | 16.88 | 22.75 | 17.56 | 16.72 |
| M₁S₃ | 9.67 | 16.33 | 22.58 | 17.28 | 16.47 |
| M₁S₄ | 8.26 | 16.69 | 20.00 | 16.20 | 15.29 |
| M₁S₅ | 8.26 | 18.75 | 23.48 | 18.41 | 17.23 |
| M₁S₆ | 8.98 | 16.23 | 23.33 | 16.10 | 16.16 |
| M₁S₇ | 10.43 | 18.41 | 24.12 | 18.32 | 17.82 |
| M₁S₈ | 9.60 | 16.78 | 23.12 | 16.05 | 16.41 |
| M₂S₁ | 8.67 | 15.38 | 20.11 | 14.21 | 14.59 |
| M₂S₂ | 9.80 | 16.64 | 23.12 | 17.75 | 16.83 |
| M₂S₃ | 9.59 | 16.77 | 24.12 | 17.38 | 16.97 |
| M₂S₄ | 8.68 | 16.81 | 23.98 | 16.75 | 16.56 |
| M₂S₅ | 10.70 | 18.94 | 24.99 | 18.55 | 18.30 |
| M₂S₆ | 8.29 | 16.64 | 23.95 | 16.12 | 16.25 |
| M₂S₇ | 10.72 | 17.85 | 25.01 | 18.43 | 18.00 |
| M₂S₈ | 9.82 | 16.80 | 23.58 | 16.24 | 16.62 |
| M₃S₁ | 8.71 | 15.39 | 21.10 | 14.27 | 14.87 |
| M₃S₂ | 9.90 | 16.71 | 24.75 | 17.86 | 17.31 |
| M₃S₃ | 9.86 | 16.65 | 24.87 | 17.43 | 17.20 |
| M₃S₄ | 8.71 | 16.84 | 24.12 | 16.86 | 16.63 |
| M₃S₅ | 10.86 | 19.01 | 25.76 | 18.68 | 18.57 |
| M₃S₆ | 8.66 | 16.81 | 24.21 | 16.25 | 16.48 |
| M₃S₇ | 10.82 | 18.95 | 24.98 | 18.48 | 18.32 |
| M₃S₈ | 9.89 | 17.11 | 24.12 | 16.35 | 16.87 |
| M₄S₁ | 8.86 | 15.42 | 21.12 | 14.32 | 14.94 |
| M₄S₂ | 9.28 | 16.67 | 25.21 | 17.92 | 17.27 |
| M₄S₃ | 9.27 | 16.61 | 27.13 | 17.52 | 17.63 |
| M₄S₄ | 8.55 | 16.77 | 28.12 | 16.92 | 17.59 |
| M₄S₅ | 10.76 | 18.90 | 33.26 | 18.77 | 20.42 |
| M₄S₆ | 8.81 | 16.92 | 28.12 | 16.55 | 17.60 |
| M₄S₇ | 10.76 | 18.76 | 30.76 | 18.53 | 19.70 |
| M₄S₈ | 9.56 | 17.01 | 26.80 | 16.45 | 17.46 |
| Mean | 9.40 | 17.03 | 24.46 | 16.90 | 16.95 |
| CD (p=0.05) | | | | | |
| M at S | 0.162 | 0.283 | 1.227 | 0.290 | |
| S at M | 0.164 | 0.285 | 1.235 | 0.290 | |

Table 13a. Effect of different levels of nitrogen and plant growth regulators on nitrate reductase activity ($\mu\text{g NO}_2 \text{ g}^{-1}\text{h}^{-1}$) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 91.8 | (0.0) | 194.8 | (0.0) | 220.3 | (0.0) | 170.1 | (0.0) | 168.8 |
| M₂ | 92.4 | (0.7) | 194.0 | (-0.4) | 223.2 | (1.3) | 171.1 | (0.6) | 169.7 |
| M₃ | 92.9 | (1.2) | 196.4 | (0.8) | 227.0 | (3.0) | 172.4 | (1.4) | 171.7 |
| M₄ | 93.8 | (2.3) | 198.0 | (1.6) | 229.7 | (4.3) | 173.1 | (1.8) | 173.1 |
| Mean | 92.8 | | 195.8 | | 225.1 | | 171.7 | | 170.8 |
| CD (p=0.05) | 0.410 | | 1.070 | | 1.210 | | 0.930 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 90.2 | (0.0) | 167.7 | (0.0) | 168.2 | (0.0) | 138.0 | (0.0) | 140.9 |
| S₂ | 93.2 | (3.3) | 198.6 | (18.4) | 248.9 | (48.0) | 179.1 | (29.8) | 179.4 |
| S₃ | 93.5 | (3.7) | 198.9 | (18.6) | 241.3 | (43.5) | 176.7 | (28.4) | 176.7 |
| S₄ | 91.1 | (1.0) | 189.9 | (13.2) | 197.8 | (17.6) | 164.8 | (19.4) | 160.2 |
| S₅ | 95.9 | (6.3) | 221.4 | (32.0) | 268.4 | (59.6) | 202.4 | (46.7) | 197.0 |
| S₆ | 91.5 | (1.4) | 189.0 | (12.7) | 207.6 | (23.1) | 144.3 | (4.6) | 157.5 |
| S₇ | 94.8 | (5.1) | 211.4 | (26.1) | 256.4 | (52.4) | 192.1 | (39.2) | 188.8 |
| S₈ | 91.8 | (1.8) | 196.7 | (17.3) | 200.6 | (19.3) | 168.8 | (22.3) | 163.9 |
| Mean | 92.8 | | 195.8 | | 225.1 | | 171.7 | | 170.8 |
| CD (p=0.05) | 0.827 | | 1.710 | | 2.010 | | 1.520 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 13b. Effect of different levels of nitrogen and plant growth regulators on nitrate reductase activity ($\mu\text{g NO}_2 \text{ g}^{-1} \text{ h}^{-1}$) at different growth stages of bananacv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 90.2 | 169.3 | 164.3 | 136.8 | 140.1 |
| M₁S₂ | 91.2 | 198.7 | 248.5 | 178.2 | 178.6 |
| M₁S₃ | 91.2 | 197.3 | 232.2 | 175.4 | 173.5 |
| M₁S₄ | 90.6 | 188.3 | 190.3 | 162.0 | 156.9 |
| M₁S₅ | 95.2 | 220.0 | 264.3 | 200.0 | 194.7 |
| M₁S₆ | 90.9 | 187.3 | 201.1 | 143.1 | 154.9 |
| M₁S₇ | 94.5 | 209.2 | 252.2 | 189.5 | 186.5 |
| M₁S₈ | 91.0 | 195.5 | 198.2 | 168.2 | 162.7 |
| M₂S₁ | 90.2 | 163.1 | 170.0 | 137.3 | 140.1 |
| M₂S₂ | 93.2 | 192.1 | 243.1 | 179.6 | 176.2 |
| M₂S₃ | 93.1 | 198.2 | 241.5 | 176.3 | 176.5 |
| M₂S₄ | 91.0 | 189.4 | 198.3 | 163.3 | 159.9 |
| M₂S₅ | 95.7 | 221.6 | 261.3 | 202.3 | 195.2 |
| M₂S₆ | 91.1 | 188.3 | 208.3 | 144.3 | 157.5 |
| M₂S₇ | 94.8 | 210.7 | 255.6 | 192.0 | 188.2 |
| M₂S₈ | 91.7 | 196.7 | 199.3 | 168.8 | 163.6 |
| M₃S₁ | 90.2 | 170.0 | 168.3 | 138.5 | 141.5 |
| M₃S₂ | 94.0 | 199.2 | 251.5 | 179.8 | 180.6 |
| M₃S₃ | 94.3 | 198.8 | 243.7 | 177.8 | 177.9 |
| M₃S₄ | 91.2 | 189.0 | 201.2 | 165.5 | 161.1 |
| M₃S₅ | 96.2 | 221.8 | 270.4 | 203.5 | 198.0 |
| M₃S₆ | 91.5 | 189.2 | 210.2 | 144.8 | 158.4 |
| M₃S₇ | 94.8 | 211.5 | 258.6 | 193.3 | 189.5 |
| M₃S₈ | 91.9 | 197.0 | 201.8 | 169.2 | 164.5 |
| M₄S₁ | 90.3 | 168.5 | 170.2 | 139.3 | 141.7 |
| M₄S₂ | 95.2 | 205.4 | 253.9 | 180.0 | 182.9 |
| M₄S₃ | 95.2 | 202.2 | 249.1 | 178.0 | 179.9 |
| M₄S₄ | 91.8 | 192.7 | 201.3 | 168.2 | 162.7 |
| M₄S₅ | 97.8 | 222.8 | 278.5 | 204.4 | 200.9 |
| M₄S₆ | 91.9 | 191.6 | 211.3 | 145.1 | 159.3 |
| M₄S₇ | 96.6 | 215.1 | 260.5 | 194.6 | 191.7 |
| M₄S₈ | 92.7 | 198.7 | 204.1 | 169.7 | 165.5 |
| Mean | 92.9 | 198.4 | 225.5 | 173.4 | 171.0 |
| CD (p=0.05) | | | | | |
| M at S | 1.590 | 3.390 | 3.980 | 3.020 | |
| S at M | 1.653 | 3.420 | 4.030 | 3.050 | |

Table 14a. Effect of different levels of nitrogen and plant growth regulators on IAA oxidase activity (unoxidised auxin $\text{g}^{-1}\text{h}^{-1}$) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 286.3 | (0.0) | 461.3 | (0.0) | 652.1 | (0.0) | 315.9 | (0.0) | 428.9 |
| M₂ | 292.2 | (2.1) | 476.7 | (3.3) | 677.0 | (3.8) | 325.5 | (3.0) | 442.9 |
| M₃ | 316.7 | (10.6) | 518.3 | (12.4) | 715.1 | (9.7) | 342.2 | (8.3) | 473.1 |
| M₄ | 315.5 | (10.2) | 548.2 | (18.8) | 750.3 | (15.1) | 371.0 | (17.4) | 496.2 |
| Mean | 302.7 | | 501.1 | | 698.6 | | 338.7 | | 460.3 |
| CD (p=0.05) | 1.598 | | 2.068 | | 2.912 | | 1.411 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 287.5 | (0.0) | 457.4 | (0.0) | 636.9 | (0.0) | 322.0 | (0.0) | 425.9 |
| S₂ | 303.7 | (5.6) | 522.7 | (14.3) | 717.7 | (12.7) | 343.1 | (6.6) | 471.8 |
| S₃ | 297.8 | (3.4) | 508.7 | (11.2) | 703.7 | (10.5) | 340.6 | (5.8) | 462.7 |
| S₄ | 314.0 | (9.2) | 467.7 | (2.3) | 650.1 | (2.1) | 325.5 | (1.1) | 439.3 |
| S₅ | 320.4 | (11.4) | 545.7 | (19.3) | 782.2 | (22.8) | 360.4 | (11.9) | 502.2 |
| S₆ | 293.1 | (1.9) | 482.2 | (5.4) | 658.9 | (3.5) | 330.5 | (2.6) | 441.2 |
| S₇ | 309.9 | (7.8) | 534.0 | (16.7) | 766.9 | (20.4) | 353.4 | (9.8) | 491.1 |
| S₈ | 294.9 | (2.6) | 490.5 | (7.2) | 672.5 | (5.6) | 333.8 | (3.7) | 447.9 |
| Mean | 302.7 | | 501.1 | | 698.6 | | 338.7 | | 460.3 |
| CD (p=0.05) | 2.582 | | 4.527 | | 6.293 | | 3.030 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 14b. Effect of different levels of nitrogen and plant growth regulators on IAA oxidase activity (unoxidised auxin $g^{-1}h^{-1}$) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 280.0 | 410.1 | 600.1 | 300.0 | 397.5 |
| M₁S₂ | 287.2 | 488.7 | 668.2 | 319.1 | 440.8 |
| M₁S₃ | 285.9 | 477.8 | 664.7 | 317.9 | 436.6 |
| M₁S₄ | 282.5 | 425.7 | 619.0 | 307.5 | 408.7 |
| M₁S₅ | 300.3 | 510.5 | 710.6 | 335.3 | 464.2 |
| M₁S₆ | 282.5 | 437.2 | 620.8 | 308.4 | 412.2 |
| M₁S₇ | 288.2 | 498.7 | 698.1 | 327.1 | 453.0 |
| M₁S₈ | 283.9 | 441.9 | 634.9 | 311.9 | 418.2 |
| M₂S₁ | 282.4 | 430.6 | 630.9 | 310.4 | 413.6 |
| M₂S₂ | 298.3 | 505.0 | 695.9 | 328.1 | 456.8 |
| M₂S₃ | 288.6 | 493.0 | 681.4 | 328.7 | 447.9 |
| M₂S₄ | 283.6 | 434.3 | 631.0 | 316.5 | 416.4 |
| M₂S₅ | 310.1 | 525.5 | 756.3 | 343.3 | 483.8 |
| M₂S₆ | 285.1 | 448.1 | 639.2 | 319.1 | 422.9 |
| M₂S₇ | 304.4 | 511.0 | 736.6 | 337.4 | 472.3 |
| M₂S₈ | 284.9 | 466.2 | 644.5 | 320.7 | 429.1 |
| M₃S₁ | 289.7 | 489.4 | 647.3 | 329.6 | 439.0 |
| M₃S₂ | 309.8 | 529.6 | 737.4 | 349.7 | 481.6 |
| M₃S₃ | 305.3 | 512.4 | 719.6 | 348.3 | 471.4 |
| M₃S₄ | 391.3 | 499.1 | 650.9 | 326.4 | 466.9 |
| M₃S₅ | 324.2 | 548.6 | 807.9 | 364.1 | 511.2 |
| M₃S₆ | 298.3 | 508.5 | 666.7 | 329.3 | 450.7 |
| M₃S₇ | 314.4 | 547.0 | 799.6 | 357.4 | 504.6 |
| M₃S₈ | 300.9 | 511.6 | 691.1 | 333.0 | 459.2 |
| M₄S₁ | 297.8 | 499.6 | 669.5 | 347.7 | 453.6 |
| M₄S₂ | 319.6 | 567.3 | 769.1 | 375.6 | 507.9 |
| M₄S₃ | 311.6 | 551.4 | 749.2 | 367.6 | 494.9 |
| M₄S₄ | 298.7 | 511.5 | 699.4 | 351.7 | 465.3 |
| M₄S₅ | 347.1 | 598.5 | 853.8 | 399.0 | 549.6 |
| M₄S₆ | 306.7 | 535.0 | 708.9 | 365.0 | 478.9 |
| M₄S₇ | 332.7 | 579.5 | 833.2 | 391.6 | 534.3 |
| M₄S₈ | 309.7 | 542.5 | 719.4 | 369.7 | 485.3 |
| Mean | 302.7 | 501.1 | 698.6 | 338.7 | 460.3 |
| CD (p=0.05) | | | | | |
| M at S | 5.080 | 8.711 | 12.127 | 5.847 | |
| S at M | 5.164 | 9.065 | 12.596 | 6.061 | |

Table 15a. Effect of different levels of nitrogen and plant growth regulators on total phenolics content (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|---------|--------------|---------|--------------|---------|----------------|---------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 0.72 | (0.0) | 0.68 | (0.0) | 0.72 | (0.0) | 0.64 | (0.0) | 0.69 |
| M₂ | 0.71 | (-1.4) | 0.67 | (-1.5) | 0.71 | (-1.6) | 0.63 | (-1.4) | 0.68 |
| M₃ | 0.69 | (-4.2) | 0.65 | (-4.4) | 0.69 | (-3.1) | 0.62 | (-4.2) | 0.66 |
| M₄ | 0.68 | (-5.6) | 0.64 | (-5.9) | 0.65 | (-3.1) | 0.62 | (-9.7) | 0.65 |
| Mean | 0.70 | | 0.66 | | 0.69 | | 0.63 | | 0.67 |
| CD (p=0.05) | 0.003 | | 0.003 | | 0.003 | | 0.003 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.77 | (0.0) | 0.72 | (0.0) | 0.78 | (0.0) | 0.67 | (0.0) | 0.73 |
| S₂ | 0.69 | (-10.4) | 0.67 | (-6.9) | 0.66 | (-15.4) | 0.64 | (-4.5) | 0.66 |
| S₃ | 0.70 | (-9.1) | 0.65 | (-9.7) | 0.67 | (-14.1) | 0.61 | (-9.0) | 0.66 |
| S₄ | 0.73 | (-5.2) | 0.70 | (-2.8) | 0.76 | (-2.6) | 0.67 | (0.0) | 0.71 |
| S₅ | 0.64 | (-16.9) | 0.59 | (-18.1) | 0.59 | (-24.4) | 0.57 | (-14.9) | 0.60 |
| S₆ | 0.72 | (-6.5) | 0.71 | (-1.4) | 0.74 | (-5.1) | 0.66 | (-1.5) | 0.71 |
| S₇ | 0.65 | (-15.6) | 0.60 | (-16.7) | 0.61 | (-21.8) | 0.58 | (-13.4) | 0.61 |
| S₈ | 0.71 | (-7.8) | 0.68 | (-5.6) | 0.72 | (-7.7) | 0.66 | (-1.5) | 0.69 |
| Mean | 0.70 | | 0.66 | | 0.69 | | 0.63 | | 0.67 |
| CD (p=0.05) | 0.006 | | 0.006 | | 0.006 | | 0.006 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 15b. Effect of different levels of nitrogen and plant growth regulators on total phenolics (mg g⁻¹) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.79 | 0.74 | 0.80 | 0.68 | 0.75 |
| M₁S₂ | 0.71 | 0.69 | 0.68 | 0.65 | 0.68 |
| M₁S₃ | 0.72 | 0.67 | 0.69 | 0.62 | 0.67 |
| M₁S₄ | 0.75 | 0.72 | 0.78 | 0.68 | 0.73 |
| M₁S₅ | 0.66 | 0.61 | 0.64 | 0.58 | 0.62 |
| M₁S₆ | 0.74 | 0.71 | 0.76 | 0.67 | 0.72 |
| M₁S₇ | 0.67 | 0.62 | 0.66 | 0.59 | 0.63 |
| M₁S₈ | 0.73 | 0.70 | 0.74 | 0.67 | 0.71 |
| M₂S₁ | 0.78 | 0.73 | 0.79 | 0.68 | 0.75 |
| M₂S₂ | 0.70 | 0.68 | 0.67 | 0.64 | 0.67 |
| M₂S₃ | 0.71 | 0.66 | 0.68 | 0.62 | 0.67 |
| M₂S₄ | 0.74 | 0.71 | 0.77 | 0.68 | 0.72 |
| M₂S₅ | 0.65 | 0.60 | 0.63 | 0.58 | 0.61 |
| M₂S₆ | 0.73 | 0.72 | 0.75 | 0.67 | 0.72 |
| M₂S₇ | 0.66 | 0.61 | 0.65 | 0.59 | 0.63 |
| M₂S₈ | 0.72 | 0.69 | 0.73 | 0.67 | 0.70 |
| M₃S₁ | 0.76 | 0.71 | 0.77 | 0.66 | 0.72 |
| M₃S₂ | 0.68 | 0.66 | 0.65 | 0.63 | 0.65 |
| M₃S₃ | 0.69 | 0.64 | 0.66 | 0.60 | 0.65 |
| M₃S₄ | 0.72 | 0.69 | 0.75 | 0.66 | 0.70 |
| M₃S₅ | 0.63 | 0.58 | 0.61 | 0.56 | 0.59 |
| M₃S₆ | 0.71 | 0.70 | 0.73 | 0.65 | 0.70 |
| M₃S₇ | 0.64 | 0.59 | 0.63 | 0.57 | 0.61 |
| M₃S₈ | 0.70 | 0.67 | 0.71 | 0.65 | 0.68 |
| M₄S₁ | 0.75 | 0.69 | 0.76 | 0.65 | 0.71 |
| M₄S₂ | 0.67 | 0.64 | 0.64 | 0.63 | 0.64 |
| M₄S₃ | 0.68 | 0.62 | 0.65 | 0.60 | 0.64 |
| M₄S₄ | 0.71 | 0.67 | 0.74 | 0.65 | 0.69 |
| M₄S₅ | 0.62 | 0.56 | 0.50 | 0.55 | 0.56 |
| M₄S₆ | 0.70 | 0.69 | 0.72 | 0.65 | 0.69 |
| M₄S₇ | 0.62 | 0.57 | 0.52 | 0.56 | 0.57 |
| M₄S₈ | 0.69 | 0.66 | 0.70 | 0.65 | 0.67 |
| Mean | 0.70 | 0.66 | 0.69 | 0.63 | 0.67 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.011 | 0.011 | 0.011 | |
| S at M | NS | 0.011 | 0.012 | 0.011 | |

Table 16a. Effect of different levels of nitrogen and plant growth regulators on relative water content (%) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|-------|--------------|-------|----------------|-------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 66.13 | (0.0) | 72.88 | (0.0) | 81.79 | (0.0) | 65.01 | (0.0) | 71.50 |
| M₂ | 66.3 | (0.3) | 73.79 | (1.2) | 81.92 | (0.2) | 65.75 | (1.3) | 71.90 |
| M₃ | 67.1 | (1.5) | 75.12 | (3.1) | 82.14 | (0.4) | 66.57 | (2.4) | 72.70 |
| M₄ | 67.89 | (2.7) | 75.82 | (4.0) | 82.34 | (0.6) | 67.72 | (4.2) | 73.40 |
| Mean | 66.86 | | 74.40 | | 82.05 | | 66.26 | | 72.39 |
| CD (p=0.05) | 0.299 | | 0.327 | | 0.369 | | 0.293 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 65.41 | (0.0) | 71.99 | (0.0) | 80.32 | (0.0) | 64.46 | (0.0) | 70.50 |
| S₂ | 67.07 | (2.5) | 74.88 | (4.0) | 82.1 | (2.2) | 66.58 | (3.3) | 72.70 |
| S₃ | 67.13 | (2.6) | 74.55 | (3.6) | 82.07 | (2.2) | 66.7 | (3.5) | 72.60 |
| S₄ | 65.99 | (0.9) | 71.96 | (0.0) | 81.23 | (1.1) | 65.09 | (1.0) | 71.10 |
| S₅ | 68.24 | (4.3) | 77.84 | (8.1) | 83.63 | (4.1) | 68.15 | (3.9) | 74.50 |
| S₆ | 66.48 | (1.6) | 73.44 | (2.0) | 81.67 | (1.7) | 65.57 | (1.7) | 71.80 |
| S₇ | 68.05 | (4.0) | 76.96 | (6.9) | 83.39 | (3.8) | 67.93 | (5.4) | 74.10 |
| S₈ | 66.49 | (1.7) | 73.6 | (2.2) | 81.95 | (2.0) | 65.63 | (1.8) | 71.90 |
| Mean | 66.86 | | 74.40 | | 82.05 | | 66.26 | | 72.39 |
| CD (p=0.05) | 0.596 | | 0.665 | | 0.731 | | 0.591 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 16b. Effect of different levels of nitrogen and plant growth regulators on relative water content (%) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 65.00 | 70.82 | 80.11 | 64.00 | 69.98 |
| M₁S₂ | 66.26 | 73.16 | 82.00 | 65.12 | 71.63 |
| M₁S₃ | 66.17 | 72.70 | 81.95 | 65.18 | 71.50 |
| M₁S₄ | 65.90 | 71.64 | 81.01 | 64.17 | 70.68 |
| M₁S₅ | 67.10 | 75.60 | 83.60 | 66.50 | 73.20 |
| M₁S₆ | 65.98 | 72.31 | 81.44 | 64.58 | 71.07 |
| M₁S₇ | 67.00 | 74.77 | 83.00 | 66.20 | 72.74 |
| M₁S₈ | 66.00 | 72.50 | 81.90 | 64.70 | 71.27 |
| M₂S₁ | 65.10 | 71.60 | 80.21 | 64.18 | 70.27 |
| M₂S₂ | 66.52 | 74.60 | 82.13 | 66.50 | 72.43 |
| M₂S₃ | 66.44 | 73.90 | 82.00 | 66.38 | 72.18 |
| M₂S₄ | 65.98 | 72.40 | 81.21 | 65.00 | 71.14 |
| M₂S₅ | 67.70 | 77.20 | 83.77 | 67.48 | 74.03 |
| M₂S₆ | 66.07 | 72.60 | 81.70 | 65.10 | 71.36 |
| M₂S₇ | 67.50 | 76.16 | 83.54 | 67.10 | 73.57 |
| M₂S₈ | 66.10 | 72.98 | 81.98 | 65.28 | 71.58 |
| M₃S₁ | 65.70 | 72.60 | 80.31 | 64.70 | 70.82 |
| M₃S₂ | 67.40 | 76.00 | 82.54 | 67.20 | 73.28 |
| M₃S₃ | 67.20 | 75.01 | 82.13 | 67.18 | 72.88 |
| M₃S₄ | 66.10 | 72.90 | 81.27 | 65.20 | 71.01 |
| M₃S₅ | 68.50 | 79.50 | 83.92 | 68.70 | 75.15 |
| M₃S₆ | 66.97 | 74.00 | 81.90 | 65.58 | 72.01 |
| M₃S₇ | 68.20 | 78.50 | 83.76 | 68.52 | 74.74 |
| M₃S₈ | 66.98 | 74.10 | 82.00 | 65.70 | 72.19 |
| M₄S₁ | 65.90 | 73.00 | 80.71 | 65.00 | 71.15 |
| M₄S₂ | 68.81 | 76.55 | 82.61 | 68.00 | 73.99 |
| M₄S₃ | 68.62 | 76.50 | 82.32 | 68.00 | 73.86 |
| M₄S₄ | 66.16 | 73.50 | 81.67 | 66.22 | 71.62 |
| M₄S₅ | 70.28 | 79.80 | 84.00 | 70.54 | 76.15 |
| M₄S₆ | 66.61 | 74.48 | 82.00 | 66.70 | 72.36 |
| M₄S₇ | 70.00 | 78.98 | 83.90 | 70.40 | 75.82 |
| M₄S₈ | 67.00 | 74.98 | 82.10 | 66.98 | 72.76 |
| Mean | 66.91 | 74.46 | 82.12 | 66.31 | 72.45 |
| CD (p=0.05) | | | | | |
| M at S | NS | 1.284 | NS | NS | |
| S at M | NS | 1.329 | NS | NS | |

Table 17a. Effect of different levels of nitrogen and plant growth regulators on transpiration ($\mu\text{g H}_2\text{O cm}^{-2}\text{s}^{-1}$) different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 6.33 | (0.0) | 8.04 | (0.0) | 7.68 | (0.0) | 2.18 | (0.0) | 6.06 |
| M₂ | 7.03 | (11.1) | 8.02 | (0.2) | 7.68 | (0.0) | 1.89 | (-13.3) | 6.15 |
| M₃ | 6.86 | (8.4) | 8.10 | (0.7) | 7.35 | (-4.3) | 2.10 | (-3.7) | 6.10 |
| M₄ | 6.72 | (6.2) | 8.07 | (0.4) | 7.37 | (-4.0) | 2.01 | (-7.8) | 6.04 |
| Mean | 6.73 | | 8.06 | | 7.52 | | 2.05 | | 6.09 |
| CD (p=0.05) | 0.002 | | 0.001 | | 0.00 | | 0.005 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 7.35 | (0.0) | 8.87 | (0.0) | 8.31 | (0.0) | 2.24 | (0.0) | 6.69 |
| S₂ | 6.00 | (-18.4) | 7.17 | (-19.5) | 7.02 | (-15.5) | 1.65 | (-26.3) | 5.46 |
| S₃ | 6.32 | (-14.0) | 7.31 | (-17.6) | 6.91 | (-16.8) | 1.63 | (-27.2) | 5.54 |
| S₄ | 6.08 | (-17.3) | 7.43 | (-16.2) | 7.37 | (-11.3) | 2.09 | (-6.7) | 5.75 |
| S₅ | 5.75 | (-21.8) | 7.50 | (-15.4) | 6.53 | (-21.4) | 1.71 | (-23.7) | 5.37 |
| S₆ | 7.08 | (-3.7) | 8.54 | (-3.7) | 7.71 | (-7.2) | 2.18 | (-2.7) | 6.38 |
| S₇ | 7.63 | (3.8) | 8.86 | (-0.1) | 8.22 | (-1.1) | 2.53 | (12.9) | 6.81 |
| S₈ | 7.66 | (4.2) | 8.78 | (-1.0) | 8.09 | (-2.6) | 2.33 | (4.0) | 6.71 |
| Mean | 6.73 | | 8.06 | | 7.52 | | 2.05 | | 6.09 |
| CD (p=0.05) | 0.004 | | 0.002 | | 0.00 | | 0.013 | | |
| | | | | | 3 | | | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 17b. Effect of different levels of nitrogen and plant growth regulators on transpiration ($\mu\text{g H}_2\text{O cm}^{-2}\text{s}^{-1}$) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 7.18 | 8.91 | 8.50 | 2.28 | 6.72 |
| M₁S₂ | 6.25 | 7.36 | 6.90 | 1.70 | 5.55 |
| M₁S₃ | 6.61 | 7.45 | 6.98 | 1.68 | 5.68 |
| M₁S₄ | 5.97 | 7.39 | 7.61 | 2.20 | 5.79 |
| M₁S₅ | 5.04 | 7.16 | 6.43 | 1.77 | 5.10 |
| M₁S₆ | 6.52 | 8.13 | 8.29 | 2.21 | 6.29 |
| M₁S₇ | 6.37 | 8.98 | 8.37 | 2.83 | 6.64 |
| M₁S₈ | 6.65 | 8.85 | 8.25 | 2.78 | 6.63 |
| M₂S₁ | 7.06 | 8.90 | 8.31 | 2.26 | 6.63 |
| M₂S₂ | 6.81 | 7.11 | 6.77 | 1.67 | 5.59 |
| M₂S₃ | 6.90 | 7.30 | 6.93 | 1.65 | 5.70 |
| M₂S₄ | 6.53 | 7.14 | 7.39 | 2.02 | 5.77 |
| M₂S₅ | 5.57 | 7.97 | 7.27 | 1.75 | 5.64 |
| M₂S₆ | 6.97 | 8.02 | 8.25 | 2.20 | 6.36 |
| M₂S₇ | 7.85 | 8.84 | 8.26 | 1.80 | 6.69 |
| M₂S₈ | 8.44 | 8.75 | 8.14 | 1.74 | 6.77 |
| M₃S₁ | 7.85 | 8.81 | 8.21 | 2.22 | 6.77 |
| M₃S₂ | 5.13 | 7.09 | 6.71 | 1.64 | 5.14 |
| M₃S₃ | 5.46 | 7.24 | 6.89 | 1.61 | 5.30 |
| M₃S₄ | 6.44 | 7.09 | 7.31 | 2.00 | 5.71 |
| M₃S₅ | 6.49 | 7.93 | 6.26 | 1.71 | 5.60 |
| M₃S₆ | 7.21 | 8.98 | 7.16 | 2.18 | 6.38 |
| M₃S₇ | 7.82 | 8.79 | 8.19 | 2.78 | 6.90 |
| M₃S₈ | 8.41 | 8.75 | 8.02 | 2.71 | 6.97 |
| M₄S₁ | 7.26 | 8.79 | 8.16 | 2.18 | 6.60 |
| M₄S₂ | 5.79 | 7.07 | 7.67 | 1.60 | 5.53 |
| M₄S₃ | 6.29 | 7.20 | 6.79 | 1.58 | 5.47 |
| M₄S₄ | 5.36 | 8.07 | 7.14 | 2.15 | 5.68 |
| M₄S₅ | 5.85 | 6.91 | 6.14 | 1.65 | 5.14 |
| M₄S₆ | 7.58 | 8.99 | 7.09 | 2.13 | 6.45 |
| M₄S₇ | 8.43 | 8.77 | 8.00 | 2.72 | 6.98 |
| M₄S₈ | 7.11 | 8.70 | 7.91 | 2.08 | 6.45 |
| Mean | 6.73 | 8.05 | 7.51 | 2.05 | 6.08 |
| CD (p=0.05) | | | | | |
| M at S | 0.002 | 0.001 | 0.001 | 0.011 | |
| S at M | 0.003 | 0.001 | 0.003 | 0.011 | |

Table 18a. Effect of different levels of nitrogen and plant growth regulators on stomatal resistance ($s\text{ cm}^{-1}$) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|---------|--------------|---------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 1.33 | (0.0) | 4.89 | (0.0) | 6.96 | (0.0) | 6.96 | (0.0) | 5.04 |
| M₂ | 1.34 | (0.8) | 4.92 | (0.6) | 6.58 | (-5.5) | 6.58 | (0.9) | 4.86 |
| M₃ | 1.28 | (-3.8) | 4.84 | (-1.0) | 5.90 | (-15.5) | 5.90 | (-8.5) | 4.48 |
| M₄ | 1.43 | (7.5) | 4.27 | (-12.7) | 4.88 | (-29.1) | 4.88 | (-5.7) | 3.87 |
| Mean | 1.34 | | 4.73 | | 6.08 | | 6.08 | | 4.56 |
| CD (p=0.05) | 0.003 | | 0.020 | | 0.020 | | 0.003 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 1.22 | (0.0) | 4.61 | (0.0) | 5.73 | (0.0) | 1.12 | (0.0) | 4.32 |
| S₂ | 1.46 | (19.7) | 4.96 | (7.6) | 6.22 | (8.6) | 1.68 | (38.6) | 4.71 |
| S₃ | 1.41 | (15.6) | 4.90 | (6.3) | 6.48 | (13.1) | 1.78 | (27.7) | 4.82 |
| S₄ | 1.33 | (9.0) | 4.76 | (3.3) | 6.72 | (17.3) | 1.38 | (44.6) | 4.88 |
| S₅ | 1.46 | (19.7) | 5.18 | (12.4) | 6.55 | (14.3) | 1.24 | (49.4) | 4.94 |
| S₆ | 1.29 | (5.7) | 4.44 | (-3.7) | 5.86 | (2.3) | 1.81 | (24.1) | 4.36 |
| S₇ | 1.33 | (9.0) | 4.46 | (-3.3) | 5.71 | (-0.3) | 1.13 | (0.0) | 4.30 |
| S₈ | 1.27 | (4.1) | 4.54 | (-1.5) | 5.37 | (-6.3) | 1.20 | (4.8) | 4.13 |
| Mean | 1.34 | | 4.73 | | 6.08 | | 6.08 | | 4.56 |
| CD (p=0.05) | 0.004 | | 0.020 | | 0.020 | | 0.003 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 18b. Effect of different levels of nitrogen and plant growth regulators on stomatal resistance ($s\text{ cm}^{-1}$) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 1.25 | 4.75 | 6.75 | 0.93 | 3.42 |
| M₁S₂ | 1.42 | 5.10 | 7.37 | 1.08 | 3.74 |
| M₁S₃ | 1.38 | 5.05 | 7.02 | 1.02 | 3.62 |
| M₁S₄ | 1.37 | 4.82 | 7.88 | 1.26 | 3.83 |
| M₁S₅ | 1.49 | 5.20 | 7.98 | 1.22 | 3.97 |
| M₁S₆ | 1.28 | 4.65 | 6.48 | 1.01 | 3.36 |
| M₁S₇ | 1.24 | 4.60 | 6.29 | 1.09 | 3.31 |
| M₁S₈ | 1.22 | 4.99 | 6.00 | 0.89 | 3.28 |
| M₂S₁ | 1.18 | 4.80 | 5.68 | 0.75 | 3.10 |
| M₂S₂ | 1.48 | 5.21 | 6.48 | 1.36 | 3.63 |
| M₂S₃ | 1.39 | 5.10 | 7.21 | 1.05 | 3.69 |
| M₂S₄ | 1.37 | 4.85 | 6.90 | 1.25 | 3.59 |
| M₂S₅ | 1.43 | 5.25 | 7.00 | 1.37 | 3.76 |
| M₂S₆ | 1.30 | 4.69 | 6.94 | 1.18 | 3.53 |
| M₂S₇ | 1.29 | 4.63 | 6.35 | 0.70 | 3.24 |
| M₂S₈ | 1.25 | 4.80 | 6.10 | 0.92 | 3.27 |
| M₃S₁ | 1.21 | 4.90 | 5.73 | 0.79 | 3.16 |
| M₃S₂ | 1.41 | 5.28 | 5.52 | 1.05 | 3.32 |
| M₃S₃ | 1.42 | 5.19 | 6.28 | 1.07 | 3.49 |
| M₃S₄ | 1.29 | 5.29 | 6.98 | 1.18 | 3.69 |
| M₃S₅ | 1.36 | 5.25 | 6.11 | 1.13 | 3.46 |
| M₃S₆ | 1.22 | 4.10 | 5.99 | 0.93 | 3.06 |
| M₃S₇ | 1.22 | 4.70 | 5.52 | 0.75 | 3.05 |
| M₃S₈ | 1.18 | 4.12 | 5.15 | 0.88 | 2.83 |
| M₄S₁ | 1.23 | 4.00 | 4.77 | 0.84 | 2.71 |
| M₄S₂ | 1.54 | 4.35 | 5.64 | 1.09 | 3.16 |
| M₄S₃ | 1.46 | 4.25 | 5.38 | 1.09 | 3.05 |
| M₄S₄ | 1.31 | 4.05 | 5.10 | 1.12 | 2.90 |
| M₄S₅ | 1.59 | 5.10 | 5.22 | 1.25 | 3.29 |
| M₄S₆ | 1.35 | 4.30 | 4.00 | 0.98 | 2.66 |
| M₄S₇ | 1.55 | 3.90 | 4.68 | 0.77 | 2.73 |
| M₄S₈ | 1.41 | 4.22 | 4.20 | 0.80 | 2.66 |
| Mean | 1.35 | 4.73 | 6.08 | 1.03 | 3.30 |
| CD (p=0.05) | | | | | |
| M at S | 0.010 | 0.030 | 0.040 | 0.010 | |
| S at M | 0.010 | 0.030 | 0.040 | 0.010 | |

Table 19a. Effect of different levels of nitrogen and plant growth regulators on leaf temperature (°C) different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 30.3 | (0.0) | 29.6 | (0.0) | 28.1 | (0.0) | 27.2 | (0.0) | 28.8 |
| M₂ | 30.3 | (0.0) | 29.6 | (0.0) | 28.1 | (0.0) | 27.4 | (0.7) | 28.9 |
| M₃ | 29.9 | (-1.3) | 29.6 | (0.0) | 27.8 | (-1.1) | 27.0 | (-0.7) | 28.6 |
| M₄ | 29.3 | (-3.3) | 29.3 | (-1.0) | 27.9 | (-0.7) | 27.6 | (1.5) | 28.5 |
| Mean | 30.0 | | 29.5 | | 28.0 | | 27.3 | | 28.7 |
| CD (p=0.05) | 0.080 | | 0.083 | | 0.081 | | 0.072 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 30.7 | (0.0) | 30.7 | (0.0) | 29.4 | (0.0) | 29.0 | (0.0) | 29.9 |
| S₂ | 29.0 | (-5.5) | 29.2 | (-4.9) | 27.2 | (-7.5) | 26.5 | (-8.6) | 28.0 |
| S₃ | 29.5 | (-3.9) | 28.5 | (-7.2) | 27.2 | (-7.5) | 27.5 | (-5.2) | 28.2 |
| S₄ | 29.6 | (-3.6) | 29.3 | (-4.6) | 27.4 | (-6.8) | 26.6 | (-8.3) | 28.2 |
| S₅ | 29.1 | (-5.2) | 28.4 | (-7.5) | 26.9 | (-8.5) | 26.3 | (-9.3) | 27.7 |
| S₆ | 30.6 | (-0.3) | 30.3 | (-1.3) | 28.7 | (-2.4) | 27.5 | (-5.2) | 29.3 |
| S₇ | 30.4 | (-1.0) | 29.3 | (-4.6) | 28.1 | (-4.4) | 27.5 | (-5.2) | 28.8 |
| S₈ | 30.6 | (-0.3) | 30.4 | (-1.0) | 29.0 | (-1.4) | 27.6 | (-4.8) | 29.4 |
| Mean | 30.0 | | 29.5 | | 28.0 | | 27.3 | | 28.7 |
| CD (p=0.05) | 0.080 | | 0.089 | | 0.087 | | 0.079 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 19b. Effect of different levels of nitrogen and plant growth regulators on leaf temperature (°C) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 31.2 | 30.0 | 29.7 | 28.8 | 29.9 |
| M₁S₂ | 29.7 | 30.1 | 27.9 | 26.8 | 28.6 |
| M₁S₃ | 29.9 | 29.0 | 27.2 | 26.8 | 28.2 |
| M₁S₄ | 30.0 | 29.0 | 27.2 | 26.7 | 28.2 |
| M₁S₅ | 29.6 | 28.0 | 26.7 | 26.9 | 27.8 |
| M₁S₆ | 30.5 | 30.8 | 28.8 | 27.1 | 29.3 |
| M₁S₇ | 30.7 | 30.0 | 27.8 | 27.3 | 29.0 |
| M₁S₈ | 30.9 | 30.5 | 29.9 | 27.1 | 29.6 |
| M₂S₁ | 31.0 | 31.0 | 29.4 | 29.1 | 30.1 |
| M₂S₂ | 29.0 | 30.0 | 27.0 | 26.0 | 28.0 |
| M₂S₃ | 29.6 | 29.0 | 27.4 | 29.9 | 29.0 |
| M₂S₄ | 29.9 | 29.0 | 27.4 | 26.4 | 28.2 |
| M₂S₅ | 29.2 | 28.2 | 28.2 | 26.0 | 27.9 |
| M₂S₆ | 31.2 | 30.2 | 29.1 | 27.0 | 29.4 |
| M₂S₇ | 31.5 | 29.7 | 28.2 | 27.6 | 29.3 |
| M₂S₈ | 30.8 | 29.5 | 28.4 | 27.3 | 29.0 |
| M₃S₁ | 29.9 | 30.8 | 29.3 | 29.0 | 29.7 |
| M₃S₂ | 29.4 | 29.1 | 27.0 | 26.8 | 28.1 |
| M₃S₃ | 29.8 | 28.0 | 27.0 | 26.4 | 27.8 |
| M₃S₄ | 29.8 | 29.2 | 27.3 | 26.5 | 28.2 |
| M₃S₅ | 29.2 | 29.0 | 27.1 | 25.9 | 27.8 |
| M₃S₆ | 30.8 | 30.0 | 28.4 | 27.9 | 29.3 |
| M₃S₇ | 30.4 | 30.6 | 28.3 | 27.1 | 29.1 |
| M₃S₈ | 30.9 | 30.5 | 28.4 | 27.0 | 29.2 |
| M₄S₁ | 30.9 | 31.0 | 29.2 | 28.9 | 30.0 |
| M₄S₂ | 28.4 | 28.1 | 27.5 | 26.8 | 27.7 |
| M₄S₃ | 28.5 | 28.0 | 27.0 | 26.7 | 27.6 |
| M₄S₄ | 28.8 | 30.0 | 27.6 | 26.9 | 28.3 |
| M₄S₅ | 28.9 | 29.0 | 26.0 | 26.9 | 27.7 |
| M₄S₆ | 29.9 | 30.0 | 28.2 | 27.8 | 29.0 |
| M₄S₇ | 29.1 | 27.0 | 28.1 | 27.9 | 28.0 |
| M₄S₈ | 29.7 | 31.0 | 29.0 | 28.8 | 29.6 |
| Mean | 30.0 | 29.5 | 28.0 | 27.3 | 28.7 |
| CD (p=0.05) | | | | | |
| M at S | 0.184 | 0.184 | 0.171 | 0.165 | |
| S at M | 0.176 | 0.176 | 0.164 | 0.179 | |

Table 20a. Effect of different levels of nitrogen and plant growth regulators on nitrogen content (%) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 1.73 | (0.0) | 2.63 | (0.0) | 2.78 | (0.0) | 1.76 | (0.0) | 2.21 |
| M₂ | 1.82 | (5.2) | 2.67 | (1.5) | 2.82 | (1.4) | 1.79 | (1.7) | 2.32 |
| M₃ | 1.82 | (5.2) | 2.72 | (3.4) | 2.90 | (4.3) | 1.81 | (2.8) | 2.30 |
| M₄ | 1.82 | (5.2) | 2.77 | (5.3) | 3.02 | (8.6) | 1.84 | (4.5) | 2.42 |
| Mean | 1.80 | | 2.70 | | 2.88 | | 1.80 | | 2.29 |
| CD (p=0.05) | NS | | 0.012 | | 0.013 | | 0.008 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 1.79 | (0.0) | 2.11 | (0.0) | 2.46 | (0.0) | 1.50 | (0.0) | 2.02 |
| S₂ | 1.79 | (0.0) | 2.84 | (34.6) | 2.95 | (19.9) | 1.86 | (24.0) | 2.42 |
| S₃ | 1.80 | (0.6) | 2.76 | (30.8) | 2.97 | (20.7) | 1.85 | (23.3) | 2.31 |
| S₄ | 1.79 | (0.0) | 2.52 | (19.4) | 2.71 | (10.2) | 1.77 | (18.0) | 2.23 |
| S₅ | 1.80 | (0.6) | 2.95 | (39.8) | 3.18 | (29.3) | 1.93 | (28.7) | 2.54 |
| S₆ | 1.80 | (0.6) | 2.63 | (24.6) | 2.83 | (15.0) | 1.79 | (19.3) | 2.33 |
| S₇ | 1.80 | (0.6) | 2.92 | (38.4) | 3.08 | (25.2) | 1.88 | (25.3) | 2.40 |
| S₈ | 1.80 | (0.6) | 2.83 | (34.1) | 2.87 | (16.7) | 1.81 | (20.7) | 2.36 |
| Mean | 1.80 | | 2.70 | | 2.88 | | 1.80 | | 2.29 |
| CD (p=0.05) | NS | | 0.025 | | 0.026 | | 0.016 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 20b. Effect of different levels of nitrogen and plant growth regulators on leaf nitrogen content (%) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 1.72 | 2.00 | 2.40 | 1.47 | 1.90 |
| M₁S₂ | 1.73 | 2.78 | 2.87 | 1.82 | 2.30 |
| M₁S₃ | 1.73 | 2.70 | 2.84 | 1.80 | 2.27 |
| M₁S₄ | 1.73 | 2.48 | 2.69 | 1.72 | 2.15 |
| M₁S₅ | 1.74 | 2.90 | 2.99 | 1.89 | 2.38 |
| M₁S₆ | 1.73 | 2.52 | 2.73 | 1.75 | 2.18 |
| M₁S₇ | 1.73 | 2.88 | 2.98 | 1.85 | 2.36 |
| M₁S₈ | 1.73 | 2.77 | 2.79 | 1.78 | 2.27 |
| M₂S₁ | 1.81 | 2.11 | 2.44 | 1.49 | 1.96 |
| M₂S₂ | 1.81 | 2.82 | 2.89 | 1.85 | 2.34 |
| M₂S₃ | 1.83 | 2.73 | 2.92 | 1.83 | 2.33 |
| M₂S₄ | 1.81 | 2.50 | 2.70 | 1.77 | 2.20 |
| M₂S₅ | 1.82 | 2.95 | 3.12 | 1.91 | 2.45 |
| M₂S₆ | 1.82 | 2.56 | 2.78 | 1.79 | 2.24 |
| M₂S₇ | 1.82 | 2.91 | 2.97 | 1.87 | 2.39 |
| M₂S₈ | 1.81 | 2.81 | 2.81 | 1.80 | 2.31 |
| M₃S₁ | 1.82 | 2.10 | 2.48 | 1.50 | 1.97 |
| M₃S₂ | 1.82 | 2.88 | 2.98 | 1.88 | 2.39 |
| M₃S₃ | 1.82 | 2.78 | 3.02 | 1.87 | 2.37 |
| M₃S₄ | 1.82 | 2.49 | 2.67 | 1.79 | 2.19 |
| M₃S₅ | 1.83 | 2.98 | 3.25 | 1.96 | 2.50 |
| M₃S₆ | 1.82 | 2.68 | 2.81 | 1.80 | 2.28 |
| M₃S₇ | 1.83 | 2.95 | 3.11 | 1.89 | 2.44 |
| M₃S₈ | 1.83 | 2.88 | 2.88 | 1.80 | 2.35 |
| M₄S₁ | 1.82 | 2.24 | 2.51 | 1.53 | 2.02 |
| M₄S₂ | 1.82 | 2.90 | 3.11 | 1.90 | 2.43 |
| M₄S₃ | 1.82 | 2.82 | 3.10 | 1.89 | 2.41 |
| M₄S₄ | 1.82 | 2.62 | 2.80 | 1.82 | 2.26 |
| M₄S₅ | 1.83 | 3.01 | 3.37 | 1.98 | 2.55 |
| M₄S₆ | 1.83 | 2.75 | 2.98 | 1.82 | 2.35 |
| M₄S₇ | 1.83 | 2.98 | 3.28 | 1.94 | 2.51 |
| M₄S₈ | 1.83 | 2.88 | 3.00 | 1.85 | 2.39 |
| Mean | 1.80 | 2.70 | 2.88 | 1.80 | 2.30 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.048 | 0.501 | NS | |
| S at M | NS | 0.049 | 0.051 | NS | |

Table 21a. Effect of different levels of nitrogen and plant growth regulators on phosphorus content (%) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|--------|--------------|-------|--------------|--------|----------------|--------|--------------|
| Main Plot | | | | | | | | | |
| M₁ | 0.170 | (0.0) | 0.520 | (0.0) | 0.941 | (0.0) | 0.580 | (0.0) | 0.553 |
| M₂ | 0.180 | (5.9) | 0.523 | (0.6) | 0.944 | (0.3) | 0.603 | (4.0) | 0.562 |
| M₃ | 0.186 | (9.4) | 0.528 | (1.5) | 0.954 | (2.8) | 0.625 | (7.7) | 0.573 |
| M₄ | 0.190 | (11.8) | 0.535 | (2.9) | 0.962 | (2.2) | 0.645 | (11.2) | 0.583 |
| Mean | 0.181 | | 0.526 | | 0.950 | | 0.613 | | 0.568 |
| CD (p=0.05) | 0.001 | | 0.002 | | 0.004 | | 0.003 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 0.180 | (0.0) | 0.510 | (0.0) | 0.740 | (0.0) | 0.512 | (0.0) | 0.486 |
| S₂ | 0.182 | (1.1) | 0.525 | (2.9) | 0.987 | (33.4) | 0.631 | (23.2) | 0.581 |
| S₃ | 0.182 | (1.1) | 0.523 | (2.5) | 0.988 | (33.5) | 0.620 | (21.1) | 0.578 |
| S₄ | 0.181 | (0.6) | 0.514 | (0.8) | 0.842 | (13.8) | 0.532 | (3.9) | 0.517 |
| S₅ | 0.182 | (1.1) | 0.553 | (8.4) | 1.060 | (43.2) | 0.728 | (42.2) | 0.631 |
| S₆ | 0.181 | (0.6) | 0.517 | (1.4) | 0.974 | (31.6) | 0.578 | (12.9) | 0.563 |
| S₇ | 0.182 | (1.1) | 0.550 | (7.8) | 1.037 | (40.1) | 0.694 | (35.5) | 0.616 |
| S₈ | 0.181 | (0.6) | 0.518 | (1.6) | 0.976 | (31.9) | 0.607 | (18.6) | 0.570 |
| Mean | 0.181 | | 0.526 | | 0.950 | | 0.613 | | 0.568 |
| CD (p=0.05) | NS | | 0.005 | | 0.009 | | 0.006 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 21b. Effect of different levels of nitrogen and plant growth regulators on leaf phosphorous content (%) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|--------------|
| Interaction effect | | | | | |
| M₁S₁ | 0.168 | 0.501 | 0.732 | 0.470 | 0.468 |
| M₁S₂ | 0.169 | 0.523 | 0.982 | 0.600 | 0.569 |
| M₁S₃ | 0.170 | 0.519 | 0.981 | 0.590 | 0.565 |
| M₁S₄ | 0.169 | 0.509 | 0.835 | 0.500 | 0.503 |
| M₁S₅ | 0.171 | 0.546 | 1.040 | 0.680 | 0.609 |
| M₁S₆ | 0.168 | 0.510 | 0.962 | 0.550 | 0.547 |
| M₁S₇ | 0.171 | 0.542 | 1.032 | 0.660 | 0.601 |
| M₁S₈ | 0.170 | 0.511 | 0.971 | 0.590 | 0.561 |
| M₂S₁ | 0.178 | 0.504 | 0.738 | 0.500 | 0.480 |
| M₂S₂ | 0.179 | 0.525 | 0.987 | 0.620 | 0.578 |
| M₂S₃ | 0.182 | 0.521 | 0.984 | 0.610 | 0.574 |
| M₂S₄ | 0.179 | 0.513 | 0.842 | 0.520 | 0.513 |
| M₂S₅ | 0.181 | 0.549 | 1.035 | 0.720 | 0.621 |
| M₂S₆ | 0.178 | 0.517 | 0.970 | 0.570 | 0.559 |
| M₂S₇ | 0.182 | 0.545 | 1.038 | 0.690 | 0.614 |
| M₂S₈ | 0.179 | 0.518 | 0.972 | 0.600 | 0.567 |
| M₃S₁ | 0.185 | 0.517 | 0.742 | 0.530 | 0.493 |
| M₃S₂ | 0.186 | 0.528 | 0.988 | 0.640 | 0.586 |
| M₃S₃ | 0.187 | 0.523 | 0.988 | 0.630 | 0.582 |
| M₃S₄ | 0.185 | 0.516 | 0.847 | 0.550 | 0.524 |
| M₃S₅ | 0.187 | 0.552 | 1.075 | 0.750 | 0.641 |
| M₃S₆ | 0.186 | 0.518 | 0.978 | 0.590 | 0.568 |
| M₃S₇ | 0.187 | 0.550 | 1.041 | 0.700 | 0.619 |
| M₃S₈ | 0.186 | 0.519 | 0.979 | 0.610 | 0.573 |
| M₄S₁ | 0.190 | 0.519 | 0.746 | 0.550 | 0.501 |
| M₄S₂ | 0.192 | 0.530 | 1.001 | 0.670 | 0.598 |
| M₄S₃ | 0.191 | 0.530 | 0.997 | 0.650 | 0.592 |
| M₄S₄ | 0.190 | 0.518 | 0.848 | 0.560 | 0.529 |
| M₄S₅ | 0.188 | 0.570 | 1.098 | 0.770 | 0.656 |
| M₄S₆ | 0.191 | 0.520 | 0.981 | 0.600 | 0.573 |
| M₄S₇ | 0.189 | 0.560 | 1.045 | 0.730 | 0.631 |
| M₄S₈ | 0.190 | 0.523 | 0.982 | 0.630 | 0.581 |
| Mean | 0.181 | 0.526 | 0.951 | 0.613 | 0.568 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.009 | 0.017 | 0.011 | |
| S at M | NS | 0.009 | 0.017 | 0.011 | |

Table 22a. Effect of different levels of nitrogen and plant growth regulators on potassium content (%) at different growth stages of banana cv. Ney Poovan (Main effect).

| Treatments | 3 MAP | | 5 MAP | | 7 MAP | | Harvest | | Mean |
|----------------------|--------------|-------|--------------|--------|--------------|--------|----------------|--------|-------------|
| Main Plot | | | | | | | | | |
| M₁ | 1.89 | (0.0) | 3.81 | (0.0) | 4.04 | (0.0) | 2.63 | (0.0) | 3.09 |
| M₂ | 1.92 | (1.6) | 3.85 | (1.1) | 4.07 | (0.7) | 2.65 | (0.7) | 3.12 |
| M₃ | 1.94 | (2.6) | 3.91 | (2.6) | 4.12 | (1.9) | 2.68 | (1.9) | 3.16 |
| M₄ | 2.00 | (5.8) | 3.95 | (3.7) | 4.17 | (3.2) | 2.64 | (0.4) | 3.19 |
| Mean | 1.94 | | 3.88 | | 4.10 | | 2.65 | | 3.14 |
| CD (p=0.05) | NS | | 0.020 | | 0.022 | | 0.003 | | |
| Sub Plot | | | | | | | | | |
| S₁ | 1.98 | (0.0) | 3.52 | (0.0) | 3.79 | (0.0) | 2.01 | (0.0) | 2.83 |
| S₂ | 2.00 | (1.0) | 3.96 | (12.5) | 4.06 | (7.1) | 2.81 | (39.8) | 3.21 |
| S₃ | 2.01 | (1.5) | 3.92 | (11.4) | 4.04 | (6.6) | 2.78 | (38.3) | 3.19 |
| S₄ | 1.99 | (0.5) | 3.73 | (5.9) | 4.03 | (6.3) | 2.61 | (25.9) | 3.09 |
| S₅ | 2.05 | (3.5) | 3.95 | (12.2) | 4.31 | (13.7) | 2.78 | (38.3) | 3.27 |
| S₆ | 2.00 | (1.0) | 3.86 | (9.7) | 4.14 | (9.2) | 2.70 | (34.3) | 3.18 |
| S₇ | 2.04 | (3.0) | 4.07 | (15.6) | 4.31 | (13.7) | 2.92 | (45.3) | 3.34 |
| S₈ | 2.01 | (1.5) | 3.78 | (7.4) | 4.06 | (7.1) | 2.57 | (27.9) | 3.11 |
| Mean | 2.01 | | 3.86 | | 4.10 | | 2.65 | | 3.16 |
| CD (p=0.05) | NS | | 0.009 | | 0.036 | | 0.010 | | |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 22b. Effect of different levels of nitrogen and plant growth regulators on leaf potassium content (%) at different growth stages of banana cv. Ney Poovan (Interaction effect).

| Treatments | 3 MAP | 5 MAP | 7 MAP | Harvest | Mean |
|-----------------------------------|--------------|--------------|--------------|----------------|-------------|
| Interaction effect | | | | | |
| M₁S₁ | 1.90 | 3.43 | 3.72 | 1.98 | 2.64 |
| M₁S₂ | 1.92 | 3.89 | 4.00 | 2.78 | 3.17 |
| M₁S₃ | 1.91 | 3.87 | 3.99 | 2.75 | 3.13 |
| M₁S₄ | 1.90 | 3.69 | 3.97 | 2.58 | 3.01 |
| M₁S₅ | 1.93 | 4.00 | 4.25 | 2.92 | 3.32 |
| M₁S₆ | 1.90 | 3.81 | 4.11 | 2.66 | 3.12 |
| M₁S₇ | 1.94 | 3.98 | 4.18 | 2.90 | 3.29 |
| M₁S₈ | 1.91 | 3.72 | 4.01 | 2.52 | 3.02 |
| M₂S₁ | 1.91 | 3.52 | 3.77 | 1.99 | 2.69 |
| M₂S₂ | 1.93 | 3.92 | 4.05 | 2.81 | 3.20 |
| M₂S₃ | 1.92 | 3.88 | 4.07 | 2.77 | 3.15 |
| M₂S₄ | 1.91 | 3.71 | 4.01 | 2.59 | 3.04 |
| M₂S₅ | 1.94 | 4.12 | 4.28 | 2.95 | 3.38 |
| M₂S₆ | 1.91 | 3.83 | 4.09 | 2.68 | 3.13 |
| M₂S₇ | 1.94 | 4.05 | 4.22 | 2.91 | 3.33 |
| M₂S₈ | 1.92 | 3.78 | 4.04 | 2.56 | 3.06 |
| M₃S₁ | 1.98 | 3.55 | 3.78 | 2.00 | 2.71 |
| M₃S₂ | 2.02 | 3.99 | 4.11 | 2.83 | 3.26 |
| M₃S₃ | 2.03 | 3.95 | 4.10 | 2.79 | 3.20 |
| M₃S₄ | 1.99 | 3.75 | 4.05 | 2.63 | 3.07 |
| M₃S₅ | 2.07 | 4.19 | 4.32 | 2.98 | 3.40 |
| M₃S₆ | 1.99 | 3.88 | 4.15 | 2.72 | 3.18 |
| M₃S₇ | 2.06 | 4.11 | 4.28 | 2.93 | 3.34 |
| M₃S₈ | 2.00 | 3.81 | 4.09 | 2.58 | 3.09 |
| M₄S₁ | 2.00 | 3.59 | 3.88 | 2.10 | 2.78 |
| M₄S₂ | 2.03 | 4.05 | 4.10 | 2.85 | 3.28 |
| M₄S₃ | 2.04 | 4.00 | 4.00 | 2.83 | 3.23 |
| M₄S₄ | 2.00 | 3.78 | 4.07 | 2.65 | 3.10 |
| M₄S₅ | 2.09 | 4.24 | 4.41 | 2.29 | 3.30 |
| M₄S₆ | 2.01 | 3.91 | 4.21 | 2.75 | 3.22 |
| M₄S₇ | 2.07 | 4.15 | 4.56 | 2.96 | 3.46 |
| M₄S₈ | 2.02 | 3.83 | 4.12 | 2.64 | 3.13 |
| Mean | 1.93 | 3.88 | 4.10 | 2.65 | 3.14 |
| CD (p=0.05) | | | | | |
| M at S | NS | 0.060 | 0.070 | 0.010 | |
| S at M | NS | 0.060 | 0.070 | 0.010 | |

Table 23a. Effect of different levels of nitrogen and plant growth regulators on yield and yield components of banana cv. Ney Poovan (Main effect)

| Treatments | Finger length (cm) | Finger girth (cm) | Number of hands/bunch | Number of fingers/bunch | Finger weight (g) | Bunch weight (kg) |
|----------------|--------------------|-------------------|-----------------------|-------------------------|-------------------|-------------------|
| Main plot | | | | | | |
| M ₁ | 13.5 (0.0) | 12.7 (0.0) | 9.7 (0.0) | 152.3 (0.0) | 50.1 (0.0) | 10.70 (0.0) |
| M ₂ | 14.2 (5.2) | 13.4 (5.5) | 10.0 (3.1) | 155.7 (2.2) | 53.6 (7.0) | 11.51 (7.6) |
| M ₃ | 14.6 (8.1) | 13.4 (5.5) | 10.0 (3.1) | 154.2 (1.2) | 56.6 (13.0) | 12.20 (14.0) |
| M ₄ | 14.5 (7.4) | 14.0 (10.2) | 10.2 (5.2) | 158.9 (4.3) | 55.4 (10.6) | 12.36 (15.5) |
| Mean | 14.2 | 13.4 | 10.0 | 155.3 | 53.9 | 11.69 |
| CD (p=0.05) | 0.10 | 0.09 | NS | 1.10 | 0.41 | 0.10 |
| Subplot | | | | | | |
| S ₁ | 13.4 (0.0) | 12.1 (0.0) | 9.1 (0.0) | 148.5 (0.0) | 52.1 (0.0) | 11.0 (0.0) |
| S ₂ | 14.1 (5.2) | 13.0 (7.4) | 9.8 (7.7) | 157.0 (5.7) | 52.4 (0.6) | 11.56 (3.8) |
| S ₃ | 14.3 (6.7) | 13.1 (8.3) | 10.0 (9.9) | 150.7 (1.5) | 54.5 (4.6) | 11.54 (4.5) |
| S ₄ | 13.4 (0.0) | 12.9 (6.6) | 10.1 (11.1) | 151.2 (1.8) | 51.2 (-1.7) | 10.93 (-1.0) |
| S ₅ | 14.9 (11.2) | 14.6 (20.7) | 10.6 (11.6) | 159.8 (7.6) | 57.2 (9.8) | 12.58 (13.9) |
| S ₆ | 14.1 (5.2) | 13.1 (8.3) | 9.9 (8.8) | 153.4 (3.3) | 53.1 (1.9) | 11.51 (4.3) |
| S ₇ | 15.0 (11.9) | 14.8 (22.3) | 10.5 (11.5) | 161.8 (9.0) | 55.6 (6.7) | 12.52 (13.4) |
| S ₈ | 14.8 (10.4) | 13.4 (10.7) | 9.8 (7.7) | 159.7 (7.5) | 55.1 (5.8) | 11.97 (8.4) |
| Mean | 14.2 | 13.4 | 10.0 | 155.3 | 53.9 | 11.69 |
| CD (p=0.05) | 0.10 | 0.09 | 0.06 | 0.95 | 0.34 | 0.09 |

[Values in parentheses are per cent changes over respective control (M₁ and S₁)]

Table 23b. Effect of different levels of nitrogen and plant growth regulators on yield and yield components of banana cv. Ney Poovan (Interaction effect)

| Treatments | Fruit length (cm) | Fruit girth (cm) | Number of hands/bunch | Number of fingers / bunch | Finger weight (g) | Bunch weight (g) |
|-------------------------------|--------------------------|-------------------------|------------------------------|----------------------------------|--------------------------|-------------------------|
| M ₁ S ₁ | 12.4 | 11.3 | 8.2 | 141.4 | 48.5 | 9.85 |
| M ₁ S ₂ | 13.6 | 12.4 | 9.5 | 155.2 | 46.7 | 10.25 |
| M ₁ S ₃ | 14.1 | 12.7 | 10.0 | 148.0 | 51.6 | 10.83 |
| M ₁ S ₄ | 11.9 | 12.2 | 9.8 | 153.8 | 49.2 | 10.65 |
| M ₁ S ₅ | 14.2 | 13.6 | 10.6 | 156.6 | 52.1 | 11.21 |
| M ₁ S ₆ | 13.8 | 12.1 | 10.0 | 150.0 | 49.3 | 10.44 |
| M ₁ S ₇ | 14.7 | 14.1 | 10.2 | 157.8 | 50.6 | 11.16 |
| M ₁ S ₈ | 13.9 | 12.9 | 9.2 | 155.2 | 52.5 | 11.21 |
| M ₂ S ₁ | 13.1 | 12.1 | 9.5 | 150.2 | 50.3 | 10.55 |
| M ₂ S ₂ | 14.2 | 12.9 | 9.8 | 156.8 | 52.7 | 11.37 |
| M ₂ S ₃ | 14.5 | 13.6 | 9.6 | 151.6 | 53.5 | 11.33 |
| M ₂ S ₄ | 13.8 | 13.1 | 10.2 | 150.2 | 50.2 | 10.68 |
| M ₂ S ₅ | 14.9 | 14.2 | 10.4 | 159.8 | 57.8 | 12.54 |
| M ₂ S ₆ | 13.2 | 13.2 | 9.8 | 153.4 | 53.4 | 11.62 |
| M ₂ S ₇ | 15.1 | 14.8 | 10.6 | 161.2 | 56.5 | 12.48 |
| M ₂ S ₈ | 14.9 | 13.4 | 10.0 | 162.4 | 54.2 | 11.54 |
| M ₃ S ₁ | 13.7 | 12.7 | 9.2 | 149.8 | 54.2 | 11.67 |
| M ₃ S ₂ | 14.1 | 13.2 | 9.8 | 154.6 | 55.5 | 11.95 |
| M ₃ S ₃ | 14.8 | 12.9 | 10.2 | 152.2 | 56.7 | 12.03 |
| M ₃ S ₄ | 14.6 | 12.6 | 10.0 | 148.0 | 53.1 | 11.15 |
| M ₃ S ₅ | 15.2 | 15.1 | 10.8 | 157.4 | 60.5 | 12.92 |
| M ₃ S ₆ | 14.7 | 13.3 | 9.6 | 155.8 | 54.3 | 12.05 |
| M ₃ S ₇ | 14.9 | 14.8 | 10.2 | 159.6 | 58.7 | 13.16 |
| M ₃ S ₈ | 15.1 | 12.5 | 9.8 | 156.0 | 59.5 | 12.68 |
| M ₄ S ₁ | 14.2 | 12.2 | 9.5 | 152.4 | 55.5 | 12.10 |
| M ₄ S ₂ | 14.4 | 13.6 | 10.0 | 161.6 | 54.8 | 12.25 |
| M ₄ S ₃ | 13.8 | 13.2 | 10.2 | 151.0 | 56.0 | 11.96 |
| M ₄ S ₄ | 13.6 | 13.7 | 10.2 | 152.6 | 52.4 | 11.24 |
| M ₄ S ₅ | 15.1 | 15.6 | 10.6 | 165.2 | 58.5 | 13.65 |
| M ₄ S ₆ | 14.7 | 13.9 | 10.2 | 154.4 | 55.2 | 11.94 |
| M ₄ S ₇ | 15.4 | 15.3 | 10.8 | 168.6 | 56.7 | 13.28 |
| M ₄ S ₈ | 15.2 | 14.8 | 10.2 | 165.4 | 54.2 | 12.46 |
| Mean | 14.2 | 13.4 | 10.0 | 155.3 | 53.90 | 11.69 |
| CD (p=0.05) | | | | | | |
| M at S | 0.19 | 0.19 | 0.14 | 2.05 | 0.19 | 0.19 |
| S at M | 0.17 | 0.17 | 0.12 | 1.89 | 0.17 | 0.17 |

Table 24. Correlation co- efficient of different parameters with yield

| Parameters | 'r' value | |
|-----------------------------|----------------|---------------|
| | Shooting stage | Harvest stage |
| Pseudostem height | 0.670** | - |
| Pseudostem girth | 0.012* | - |
| Number of green leaves | 0.904** | 0.835** |
| Phyllochron | -0.866** | - |
| Leaf area | 0.723** | 0.751** |
| Total chlorophyll | 0.266* | 0.821* |
| Chlorophyll stability index | 0.593** | 0.470* |
| Chlorophyll fluorescence | 0.729** | 0.237** |
| Soluble protein | 0.826** | 0.616** |
| Nitrate reductase | 0.639** | 0.641** |
| IAA oxidase | 0.886** | 0.875* |
| Total phenolics | -0.805* | -0.743* |
| Relative water content | 0.809* | 0.889* |
| Leaf nitrogen content | 0.807** | 0.642** |
| Leaf phosphorus content | 0.691* | 0.862* |
| Leaf potassium content | 0.782* | 0.492* |