

**CLUMP MANAGEMENT IN HILL BANANA (*Musa Sp*)
'VIRUPAKSHI'**

BY

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**HORTICULTURAL COLLEGE AND RESEARCH INSTITUTE
TAMIL NADU AGRICULTURAL UNIVERSITY
PERIYAKULAM-625 604**

2008

**CLUMP MANAGEMENT IN HILL BANANA (*Musa Sp*)
'VIRUPAKSHI'**

Thesis submitted in part fulfillment of the requirements for the degree of
MASTER OF SCIENCE (HORTICULTURE) – Fruit Science to the
Tamil Nadu Agricultural University, Coimbatore.

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CERTIFICATE

This is to certify that the thesis entitled “**Clump Management in Hill Banana (*Musa sp*) ‘virupakshi’**” submitted in part fulfillment of requirements for the degree of **MASTER OF SCIENCE (HORTCULTURE) – Fruit Science** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mr. M.SUBRAMANIAN** under my supervision and guidance and that no part of this thesis has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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(SUBRAMANIAN. M)

ABSTRACT

CLUMP MANAGEMENT IN HILL BANANA cv. Virupakshi (AAB)

BY

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To study the effect of different planting systems on clump management in hill banana cv. Virupakshi (AAB), an experiment was laid out under Randomized Block Design with four replications and six treatments, at panikkarai estate, kamannor, kodaikanal taluk, Dindigul district. Each treatment unit consisted of two clumps. T₁, T₂, T₃ consisted of planting one sucker per pit and T₄, T₅, T₆ consisted of planting two suckers per pit. In T₁ and T₄ two suckers, in T₂ and T₅ three suckers and T₃ and T₆, four suckers were allowed at shooting stage of main crop.

In the main crop, maximum pseudostem girth, total number of leaves and leaf area were recorded, when planting of one sucker per pit was practiced, allowing of two followers at shooting stage of main crop.

The same treatment showed the lowest pseudostem height, phyllochron of leaves and days taken from shooting to harvest. However the number of functional leaves was the lowest with T₆ in main crop.

The fruit characters like bunch weight, hand weight, number of hands, number of fingers per bunch, finger weight, finger volume, finger length, finger circumference were highest in T₅.

Similarly biochemical characters like TSS, acidity, total sugars, reducing sugars, non reducing sugars, leaf nitrogen, phosphorous, and potassium contents were highest in T₅.

Planting of two suckers per pit and allowing three suckers at shooting stage of the main crop resulted in higher productivity of hill banana.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Banana popularly known as 'Apple of Paradise' is the most popular and widely consumed fruit of the world. India is the largest producer of banana in the world with the production of 19.19 MT from an area of 565 thousand hectares with the productivity of 34 tonnes / ha (FAO statistics, 2005-06). Tamil Nadu has the largest area under banana (81.50 thousand hectare) in India with an annual production of 3462 thousand MT. In this state, banana is grown under garden land, wet land and perennial systems of cultivation. In hilly areas, farmers grow hill banana as a perennial crop and maintain in the fields for 5 – 6 years. This perennial system is mostly practiced at the lower Pulney hills of Dindugal district in Tamil Nadu, where the most popular and choice variety called Virupakshi (AAB) is grown in almost the entire hill. It is grown as a pure crop or as inter crop in coffee plantation. In multi-tier cropping system banana is also a component.

. The dual importance of hill banana both as a commercial and shade crop received the best attention of the planters in Pulney, Sirumalai, Agamalai and in similar agro- climatic hill zones suitable for its cultivation. Hill banana grows well at an elevation ranging from 800 to 1800m above MSL with an average rain fall of 1500 mm and maximum and minimum temperatures ranging from 24 to 32°C and 10 to 18°C, respectively for better growth and development (Irulappan and Vadivel, 1980).

The hill Banana growers are generally following varying spacing without any specific recommendation and also allowing uneven number of suckers due to absence of specific recommendation. On account of this, bunches with lower weight, grade and poor quality are produced. Furthermore pest and disease occurrence is also seen due to the shading effect caused by allowing unlimited number of suckers. Further many growers in the hills after cleaning the old coffee plantations take up banana cultivation and they go for single as well as double suckers planting per pit as recommended for high density planting of banana in the plains. Elain Apshara (1997) recommended that planting of three suckers per pit at 3m × 2m spacing for Nendran and Nalina (1999) suggested that planting of three suckers at 3.6m × 1.8m spacing for cv.Robusta gave the

highest bunch yield with the quality grade bunches. However, no such informations on the effect of HDP in hill banana are available. Being a perennial crop, under rainfed cultivation, the effect of HDP on the number of suckers allowed is also not available. Currently, the practice is to allow two bearing plants and two followers per clump (Anon, 2004). With this background, this experiment was laid out with the following objectives

- To standardize an optimum planting density for maximizing productivity with quality bunches in hill banana
- To study the effect of the ratooning practices on the bunch grade of planted crop and the vegetative growth of the follower.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Owing to the limited land resources the scope for expanding the cultivable area remains narrow and hence emphasis is being given to higher production per unit area. The increased productivity can be achieved through high density planting (HDP) system, which has gained prime importance in recent years especially in fruit crops. Another approach is to plant hill banana in multi-tier system of cropping to exploit land and solar resources to maximise net income per unit area. Since most of the banana growing regions have the privilege of abundant solar radiation, this research has been attempted through high density planting. The literatures collected in this aspect are reviewed here.

Pseudostem height and girth

The pseudostem of the plant being the over lapping of leafsheaths, its height and girth are closely related to the foliage growth. Increase in the plant height and decrease in girth were observed in several studies with increase in planting densities as indicated below:

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|--------------------|---|-----------------------------------|
| Amritsagar | 1.2 x 1.2, 1.8 x 1.8, 2.4 x 2.4 | Ahamed and Mannan (1970) |
| Basrai | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Anon (1995) |
| Dwarf Cavendish | 1.8x1.8 (3086), 1.2x1.8 (4629) | Chakarabarty <i>et al.</i> (1992) |
| Giant Governor | 1 x 1 (10000), 1.5 x 2 (6666), 1.5 x 1.5 (4444), 2x1.5 (2222), 2x2 (25000), 2.5x2 (2222), 2.5x2.5 (1600) | Bose <i>et al.</i> (1992) |
| Nendran | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Anon (1995) |
| Nendran | 2x2, 2x2.5, 2x3 | Elia Apshara (1997) |

| | | |
|----------|--------------------------|-------------------------------|
| Poovan | 2.1x2.2,1.5x1.8 | Sathyararayana and Rao (1985) |
| Williams | 1000,1250,1333,1666,2222 | Raobinson (1983) |
| Williams | 3x2, 4x1.5, 6x2x1.5 | Robinson (1985) |

On the other hand in sum of the high-density planting experiments, no significant increase in plant height or a decrease in girth was observed by the following authors.

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|----------------------------|---|--------------------------|
| Kabuli and Dwarf Cavendish | 6x6', 8x8' | Bhan and Majumdar (1961) |
| Martaman and Champa | 9x9', 12x12' | Bhan and Majumdar (1961) |
| Williams | 1000,1250,1333,1666,2222 | Raobinson (1983) |
| Williams | 1333,1666,1900,2222,3333 | Robinson and Nel (1989) |

Leaf number and leaf area

The number of leaves was reduced under closer spacing than wider spacing. This was observed in many studies conducted in various cultivars of banana as indicated below:

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|-----------------|--|------------------------------------|
| Dwarf Cavendish | 1.8x1.8 (3086), 1.2x1.8 (4629) | Chakarabarty <i>et al.</i> (1992) |
| Giant Governor | 10000, 6666, 4444, 3333,2500, 2222, 1666 | Chattopadhyay <i>et al.</i> (1980) |
| Giant Governor | 2 x 2, 3 x 3 | Chattopadhyay <i>et al.</i> (1980) |
| Poovan | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Anon (1995) |

| | | |
|---------|-----------------|-------------------------------|
| Poovan | 2.1x2.2,1.5x1.8 | Sathyanarayana and Rao (1985) |
| Robusta | 2.4x1.8, 1x1 | Rajeevan and Geetha (1989) |

In some of the experiments on high-density planting, increase in leaf number and leaf area were also observed.

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|-----------------|--|----------------------|
| Nendran | 2x2, 2x2.5, 2x3 | Elian Apshara (1997) |
| Poovan | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Manivannan (1994) |

Phyllochron

The number of days taken for successive leaf emergence was reduced under close planting than at wider spacing as observed in the following cases.

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|-----------------|--|-------------------------------|
| Grande Naine | 1700,1900,2100 | Stover (1984) |
| Maricongo | 10x5', 10x4', 6x6', 6x5', 5x5' | Irizarry <i>et al.</i> (1978) |
| Nendran | 2x2, 2x2.5, 2x3 | Elian Apshara (1997) |
| Robusta | 1.2x1.2 (6944), 1.5x1.5 (4444) 1.8x1.8 (3086), 2.1x2.1 (2227) | Chacko and Reddy (1981) |
| Williams | 1600 and 1250 | Robinson and Nel (1986) |
| Williams | 1333,1666,1900,2222,3333 | Robinson and Nel (1989) |

Some of the high-density planting experiment, the number of taken for successive leaf emergence get delayed under close planting than also at wider spacing as observed in the following experiments

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|-----------------|---|-----------------------------------|
| Dwarf Cavendish | 1.8x1.8 (3086), 1.2x1.8 (4629) | Chakarabarty <i>et al.</i> (1992) |
| Robusta | 1.8x3.6, 1.8x3.6, 1.8x1.8 (4,3, 1 plants per hill) | Vengadarajarengan (2000) |

Sucker production

Shading effect in close spacing reduced the number of suckers produced per mat and also their growth rate and the number of suckers per plant was more under wider spacing as observed in following experiments

| Cultivar | Plant Spacing (M) adopted (or) population / ha | Reference |
|-------------------|--|------------------------------------|
| Amritsagar | 1.2 x 1.2, 1.8 x 1.8, 2.4 x 2.4 | Ahamed and Mannan (1970) |
| Canvendish | 1210,968,806,691,605,537,487 | Berill (1963) |
| Giant Governor | 10000, 6666, 4444, 3333,2500, 2222, 1666 | Chattopadhyay <i>et al.</i> (1980) |
| Giant Governor | 1 x 1 (10000), 1.5 x 2 (6666), 1.5 x 1.5 (4444), 2x1.5 (2222), 2x2 (25000), 2.5x2 (2222), 2.5x2.5 (1600) | Bose <i>et al.</i> (1992) |
| Nendran | 2x2, 2x2.5, 2x3 | Elian Apshara (1997) |
| Poovan | 2.1x2.2,1.5x1.8 | Sathyanarayana and Rao (1985) |
| Poovan | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Manivannan (1994) |
| Robusta | 1.2x1.2 (6944), 1.5x1.5 (4444), 1.8x1.8 (3086), 2.1x2.1 (2267) | Aravind Reddy and Chacko (1992) |
| Robusta | 1.8x3.6, 1.8x3.6, 1.8x1.8 (4,3, 1 plants per hill) | Vengadarajarengan (2000) |

Crop duration:

The crop duration, which includes the number of days from planting to shooting and shooting to harvest was found to be significantly influenced by the plant densities. Pronounced extension of crop duration at high plant density is a universal phenomenon in banana plantations as observed by many workers.

| Cultivar | Plant spacing (M) adopted (or) population / ha | Reference |
|--------------------|--|--|
| Amritsagar | 1.2 x 1.2, 1.8 x 1.8, 2.4 x 2.4 | Ahamed and Mannan (1970) |
| Basrai banana | 1.2x1.2, 1.3x1.3, 1.5x1.5, 1.7x1.7, 1.8x1.8 | Chundawat <i>et al.</i> (1982) |
| Dwarf Cavendish | 1.4x1.4 (5120), 1.2x1.4 (5952) 1.2x1.2 (5208), 1x1.2x2 (6250) | Kothavade <i>et al.</i> (1992) |
| Enxerto banana | 930 to 3980 | Lichtemberg <i>et al.</i> (1986) |
| Giant Governor | 1 x 1 (10000), 1.5 x 2 (6666), 1.5 x 1.5 (4444), 2x1.5 (2222), 2x2 (25000), 2.5x2 (2222), 2.5x2.5 (1600) | Bose <i>et al.</i> (1992) |
| Giant Governor | 1600, 2222, 2500, 3333, 4444, 6666, 10000 | Chattopadhyay <i>et al.</i> (1985) |
| Grande Naine | 1700,1900,2100 | Stover (1984) |
| Lacatan | 1.2x1.2, 1.3x1.3, 1.5x1.5, 1.7x1.7, 1.8x1.8 | Chundawat <i>et al.</i> (1983) |
| Maricongo | 10x5', 10x4', 6x6', 6x5', 5x5' | Irizarry <i>et al.</i> (1978) |
| Nendran | 2x2, 2x2.5, 2x3 | Elian Apshara (1997) |
| Poovan | 2.1x2.2,1.5x1.8 | Sathyanarayana and Rao (1985) |
| Poovan | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | Manivannan (1994) |
| Poovan | 1.2x1.5 | Premalatha <i>et al.</i> (1996) |
| Robusta | 2.4x1.8 (Double planting) | Azhaikiamanavalan and Balakrishnan (1976) |
| Robusta | 1.8x3.6, 1.8x3.6, 1.8x1.8 (4,3, 1 plants per hill) | Vengadarajarengan (2000) |
| Williams | 1000,1250,1333,1666,2222 | Robinson (1983) |

| | | |
|----------|---------------------------------------|-------------------------------|
| Williams | 1000,1250,1666,2222 | Reynolds and Robinson (1985) |
| Williams | 930 to 3980 | Daniells <i>et al.</i> (1985) |
| Williams | 1600 and 1250 | Robinson and Nel (1986 a) |
| Williams | 2381,3575,4762 (2,3,4 plants/hill) | Israeli and Nameri (1988) |
| Williams | 1000,1250,1666,2222 | Robinson and Nel (1988) |

Fruit yield

High density planting normally results in reduced bunch weight of the individual plant. However total fruit yield per unit area is high due to increased plant population as observed in the following case

| Cultivars | Plant Spacing (M) adopted (or) population / ha | Increment in yield / unit area | Reference |
|----------------------------------|--|--------------------------------------|---|
| Canvendish | 1210,968,806,691,605, 537,487 | 14.2 tonns | Berill (1963) |
| Kabuli and Dwarf Cavendish | 6x6', 8x8' | 78.6 % | Bhan and Majumdar (1961) |
| Nendran | 4500 to 7000 | 26.3 tons | Anon (1978) |
| Nendran | 2.25 x 2.25, 2 x2, 1.75 x 1.75, 1.5 x1.5, 1.25 x 1.25 | 28.3 % | Anil <i>et al.</i> (1994) |
| Nendran | 2x2, 2 x2.5, 2x3 | 79.04 % | Elian Apshara (1997) |
| Robusta | 2.4 x1.8, 2.4x2.4 | 10.4 tons | Randhawa <i>et al.</i> (1973) |
| Robusta | 2.4 x 1.8 (Double planting) | | Azhaikiamanav alan and Balakrishnan (1976) |
| Williams | 930 to 3980 | | Daniells <i>et al.</i> (1985) |

| | | | |
|----------|---------------------------------------|---------|---------------------------|
| Williams | 2381,3575,4762 (2,3,4 plants/hill) | 32 tons | Israeli and Nameri (1988) |
| Williams | 1666, 2222, 3333 | 30 % | Robinson and Nel (1989) |

On contrary, reduction in the yield characters in high density planting of banana was also observed by some authors:

| Cultivars | Plant spacing (M) adopted (or) population / ha | Reference | Reduction in yield / unit area (tonns / ha) |
|------------------|---|----------------------------|--|
| Robusta | 2.4x1.8, 1x1 | Rajeevan and Geetha (1989) | 10.77 |
| Robusta | 1.8x3.6, 1.8x3.6, 1.8x1.8 (4,3, 1 plants per hill) | Vengadarajarengan (2000) | 9.92 |

Bunch weight

In most of the cases of high density planting, reduction in bunch weight manifested in the reduction of number of hands, number of fingers per bunch or their size and weight of the fingers have been observed by some authors

| Cultivars | Plant spacing (M) adopted (or) population / ha | Reduction in bunch weight (kg) | Reference |
|------------------|---|---------------------------------------|------------------------------------|
| Amritsagar | 1.2 x 1.2, 1.8 x 1.8, 2.4 x 2.4 | | Ahamed and Mannan (1970) |
| Basrai banana | 1.2x1.2, 1.3x1.3, 1.5x1.5, 1.7x1.7, 1.8x1.8 | 17.45 – 10.31 | Chundawat <i>et al.</i> (1982) |
| Giant Governor | 2.5 x 2.5 to 1 x 1 | 15.0 – 10.1 | Chattopadhyay <i>et al.</i> (1985) |

| | | | |
|---------|---|----------------|-----------------------------------|
| Nendran | 2.25x2.25, 2x2, 1.75x1.75, 1.5x1.5, 1.25x1.25 | 9.50 to 6.05 | Anil <i>et al.</i> (1994) |
| Nendran | 2x2, 2x2.5, 2x3 | 12.72 to 7.82 | Elian Apshara (1997) |
| Poovan | 1.8x1.8, 1.5x1.5, 1.2x1.8, 1.2x1.5, 1.2x1.2x2, 2.1x2.1 | 16.3 to 14.71 | Manivannan (1994) |
| Poovan | 2.1x2.2, 1.5x1.8 | 14.7 – 11.7 | Sathyanarayanan and Rao (1985) |
| Robusta | 2.1 x2.1 to 1.2 x 1.2 | 38.39 to 29.63 | Reddy (1982) |
| Robusta | 2.4 x 1.8, to 1.8 x 1.8 | | Mustaffa (1988) |
| Robusta | 1.8x3.6, 1.8x3.6, 1.8x1.8 (4,3, 1 plants per hill) | 18.35 – 12.88 | Vengadarajarengan (2000) |

Fruit quality

Fruit quality such as TSS and sugars were not much affected by closer spacing as reported by Chundawat *et al.* (1982) in cv. Basrai and Lacatan, Chattopadyay *et al.* (1985) in cv. Gaint Governor, Manivannan (1994) and Premalatha *et al.* (1996) in cv. Poovan.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment on clump management of hill banana was carried out at the Department of Fruit crops and Post Harvest Technology, Horticultural College and Research Institute, Periyakulam during the year 2006-2008.

3.1. Materials

3.1.1. Field Location

The experimental field was located at Panikarai Estate, Kamannor (Mangalamkumbu), Kodaikanal Taluk, Dindigul District with an altitude of 1500 m above MSL. The temperature and relative humidity during the experimental period were monitored daily using a digital temperature and RH meter. The rainfall data were measured using rain gauge. The annual rain fall is around 1200 mm. The mean maximum and minimum temperatures were 32.6°C and 10.7°C respectively with mean relative humidity of 66.5 per cent (Annexure I).

3.1.2. Soil characteristics

The physical and chemical properties of the soil of the experimental field is given in Annexure-II

3.1.3. The material used

The variety used in this study was hill banana cv.Virupakshi (AAB) which is a pome type.

3.2. Methods

3.2.1. Experimental details

The experiment was laid out in Randomized Block Design replicated four times with six treatments. Each treatment unit consisted of two clumps. The details of treatments are furnished below.

Treatment details

| Treatment No. | Details | Population / ha |
|----------------|---|-----------------|
| T ₁ | Planting of one sucker per pit and allowing two suckers at shooting stage of the main crop | 771 plants |
| T ₂ | Planting of one sucker per pit and allowing three suckers at shooting stage of the main crop | 771 plants |
| T ₃ | Planting of one sucker per pit and allowing four suckers at shooting stage of the main crop | 771 plants |
| T ₄ | Planting of two suckers per pit and allowing two suckers at shooting stage of the main crop | 1542 plants |
| T ₅ | Planting of two suckers per pit and allowing three suckers at shooting stage of the main crop | 1542 plants |
| T ₆ | Planting of two suckers per pit and allowing four suckers at shooting stage of the main crop | 1542 plants |

Note: In the entire planted main crop, periodical removal of suckers (desuckering) was carried out at monthly intervals.

3.2.2. Field preparation and planting

The field was completely weeded and the pits of 45 cm³ were dug out with the spacing of 3.6 x 3.6 m. The healthy and disease free suckers were selected from mother clumps. Good sword suckers of 1.2 to 1.5 m height with well developed corm are chosen and trimmed or pared free of roots and reddish brown or black tissues. Before

planting, the corms were subjected to prophylactic dipping in Monochrotophos (1ml lit⁻¹) and Bavistin (1g lit⁻¹) in order to minimize the pest and disease incidence at early stage. The pit was filled with 10 kg of FYM along with 20 g Phorate granules to minimize the nematode incidence. Desuckering was regularly done at monthly interval until shooting.

3.3. Observations recorded

a. Main crop

Two clumps were randomly selected in each treatment for recording the biometric, yield and quality traits.

3.3.1. Morphological characters

3.3.1.1. Pseudostem height

The height of the pseudostem was measured from the base of the trunk to the axil of the youngest leaf at shooting and harvesting stage and expressed in meter (m).

3.3.1.2. Pseudostem girth

The girth of the pseudostem was measured at 30 cm height from the ground level during shooting and harvesting stage and expressed in centimeter (cm).

3.3.1.3. Number of leaves

The number of functional leaves at shooting and harvesting stage was recorded and expressed in number.

3.3.1.4. Leaf area

The leaf area was calculated by multiplying the product of length and breadth of the lamina with the factor 0.8 (Murray, 1960) and expressed in metre square (m²). The length of the lamina was measured from the base to its apex along the midrib and width at the broadest portion of the lamina. This was recorded at harvesting stage alone.

3.3.1.5. Crop Duration

The number of days taken from shooting to harvesting was recorded and expressed in number of days.

3.3.2. Yield and yield components

3.3.2.1. Bunch weight

The weight of the bunch was recorded including the peduncle above the first hand upto first bract of the leaf node and expressed in kilogram (kg).

3.3.2.2. Bunch length

The length of the bunch was measured from the point of attachment of the first hand on the peduncle to the last hand and expressed in centimeter (cm).

3.3.2.3. Number of hands

The total number of hands in the bunch were counted and expressed in number.

3.3.2.4. Hand weight

The individual hand weight is recorded and expressed in gram (g).

3.3.2.5. Number of fingers

The total number of fingers in the hand and bunch were counted and expressed in number.

3.3.2.6. Average weight of finger

The middle finger in the top row of the second hand was selected as representative finger (Gotterich *et al.*, 1964) to record the average weight of the finger and for the study of other physical and chemical parameters. The finger weight was expressed in gram (g).

3.3.2.7. Finger length

The length of the fingers was measured from the base of the pedicel to the tip of the fruit along the outer curvature and expressed in centimeter (cm).

3.3.2.8. Finger circumference

The mid portion of the finger was measured using nylon thread and a scale and expressed in centimeter (cm).

3.3.2.9. Fruit volume

The fruit volume was measured by water displacement technique and expressed in millimeter (cc).

3.3.3. Leaf Analysis

The leaf samples collected from four plants of same replication of a treatment were pooled. The leaf samples were dried in shade and then in oven at 60⁰C for 3 hours. The dried leaves were chopped and powdered in stainless steel mixer grinder and then used for analysis. The estimation was carried out at shooting and harvesting stages.

3.3.3.1. Nitrogen

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

3.3.3.2. Phosphorus

The phosphorus content in leaf samples was estimated by Vanadomolybdate method (Jackson, 1973) and expressed in per cent.

3.3.3.3. Potassium

The potassium content of leaf samples was estimated by using Flame Photometer (Jackson, 1973) and expressed in per cent.

3.3.4. Biochemical Analysis

The representative fingers were allowed for natural and uniform ripening. These fruits were utilized for determining the various fruit biochemical parameters.

3.3.4.1. Total soluble solids

The total soluble solids content was determined by using a hand refractometer and expressed in ⁰Brix.

3.3.4.2. Total sugars

The total sugars were estimated as per the method suggested by Somogyi (1952) and expressed in percentage.

3.3.4.3. Reducing sugars

It was estimated by the method suggested by Somogyi (1952) and expressed in percentage.

3.3.4.4. Non reducing sugars

The non reducing sugars were estimated by the method suggested by Somogyi (1952) and expressed in percentage.

3.3.4.5. Titrable acidity

Acidity was determined as per the A.O.A.C. method (1980) and expressed in per cent of citric acid equivalents.

3.3.4.6. Ascorbic acid

The ascorbic acid content was estimated using 2, 6, dichlorophenol indophenol dye and expressed as mg of ascorbic acid per 100 g (Freed, 1966).

3.3.4.7. Sugar – acid ratio

The ratio was computed by dividing the total sugars, by the acidity.

b. Followers

The following observations as described earlier under this chapter was recorded in all the suckers (followers) at shooting stage of the main crop and also at harvesting stage of the main crop.

3.3.5. Morphological characters

3.3.5.1. Pseudostem height

The height of the pseudostem was measured from the base of the trunk to the axil of the youngest leaf at shooting and harvesting stage and expressed in meter (m).

3.3.5.2. Pseudostem girth

The girth of the pseudostem was measured at 30 cm height from the ground level during shooting and harvesting stage and expressed in centimeter (cm).

3.3.5.3. Number of leaves

The number of functional leaves at shooting and harvesting stage was recorded and expressed in number.

3.3.5.4. Phyllochron

The date of emergence of each leaf was recorded from which the phyllochron (i.e., the time interval (days) between the production of leaves) was calculated (Summerville, 1944). The phyllochron value was calculated between shooting to harvesting phase (i.e., bunch development phase) of the main crop and expressed in days.

3.3.6. Statistical Analysis

The statistical analysis of data to estimate variance and critical differences in randomized block design was done by adopting the standard procedures outlined by Gomez and Gomez (1984).

EXPERIMENTAL RESULTS

CHAPTER IV

RESULTS

Experiments on clump management of hill banana cv. Virupakshi (AAB) was carried out at the Department of Fruit Crops and Postharvest Technology, Horticultural College and Research Institute, Periyakulam during the year 2006-2008 and the results obtained are presented below.

4.1. Pseudostem Height

The Pseudostem height of the main crop recorded at shooting stage differed significantly with treatments and it was shortest with T₁ (3.88 m) and tallest with T₅ (4.89 m).

The Pseudostem height recorded in the followers at shooting and harvesting stages of main crop revealed that it was also significantly affected by the treatments. The lowest height was obtained with T₁ at both the stages while the highest was recorded with T₆ at harvesting stage.

Increment in Pseudostem height during the fruit development phase of main crop also differed significantly with the treatments. Under the single plant system (T₁ to T₃) the increment in Pseudostem height showed increased value with increase in number of followers per clump. Similarly in the case of treatments involving two plants per pit, increment in Pseudostem height was found to increase with the increase in the number of followers (Table-1).

4.2. Pseudostem Girth

Pseudostem girth at shooting stage of main crop exhibited significant differences among the treatments. All the treatments registered reduced Pseudostem girth with increasing plant densities and it was the lowest with T₆ (82.56 cm) and the highest with T₁ (100.80 cm).

The Pseudostem girth recorded in the followers at shooting and harvesting stages of main crop also showed significant differences. It was the lowest with T₆ at both the stages while it was the highest with T₁ at harvesting stage.

Increment in Pseudostem girth with followers during shooting to harvesting phase of main crop also differed significantly among the treatments. Under both the

single and double planting system (T₁ to T₆), the increment in plant girth showed decreased value with increase in number of followers per clump (Table-2).

4.3. Total Number of leaves

Total number of leaves was significantly different among the treatments. The number of leaves decreased significantly with increasing number of followers per clump and it was the lowest with T₆ (33.20) and the highest in T₁ & T₄ (35.75).

At shooting and harvesting stages of main crop, the number of leaves recorded in followers also exhibited significant differences. The lowest number of leaves was obtained with T₁ at both the stages while highest number of leaves was recorded with T₄ (26.15), followed by T₆ (26.08). At harvesting stage of main crop the highest number of leaves was recorded in T₂ (35.04), followed by T₄ (33.38) and the lowest in T₁ at both the stages.

Increment in number of leaves of the followers during the fruit development phase of main crop also manifested differences significantly with the treatments. Under the single plant system (T₁ to T₃) the increment in number of leaves showed decreased values with increase in density while under two sucker per pit system (T₄ to T₆), the differences in increment was not perceptible (Table-3).

4.4. Functional leaves

In both the main crop and followers, the functional leaves recorded at the shooting and harvesting stages exhibited statistical differences among the treatments. It was the lowest with T₆ (8.98, 8.68) at shooting and harvesting stages respectively of main crop. While it was the highest with T₅ (10.69) at shooting and with T₁ & T₂ (10.37) at harvesting stage.

Functional leaves of followers were found to be the highest maximum with T₂ (10.58) followed by T₅ (10.55) and least with T₄ (8.69) at shooting stage of main crop. However, at harvesting stage, all the double planting had relatively more functional leaves than single planting. It was the highest with T₄ (10.31) followed by T₅ (9.79) and the lowest in T₃ (9.19) (Table-4).

4.5. Phyllochron

The phyllochron of the leaves of the followers showed significant differences at shooting and harvesting stages. A wider phyllochron values (10.85, 12.25) was

observed in T₆ at both the stages and it was lowest with T₁ (8.68) at shooting stage and T₄ (10.80) at harvesting stages.

Differences in phyllochron during fruit development phase of main crop also differed significantly among the treatments and it was the highest with T₂ (2.32) and the lowest with T₃ (2.15). In general, double planting systems (T₄ to T₆) showed a narrow difference (Table-5).

4.6. Leaf area

The leaf area differed significantly among the treatments at harvesting stage of main crop. All the double planting treatments recorded reduced leaf area than the treatments with one plant per hill. Besides, the leaf area decreased with increasing in number of followers in both the planting system. Among the treatments, the highest value was recorded in T₁ (2.74 m²) and the lowest was in T₆ (1.60 m²) in main crop. In case of followers, the highest value was in T₁ (1.46 m²) and lowest was in T₆ (0.78 m²) at harvesting stage of main crop (Table-6).

4.7. Days taken from shooting to harvest

Days taken from shooting to harvest differed significantly among the treatments. The treatments with two plants per hill took more number of days than the treatments with one plant per hill. With increase in number of followers, there was a corresponding increase in crop duration excepting with T₃. T₁ took lowest number of days from shooting to harvest (120.5 days) while T₆ took the highest number of days from shooting to harvest (145 days) (Table-7).

4.8. Bunch weight

The mean bunch weight was differed significantly among the treatments. All the double planting treatments registered relatively better bunch weight than those treatments with one plant per pit. Besides, the bunch weight decreased with increasing number of followers in single planting system. The highest bunch weight was recorded in T₅ (13.54 kg) and the lowest was in T₃ (8.10 kg) (Table-8).

4.9. Hand weight

Hand weight differs significantly among the treatments. Under both the double and single planting system, the hand weight increased with increase in followers up to two numbers and then it declined. The highest hand weight was obtained with T₅ (1285.01 g) and lowest was obtained with T₃ (785.26 g) (Table-8).

4.10. Number of hands

The mean number of hands per bunch was also significantly influenced by the treatments. Relatively, higher number of hands was recorded with double planting than single planting. Among the plant densities and number of followers, mean number of hands were the highest in T₅ (10.5) followed by T₆ (10.13) and the lowest in T₂ (8.75) (Table-8).

4.11. Number of fingers per hand

Number of fingers per hand differed significantly among the treatments. Under the double planting, the highest number of fingers per hand was recorded as compared to single planting. In double planting, number of fingers per hand increased with increased number of followers upto two followers. Among the treatment, mean number of fingers per hand was the highest in T₆ (10.49) followed by (10.44) in T₅ and the lowest number of fingers were recorded in T₃ (9.06) (Table-8).

4.12. Number of fingers per bunch

Number of fingers in a bunch differed significantly among the treatments. All the double planting treatments had highest number of fingers per bunch as compared to single planting treatments. In single planting, the number of fingers per bunch decreased with increased number of followers. Among the treatments, the mean number of finger per bunch was the highest in T₅ (111.44) and the lowest in T₃ (85.88) (Table-8).

4.13. Finger weight

Finger weight differed significantly among the treatments. All the double planting treatments had more finger weight as compared to single planting treatments. The finger weight increased initially upto three followers but over increased number declined there after. Among the treatments the maximum finger weight was recorded

with T₅ (116.49 g) followed by T₄ (101.59 g) and minimum with T₃ (88.29 g) (Table-9).

4.14. Finger volume

Finger volume followed a similar trend as that of fruit weight. Among the treatments T₅ recorded the highest finger volume (114.8 cc) followed by T₄ (100.32 cc) and the lowest with T₃ (85.26 cc) (Table-9).

4.15. Finger length

Finger length differed significantly among the treatments. All the single planting treatments showed reduction in finger length than the treatments with two plants per hill. Among the treatments, T₅ recorded the highest finger length (13.79 cm) followed by (12.23 cm) and the lowest with T₃ (8.86 cm) (Table-9).

4.16. Finger circumference

Finger circumference also manifested statistical difference among the treatments. All the single planting had lowest finger circumference than the treatments with two plants per hill. Among the treatments, T₅ recorded the highest circumference (13.80 cm) followed by T₆ (12.11 cm) and lowest with T₃ (8.94 cm) (Table-9).

4.17. TSS

The TSS showed significant differences among the treatments. All the double planting recorded increased TSS content than the treatments with one plant per hill. The highest TSS was recorded in T₅ (20.31⁰ brix) while T₃ recorded the lowest value (19.17⁰ brix) (Table-10).

4.18. Acidity

Treatments also differed significantly among themselves in affecting the acidity of the fruits. All the single planting recorded the highest acidity than the treatments with two plants per hill. The acidity ranged from 0.32% (T₅) to 0.60% (T₄) (Table-10).

4.19. Ascorbic acid

Ascorbic acid content showed significant differences among the treatments. Invariably all the double plants recorded higher ascorbic acid content than the

treatments with one plant per hill. The mean values for ascorbic acid ranged from 4.84 mg/100 g (T₄) to 3.37 mg/100g (T₃) (Table-10).

4.20. Sugars

Total sugar, reducing sugar and non reducing sugar contents differed significantly among the treatments. All the double planting had increased sugar content in the fruit than the treatments with one plant per hill. Total sugar content was the highest with T₅ (14.73 %) while the lowest was observed with T₃ (12.59%). A similar trend was also observed for reducing sugars.

Non reducing sugar recorded highest with T₅ (5.41%) and lowest with T₁ (4.71%) (Table-10).

4.21. Sugar – Acid ratio

Sugar – acid ratio differed significantly among the treatments. When compared to one plant per hill, all the double planting treatments showed increased sugar –acid ratio. The mean value ranged from 22.14% (T₃) to 46.78% (T₅) (Table-11).

4.22. Leaf nitrogen

Leaf nitrogen differed significantly among the treatments at shooting & harvesting stages. All the double planting registered higher leaf nitrogen content than the treatments with one plant per hill at shooting and harvesting stages. With increase in number of followers, there was an increase in leaf nitrogen content in single planting but it has different with double planting. Among the treatments, leaf nitrogen content was the highest in T₅ (2.92 % & 2.77 %) and the lowest in T₂ (2.67 % & 2.50 %) at shooting & harvesting stages. Similar trend was observed in leaf nitrogen with followers also. It was the highest in T₅ (3.10 % & 3.25 %) and the lowest in T₂ (2.89 % & 2.98 %) at both the stages (Table-12).

4.23. Leaf phosphorous

Leaf phosphorous content at shooting and harvesting stages differed significantly among the treatments, T₂ registered the lowest leaf phosphorous content (0.120 %) and the highest value was registered in T₅ (0.138 %) at shooting stage. At harvesting stage, T₃ (0.0716 %) registered lowest value, and highest value was in T₅ (0.0847 %).

In case of followers, highest value was in T₅ (0.0662 % & 0.2144 %) at shooting and harvesting stages respectively. Lowest leaf phosphorous was recorded in T₂ (0.0646 %) at shooting stage of main crop, and T₆ (0.2118 %) at harvesting stage of main crop. (Table-13).

4.24. Leaf potassium

Leaf potassium at shooting and harvesting stages differed significantly among the treatments. Highest leaf potassium content was observed in T₅ (4.060 % & 3.87 %) and lowest value in T₃ (3.97 % & 3.82 %) at both the stages.

In the case of followers, the treatments failed to attain the significant level at shooting stage but did not with harvesting stages. The highest value was observed in T₃ (4.333 %) and the lowest value was in T₄ (4.119 %) treatments with two plants per hill and allowing three suckers at harvesting stage. (Table-14).

Table -1. Effect of clump management on the Pseudostem height (m) of hill banana cv. Virupakshi (AAB)

| Treatments | Main crop at shooting stage | Followers | | |
|----------------|-----------------------------|-----------------------------|-------------------------------|------------------------------------|
| | | Shooting stage of main crop | Harvesting stage of main crop | Increment in Pseudostem height (m) |
| T ₁ | 3.88 | 1.93 | 2.47 | 0.525 |
| T ₂ | 4.28 | 3.17 | 3.70 | 0.573 |
| T ₃ | 4.35 | 3.44 | 3.99 | 0.724 |
| T ₄ | 4.72 | 3.36 | 3.85 | 0.500 |
| T ₅ | 4.89 | 3.26 | 3.80 | 0.658 |
| T ₆ | 4.54 | 2.94 | 4.04 | 0.692 |
| S Ed | 0.1995 | 0.1779 | 0.2815 | 0.0260 |
| CD 5% | 0.4252 | 0.3791 | 0.6000 | 0.0553 |
| CD 1% | 0.5879 | 0.5241 | 8.8295 | 0.0765 |

Table -2. Effect of clump management on the Pseudostem girth (cm) of hill banana cv. Virupakshi (AAB)

| Treatments | Main crop at shooting stage | Followers | | |
|----------------|-----------------------------|-----------------------------|-------------------------------|----------------------------------|
| | | Shooting stage of main crop | Harvesting stage of main crop | Increment in Pseudostem girth(m) |
| T ₁ | 100.80 | 72.25 | 107.13 | 36.50 |
| T ₂ | 100.10 | 70.74 | 103.09 | 33.38 |
| T ₃ | 97.88 | 73.74 | 103.81 | 25.97 |
| T ₄ | 92.83 | 71.81 | 94.34 | 32.00 |
| T ₅ | 87.38 | 61.85 | 103.79 | 28.83 |
| T ₆ | 82.56 | 60.90 | 92.59 | 27.70 |
| S Ed | 1.7905 | 3.3381 | 2.5610 | 0.9137 |
| CD 5% | 3.8163 | 7.1150 | 5.4586 | 1.9474 |
| CD 1% | 5.2761 | 9.8366 | 7.5466 | 2.6923 |

Table – 3. Effect of clump management on total number of leaves of hill banana cv.Virupakshi (AAB)

| Treatments | Main crop at shooting stage | Followers | | |
|----------------|-----------------------------|-----------------------------|-------------------------------|-------------------------------|
| | | Shooting stage of main crop | Harvesting stage of main crop | Increment in number of leaves |
| T ₁ | 35.75 | 15.50 | 27.19 | 11.69 |
| T ₂ | 35.00 | 25.70 | 35.04 | 9.04 |
| T ₃ | 33.88 | 24.33 | 32.91 | 8.58 |
| T ₄ | 35.75 | 26.15 | 33.38 | 7.25 |
| T ₅ | 35.20 | 24.59 | 32.20 | 7.58 |
| T ₆ | 33.20 | 26.08 | 32.50 | 6.44 |
| S Ed | 0.7611 | 0.8075 | 0.6893 | 0.5364 |
| CD 5% | 1.6222 | 1.7212 | 1.4692 | 1.1434 |
| CD 1% | 2.2427 | 2.3796 | 2.0312 | 1.5807 |

Table – 4. Effect of clump management on functional leaves of hill banana cv.Virupakshi (AAB)

| Treatments | Main crop | | Followers | |
|----------------|----------------|------------------|----------------|------------------|
| | Shooting stage | Harvesting stage | Shooting stage | Harvesting stage |
| T ₁ | 9.13 | 10.37 | 9.75 | 9.30 |
| T ₂ | 9.30 | 10.37 | 10.58 | 9.62 |
| T ₃ | 9.75 | 9.50 | 9.94 | 9.19 |
| T ₄ | 9.13 | 8.75 | 8.69 | 10.31 |
| T ₅ | 10.69 | 8.68 | 10.55 | 9.79 |
| T ₆ | 8.98 | 8.68 | 9.31 | 9.66 |
| S Ed | 0.4166 | 0.3385 | 0.2721 | 0.2794 |
| CD 5% | 0.8879 | 0.7215 | 0.5800 | 0.5956 |
| CD 1% | 1.2275 | 0.9975 | 0.8019 | 0.8235 |

Table – 5. Effect of clump management on phyllochron of the followers of hill banana cv.Virupakshi (AAB)

| Treatments | Shooting stage of main crop | Harvesting stage of main crop | Differences in phyllochron |
|----------------|-----------------------------|-------------------------------|----------------------------|
| T ₁ | 8.68 | 10.93 | 2.31 |
| T ₂ | 8.91 | 11.25 | 2.32 |
| T ₃ | 9.22 | 11.38 | 2.15 |
| T ₄ | 9.75 | 10.80 | 1.13 |
| T ₅ | 10.04 | 11.25 | 1.37 |
| T ₆ | 10.85 | 12.25 | 1.53 |
| S Ed | 0.3140 | 0.2734 | 0.3641 |
| CD 5% | 0.6692 | 0.5827 | 0.7762 |
| CD 1% | 0.9252 | 0.8055 | 1.0730 |

Table – 6. Effect of clump management on leaf area (m²) of hill banana cv.Virupakshi (AAB)

| Treatments | Main crop | Followers |
|----------------|-----------|-----------|
| T ₁ | 2.74 | 1.46 |
| T ₂ | 2.59 | 1.43 |
| T ₃ | 2.32 | 1.30 |
| T ₄ | 1.91 | 1.04 |
| T ₅ | 1.67 | 0.90 |
| T ₆ | 1.60 | 0.78 |
| S Ed | 0.0389 | 0.0224 |
| CD 5% | 0.0829 | 0.0477 |
| CD 1% | 0.1146 | 0.0660 |

Table – 7. Effect of clump management on the crop duration of hill banana cv.Virupakshi (AAB)

| Treatments | Shooting to harvesting |
|-------------------|-------------------------------|
| T ₁ | 120.5 |
| T ₂ | 127.0 |
| T ₃ | 125.0 |
| T ₄ | 142.0 |
| T ₅ | 144.5 |
| T ₆ | 145.0 |
| S Ed | 1.1499 |
| CD 5% | 2.4509 |
| CD 1% | 3.3884 |

Table – 8. Effect of clump management on bunch characters of hill banana cv.Virupakshi (AAB)

| Treatments | Bunch Weight (kg) | Hand weight (g) | Mean no. of hands / Bunch | Mean no. of fingers / hand | Total no. of fingers / bunch |
|-------------------|--------------------------|------------------------|----------------------------------|-----------------------------------|-------------------------------------|
| T ₁ | 9.66 | 926.55 | 9.88 | 9.66 | 94.50 |
| T ₂ | 9.23 | 993.65 | 8.75 | 10.13 | 89.50 |
| T ₃ | 8.10 | 785.26 | 9.25 | 9.06 | 85.88 |
| T ₄ | 10.60 | 1008.15 | 9.93 | 9.96 | 99.63 |
| T ₅ | 13.54 | 1285.01 | 10.5 | 10.44 | 111.44 |
| T ₆ | 11.19 | 1053.73 | 10.13 | 10.49 | 107.68 |
| S Ed | 0.3205 | 44.65 | 0.3284 | 0.2813 | 4.2654 |
| CD 5% | 0.6831 | 95.18 | 0.6999 | 0.5996 | 9.0916 |
| CD 1% | 0.9444 | 131.59 | 0.9676 | 0.8289 | 12.569 |

Table -9. Effect of clump management on Finger characters of hill banana cv.Virupakshi (AAB)

| Treatments | Finger weight (g) | Finger Volume (cc) | Finger length (cm) | Finger circumference (cm) |
|-------------------|--------------------------|---------------------------|---------------------------|----------------------------------|
| T ₁ | 95.75 | 94.25 | 10.24 | 10.15 |
| T ₂ | 98.24 | 97.50 | 10.41 | 10.36 |
| T ₃ | 88.29 | 85.26 | 8.86 | 8.94 |
| T ₄ | 101.50 | 100.32 | 11.22 | 11.11 |
| T ₅ | 116.49 | 114.8 | 13.79 | 13.80 |
| T ₆ | 100.51 | 98.85 | 12.23 | 12.11 |
| S Ed | 2.5298 | 2.6834 | 0.3525 | 0.3745 |
| CD 5% | 5.3921 | 5.7196 | 0.7513 | 0.7983 |
| CD 1% | 7.4547 | 7.9074 | 1.0386 | 1.1036 |

Table – 10. Effect of clump management on fruit quality traits of hill banana cv.Virupakshi (AAB)

| Treatments | TSS (^oBrix) | Acidity (%) | Ascorbic acid (mg/100g) |
|-------------------|-------------------------------|--------------------|--------------------------------|
| T ₁ | 21.35 | 0.60 | 4.13 |
| T ₂ | 20.97 | 0.43 | 3.88 |
| T ₃ | 19.17 | 0.59 | 3.37 |
| T ₄ | 21.98 | 0.43 | 4.84 |
| T ₅ | 23.31 | 0.32 | 4.63 |
| T ₆ | 21.78 | 0.45 | 4.25 |
| SEd | 0.7096 | 0.0176 | 0.1302 |
| CD 5% | 1.5124 | 0.0375 | 0.2776 |
| CD1% | 2.0909 | 0.0518 | 0.3838 |

Table – 11. Effect of clump management on fruit quality traits of hill banana cv.Virupakshi (AAB)

| Treatments | Total Sugar (%) | Reducing sugar (%) | Non-reducing sugar (%) | Sugar- acid ratio (%) |
|-------------------|------------------------|---------------------------|-------------------------------|------------------------------|
| T ₁ | 13.58 | 8.37 | 4.71 | 22.59 |
| T ₂ | 12.92 | 7.87 | 5.05 | 30.01 |
| T ₃ | 12.59 | 7.70 | 4.89 | 21.14 |
| T ₄ | 14.52 | 9.25 | 5.27 | 34.06 |
| T ₅ | 14.73 | 9.33 | 5.41 | 46.78 |
| T ₆ | 13.18 | 7.98 | 5.15 | 29.43 |
| SEd | 0.2439 | 0.2219 | 0.0893 | 1.635 |
| CD 5% | 0.5198 | 0.4729 | 0.1903 | 2.267 |
| CD1% | 0.7186 | 0.6538 | 0.2631 | 3.134 |

Table -12. Effect of clump management on leaf nitrogen content (%) of hill banana cv.Virupakshi

| Treatments | Shooting stage | | Harvesting stage | |
|-------------------|-----------------------|------------------|-------------------------|------------------|
| | Main crop | Followers | Main crop | Followers |
| T ₁ | 2.69 | 2.90 | 2.58 | 3.09 |
| T ₂ | 2.67 | 2.89 | 2.50 | 2.98 |
| T ₃ | 2.73 | 2.96 | 2.57 | 3.10 |
| T ₄ | 2.72 | 2.99 | 2.62 | 3.13 |
| T ₅ | 2.92 | 3.10 | 2.77 | 3.25 |
| T ₆ | 2.81 | 3.05 | 2.70 | 3.19 |
| Sed | 0.0532 | 0.0330 | 0.0424 | 0.0178 |
| CD 5% | 0.1133 | 0.0702 | 0.0904 | 0.0380 |
| CD 1% | 0.1567 | 0.0971 | 0.1250 | 0.0526 |

Table -13. Effect of clump management on leaf phosphorous content (%) of hill banana cv.Virupakshi

| Treatments | Shooting stage | | Harvesting stage | |
|----------------|----------------|-----------|------------------|-----------|
| | Main crop | Followers | Main crop | Followers |
| T ₁ | 0.122 | 0.0647 | 0.0794 | 0.2119 |
| T ₂ | 0.120 | 0.0646 | 0.0720 | 0.2123 |
| T ₃ | 0.123 | 0.0647 | 0.0716 | 0.2144 |
| T ₄ | 0.126 | 0.0648 | 0.0821 | 0.2121 |
| T ₅ | 0.138 | 0.0662 | 0.0847 | 0.2124 |
| T ₆ | 0.134 | 0.0656 | 0.0832 | 0.2118 |
| S Ed | 0.0010 | 0.0003 | 0.0011 | 0.0013 |
| CD 5% | 0.0022 | 0.0007 | 0.0024 | 0.0028 |
| CD 1% | 0.0031 | 0.0010 | 0.0034 | 0.0039 |

Table -14. Effect of clump management on leaf potassium of content (%) of hill banana cv.Virupakshi

| Treatments | Shooting stage | | Harvesting stage | |
|----------------|----------------|-----------|------------------|-----------|
| | Main crop | Followers | Main crop | Followers |
| T ₁ | 4.025 | 3.886 | 3.85 | 4.180 |
| T ₂ | 4.028 | 3.886 | 3.85 | 4.135 |
| T ₃ | 3.970 | 3.865 | 3.82 | 4.333 |
| T ₄ | 4.024 | 3.877 | 3.83 | 4.119 |
| T ₅ | 4.060 | 3.895 | 3.87 | 4.126 |
| T ₆ | 4.042 | 3.891 | 3.84 | 4.126 |
| S Ed | 0.0033 | N.S | 0.0053 | 0.0023 |
| CD 5% | 0.0070 | N.S | 0.0112 | 0.0049 |
| CD 1% | 0.0097 | N.S | 0.0155 | 0.0067 |

DISCUSSION

CHAPTER V

DISCUSSION

High density planting (HDP) is one of the recent and novel concepts of increasing the productivity per unit area in fruit crops. The productivity under HDP depends upon the extent of utilization of solar energy which is abundant in tropical regions. An ideal planting density is often determined by complex interaction of factors such as cultivar, soil fertility, management level and economic consideration. High density planting has been recently exploited in banana in Tamil nadu. HDP with planting of more than one sucker per hill was adopted in cultivars like Nendran (Elia Apshara, 1997), Robusta (Mahalakshmi, 2000), and Red banana (suganthi, 2002) with variable planting distances. Virupaksi, the dessert and choice variety of Lower Pulney hills, is grown as an intercrop under multi-tier cropping system along with coffee plantations and recently as a pure crop in the newly cleared coffee plantations under perennial system of cultivation. Information on the effect of planting of more than one sucker per pit or the effect of allowing more number of followers on the main crop is lacking. In the present investigation, effect of planting of one and two suckers per hill besides allowing two suckers, three suckers, four suckers per hill as followers were adopted and its effect on the main crop as well as on the vegetative growth of the followers were studied and results obtained are discussed in this chapter.

Effect on vegetative characters

In banana, vigour is judged by optimum pseudostem height and good girth, as these parameters have a direct bearing on the bunch yield. In the present study, increment in pseudostem height and reduction in pseudostem girth were observed in general, with main crop under two suckers per hill planting system than under single sucker per pit system (Fig.1). This is primarily due to mutual shading of plants resulting in competitive growth rate to intercept light (Murray, 1960). Further, with more number of followers allowed per mat more reduction in girth was observed, again highlighting the influence of light and mutual shading of plant. The increment in pseudostem height or girth when compared between two planting systems, increment of pseudostem girth was less under two planting system (Fig.2). This is probably due to competition for nutrients and light under high density planting system. Increments in pseudostem girth of the followers were also very less with four followers allowed at single plant per pit

system and double plants per pit system was also due to the competition for nutrients and light.

Leaf production in banana is influenced by various agro climatic, genetic, cultural practices (Turner, 1970). In the present investigation, the leaf number recorded at shooting stage of main crop was influenced by the planting density as well as number of followers allowed. More than the total number of leaves, number of functional leaves retained in banana especially under high humid and high rain fall zones of pulney hills is essential for the plants to carry out the photosynthetic activities. In this study, number of functional leaves which was relatively lesser under two suckers per hill system than under single sucker per pit system (Fig.3). This is in controversy to the earlier findings of Robinson and Nel (1989) and Elain Apshara (1997) who recorded more number of leaves under high density planting system than the conventional planting. This may be due to the effect of allowing followers for successive cropping as well as the agro ecological climate of Lower Pulney hills, where sunshine hours are limited as compared to plains.

Phyllochron or the rate of leaf emergence should be at closer interval in any system of planting so that the vegetative crop cycle is not extended unduly. In the present investigation, phyllochron of the followers were found to be at closer interval at shooting stage with single sucker per pit system than under double suckers per pit systems (Fig.4). However at harvesting stage, the difference between single sucker per pit and double sucker per pit system became insignificant. With more number of followers per mat, there was a delay in the rate of leaf production at both the systems of planting. Leaf emergence is normally reported to be at slower rate under very closer planting owing to low temperature experienced inside the canopy as temperature had greater influence on leaf production (Robinson and Nel, 1989; Singh, 1990). With increase in number of followers there was an extension of leaf emergence which may be due to the influence of apical dominance of the mother plant with the followers.

Besides, the number of functional leaves and the rate of leaf production, the size of the leaf and leaf area is another important factor which has a direct bearing on the photosynthetic activity of the plants. The leaf area of main crop as well as the followers was relatively lesser under double sucker per pit system, besides increase in leaf area was found with increase in number of followers per mat (Fig.5). This is normally expected in a variety like Virupakshi which is grown under low sunlight condition in Lower Pulney hills. Leaf emergence, leaf production and leaf size are generally reduced

under closer planting system owing to low temperature inside the canopy since the temperature has a significant influence on these parameters (Singh, 1990).

Effect on crop duration

Crop duration is an important factor to be considered in banana. Crop duration have two phases namely days taken from planting to shooting and days taken from shooting to harvest, otherwise known as 'vegetative cycle' and 'bunch development phase' respectively. As in this experiment followers of varying numbers were allowed only at shooting stage in each treatment, effect of clump management on crop duration particularly shooting to harvesting was alone considered. Double planting had pronounced effect on crop duration than the single planting system (Fig.6). However within each planting system, with the number of followers there was not much of difference in crop duration between two suckers and three suckers per mat. Nalina (1999) experienced extended crop duration from shooting to harvest under four suckers per pit than three suckers per pit system under plains. This may be explained due to the competition between plants for nutrient and light, resulting in more number of days for growth, development and maturation (Azhaikiamanavalan and Balakrishnan, 1976; Nalina, 1999).

Effect on yield and yield components

The bunch weight recorded under two suckers per pit system was relatively higher than under single sucker per pit system and again with increase in number of followers per mat, there was a reduction in bunch weight under single sucker per pit system, while with two suckers per pit system, bunch weight was more upto three followers per mat and then declined (Fig.7). Normally under high density planting system reduction in bunch weight was observed by many workers (Azhaikiamanavalan and Balakrishnan 1976; Nalina, 1999; Mahalakshmi, 2000). This is a unique result with cultivar like Virupakshi which is a highly adaptable variety grown under heavy competition in multi-tier system of cropping with coffee, oranges, pepper and other shade crops. Moreover the developing bunches of the main crop would have derived benefits from the followers on more nutrient uptake and supply of photosynthates etc. However this concept need to be verified with the first ratoon and second ratoon conditions so as to conclude that two suckers per pit with more number of followers was suitable for this variety. Robinson (1989) opined that banana plants are physiologically efficient than placed at different competitive inhibition increased when

crowding take place. In Virupakshi on the other hand is a choice cultivar which is adoptable under multiple clump management system.

In Lower Pulney condition, banana bunch is sold by finger number basis in the market and also based on the bunch grade. Bunch grade is a comprehensive term which apart from bunch weight is dependant upon number of fingers per bunch, finger weight and size etc. An analysis of the bunch characters of the present study showed that hand weight, number of hands, number of fingers per hand and total number of finger per bunch were not reduced under double suckers per pit planting system (Fig.7). This again highlights the adaptability of the cv.Virupakshi under multiple clump management system. Azhaikiamanavalan and Balakrishnan (1976) also obtained higher grades of bunches in Robusta under double planting system.

The finger weight, finger volume, finger length and finger circumference are other characters of better grade in cv.Virupakshi. This grades were appeared to be good in double suckers per pit planting system particularly in three followers per mat (Fig.8). Nalina (1999) reported that among the high density planting systems, three suckers per hill had least effect on finger characters than four suckers per hill in cv. Robusta.

In any high density planting system primary objective is to obtain maximum fruits per unit area without affecting fruit quality. Fruit quality is mainly judged by acidity and total sugars present besides ascorbic acid content. These traits in present study were found to be comparatively better under double suckers per pit planting system and with an increase in number of followers per mat there was a reduction in quality under single planting system. However this effect was not much depicted under two suckers per pit (Fig.9). This may be explained due to the mutual benefit of mother and suckers in synthesising the food material (source) and supplying to the developing bunches (sink). Nalina (1999) found that reduction in TSS and ascorbic acid content in Robusta relatively lesser under three suckers per pit system of planting than under four suckers system of planting. However many banana workers had reported reduction in fruit quality in many HDP studies (Irizarry et al., 1978; Chundawat et al., 1983; Anil et al., 1995; Elain Apshara, 1997). The controversy in present study may be explained due to the unique nature of this variety which when grown in plains did not develop a quality grade bunch as compared to those harvested from multi-tier system of cropping in the hills. This explained that this variety tolerate shade, competition and produce better quality under unique environmental condition.

Effect on leaf nutrient

Estimation of Leaf nutrient concentration in plant tissue provides information on nutrient status of plant, indicating often the diagnosis of toxicity as well as deficiency status in the plant. Hence the estimation of leaf nutrient content under high density planting is highly essential where the plants are competing for nutrients. In the present study, leaf nitrogen content ranged from 2.72 to 2.92 % under double sucker per pit planting system when compared to single sucker per pit planting system ranged from 2.67 to 2.73 %. This shows that there is not much difference between leaf nitrogen content under varying planting system. This is also true with harvesting stage or with followers in respect of leaf phosphorus content as well as leaf potassium content (Fig.10).

This results highlight that nutrient is not a limiting factor under high density planting in lower pulney hills where the bunches were alone harvested and taken off from the field where as the rest of the part of the plant like psuedostem, desuckered materials, peduncle are recycled (as crop residues) which are known to supply nearly 50 % of the major as well as minor nutrients required for banana on decomposition (Lahav and Turner, 1983). Thus, over all results indicate that planting of two suckers per pit in cv.Virupakshi as a mean of high density planting system holds promise to get higher yield with good bunch grade and quality. As it is grown under perennial system, one year data may not be adequate to support the above concept as varying number of followers were allowed and their effect may be different in subsequent years. Hence there is a need to continue this experiment for two or three years to get concrete results.

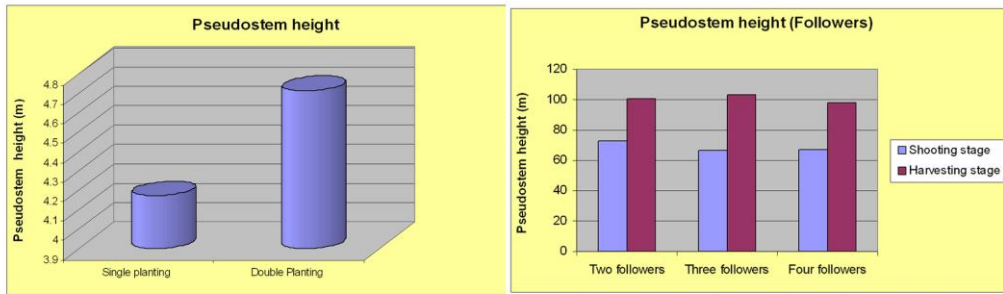


Fig.1. Effect of clump management on pseudostem height (m) of hill banana cv. Virupakshi (AAB)

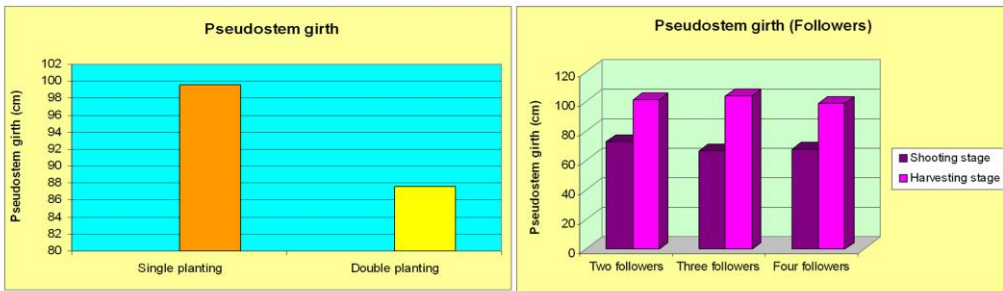


Fig.2. Effect of clump management on Pseudostem girth (cm) of hill banana cv. Virupakshi (AAB)

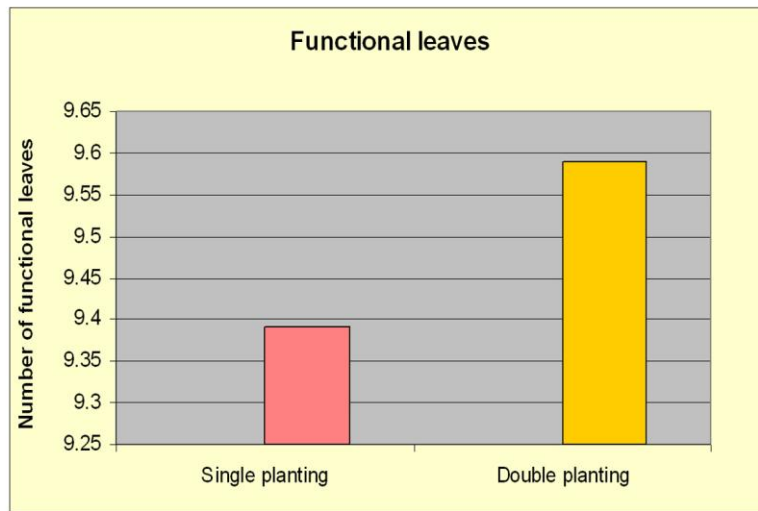


Fig .3.Effect of clump management on functional leaves of hill banana cv. Virupakshi (AAB)

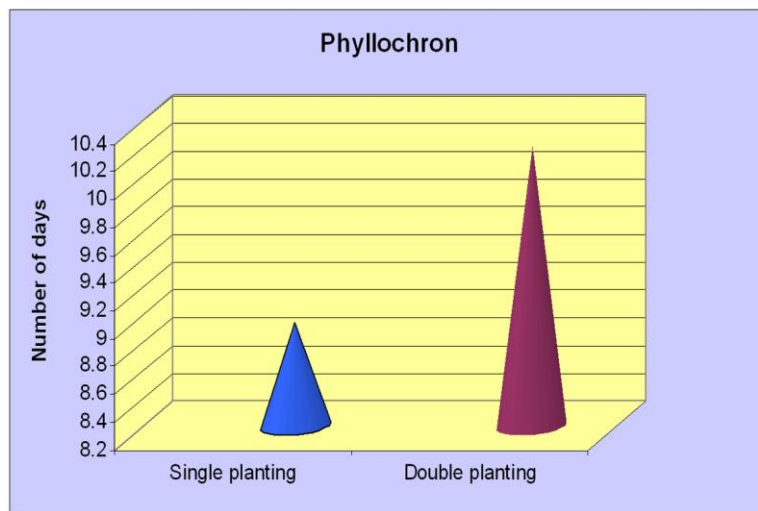


Fig .4.Effect of clump management on phyllochron of the followers of hill banana cv.Virupakshi (AAB)

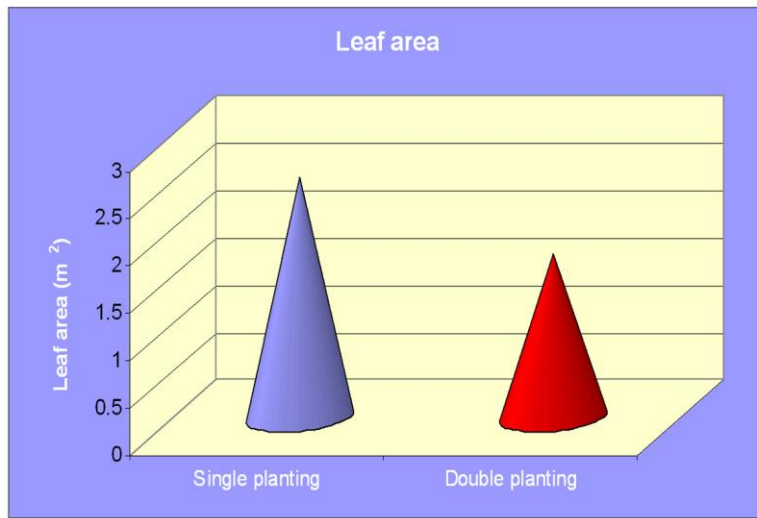


Fig .5.Effect of clump management on leaf area (m2) of hill banana cv. Virupakshi (AAB)

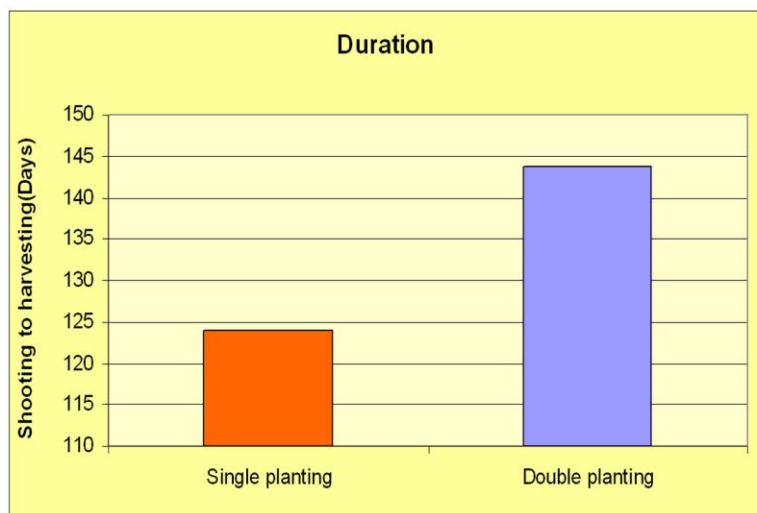


Fig .6.Effect of clump management on crop duration of hill banana cv. Virupakshi (AAB)

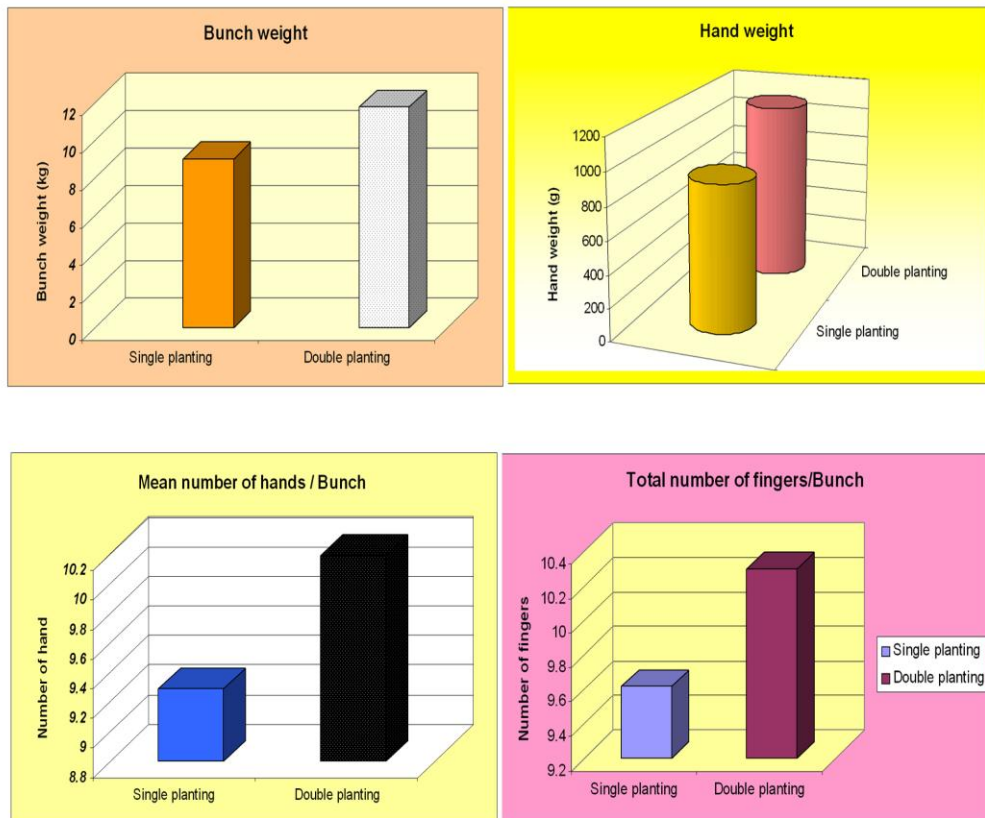


Fig .7.Effect of clump management on bunch charecters of hill banana cv.Virupakshi (AAB)

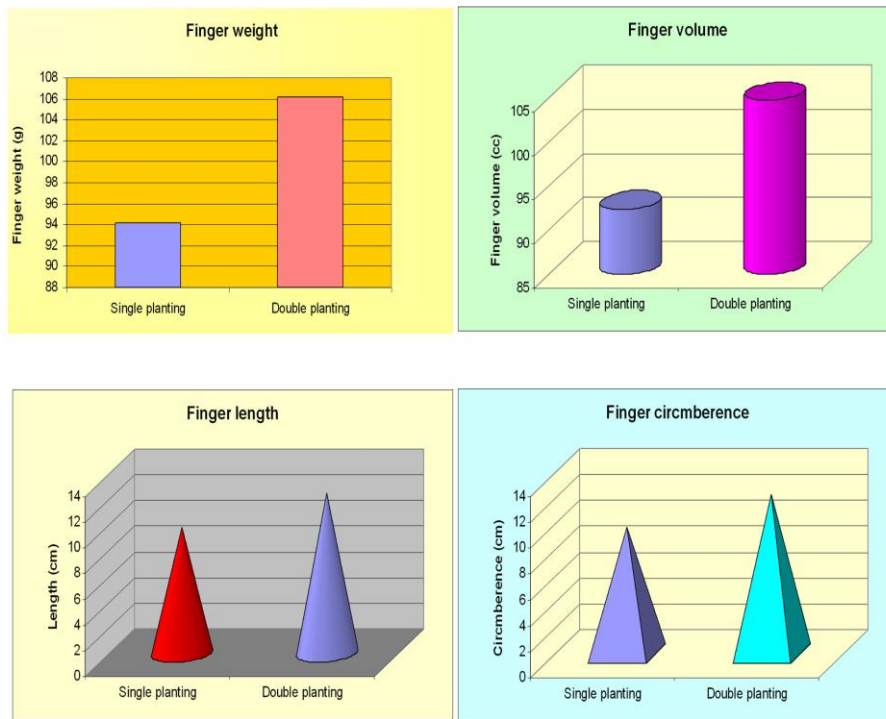


Fig .8.Effect of clump management on finger charecters of hill banana cv.Virupakshi (AAB)

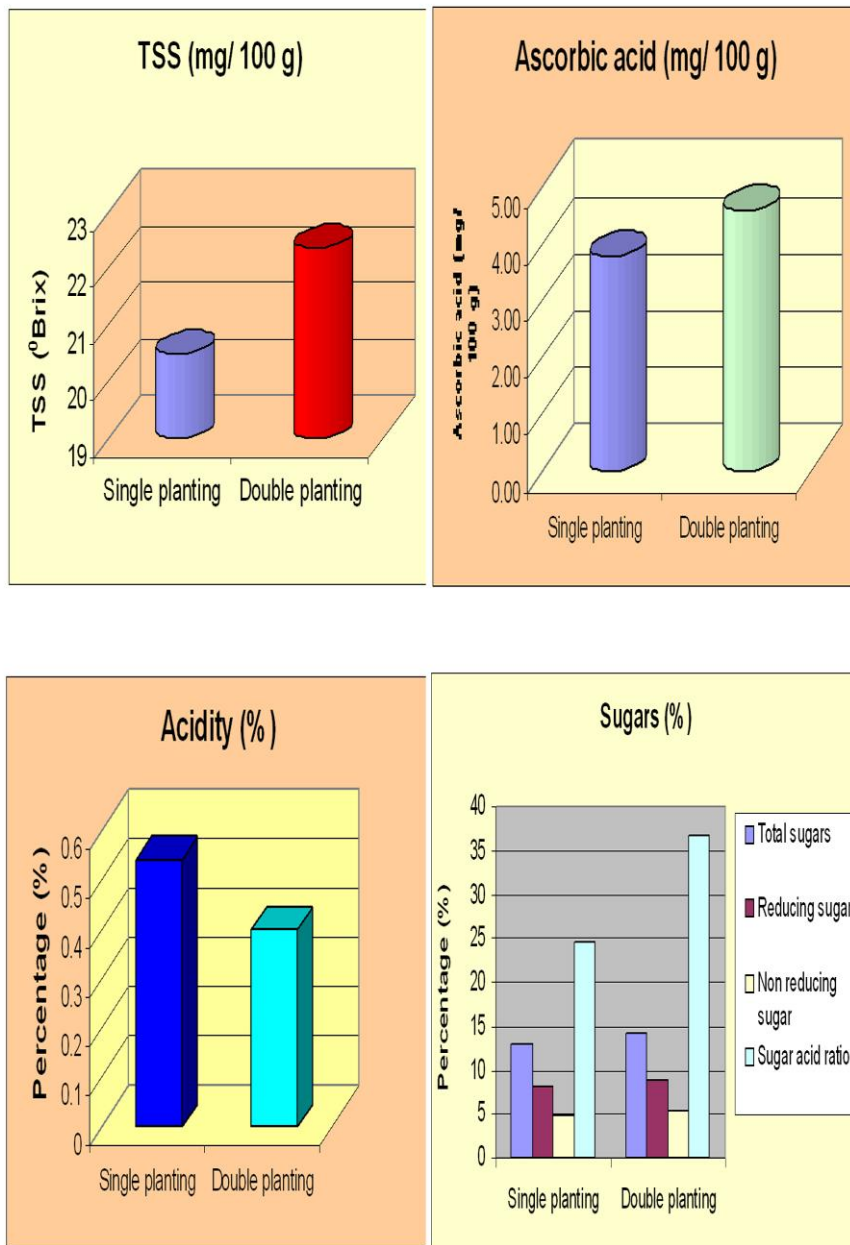


Fig .9.Effect of clump management on quality charecters of hill banana cv.Virupakshi (AAB)

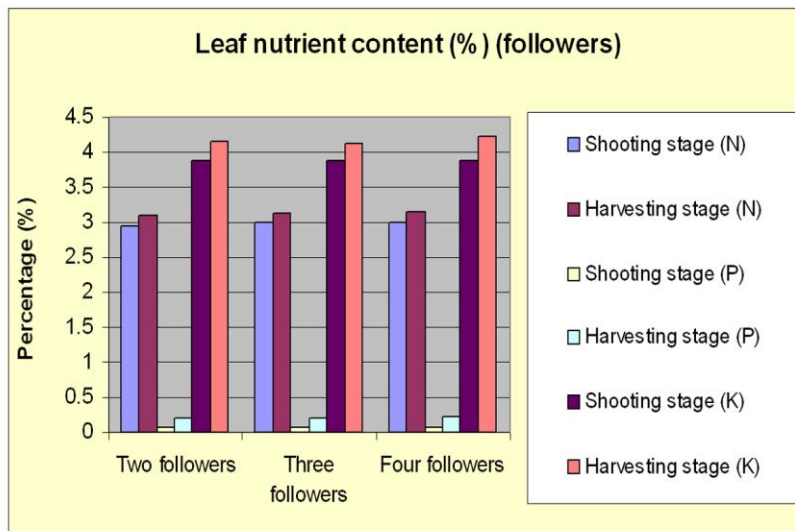
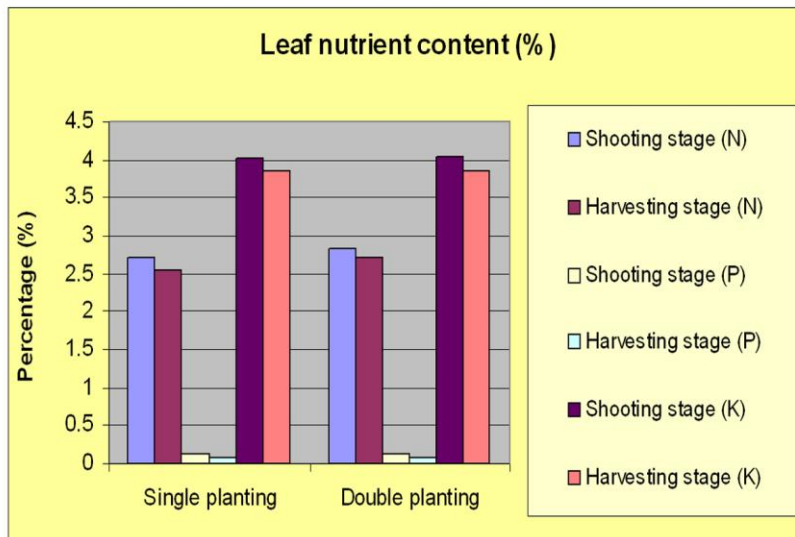


Fig .10.Effect of clump management on leaf nutrient content (%) of hill banana cv. Virupakshi (AAB)

SUMMARY

CHAPTER VI

SUMMARY

An experiment was conducted to study the effect of clump management in hill banana cv. Virupakshi (AAB) during 2006 – 08 in a private farm at panikkarai estate, Kamannor, Kodaikanal taluk of Dindigul district. The experiment was laid out with six treatments each replicated four times in RBD. The treatments included conventional single sucker per pit and two suckers per pit at a spacing of 3.6 x 3.6 m, and allowing two, three, four followers at the time of shooting stage of main crop. Observation on vegetative characters, crop duration, bunch yield and its components, quality characters and leaf nutrients were analysed. Based on the results, the following conclusions were drawn.

1. In the main crop, pseudostem height and number of functional leaves was highest in double planting system allowing three followers.
2. Most of the other vegetative characters like Pseudostem girth, number of leaves and leaf area were highest in single planting system allowing two followers for the main crop.
3. The time taken from shooting to harvest was less in all single planting system when compared to all double planting systems.
4. With regard to the yield components, double planting system with three followers recorded the highest bunch weight, hand weight, number of hands per bunch, number of fingers per bunch, finger weight, finger volume, finger length and finger circumference.
5. Quality characters like TSS, acidity, total sugars, and sugar acid ratio in the fruit was also the highest in double planting system with three followers. However the ascorbic acid content was the highest in double planting with two followers.
6. Leaf N, P, K content was highest in double planting with three followers in both shooting and harvesting stages.
7. In the followers, vegetative characters like pseudostem height and number of functional leaves was highest in double planting system at shooting stage and harvesting stage of main crop.

The same treatment recorded highest number of leaves in shooting stage of main crop. However, girth was highest in single planting system at both shooting and harvesting stage of main crop.

8. The phyllochron of leaves of the followers was wider in double planting with four followers in both shooting and harvesting stage of main crop.
9. Leaf N content was highest in double planting at both shooting and harvesting stage of main crop.
10. Leaf P content was highest in double planting at shooting stage of main crop and in single planting at harvesting stage of main crop.
11. Leaf K content was highest in single planting at harvesting stage of main crop whereas the levels were non significant in shooting stage of main crop.

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PLATES

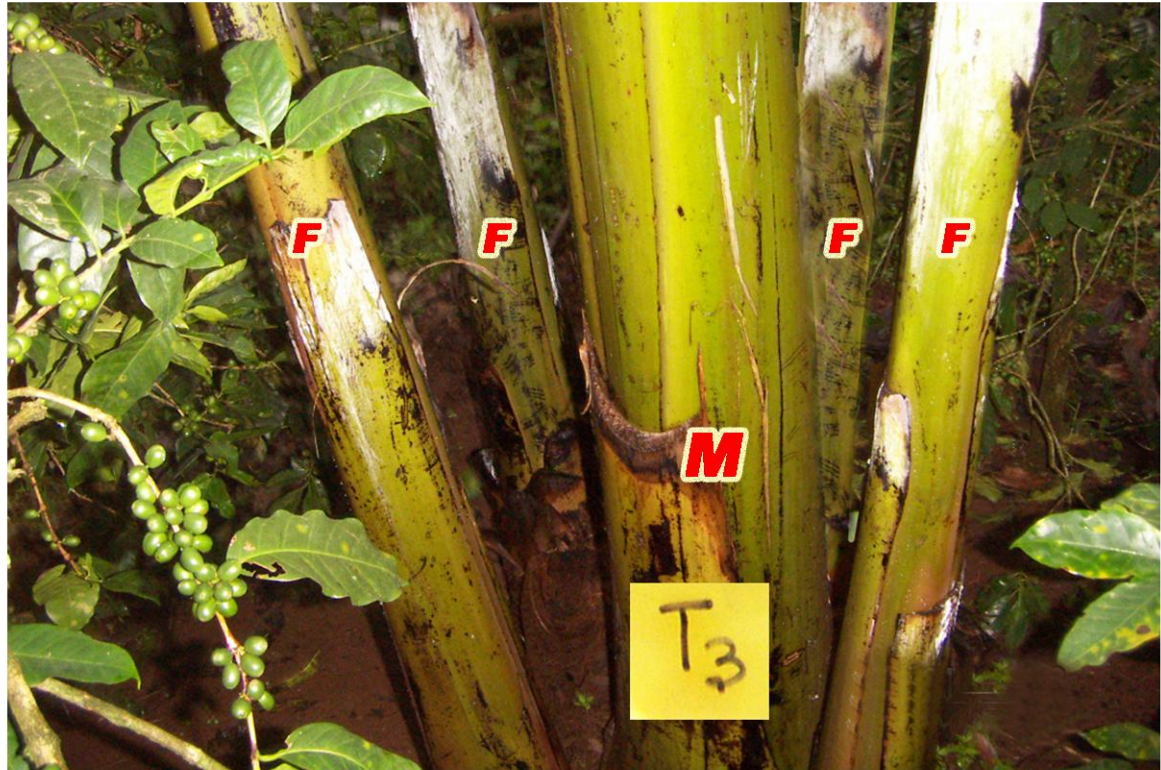


Plate.4.Planting of one sucker per pit and allowing four suckers at shooting stage of the main crop

M - Main Crop

F - Followers

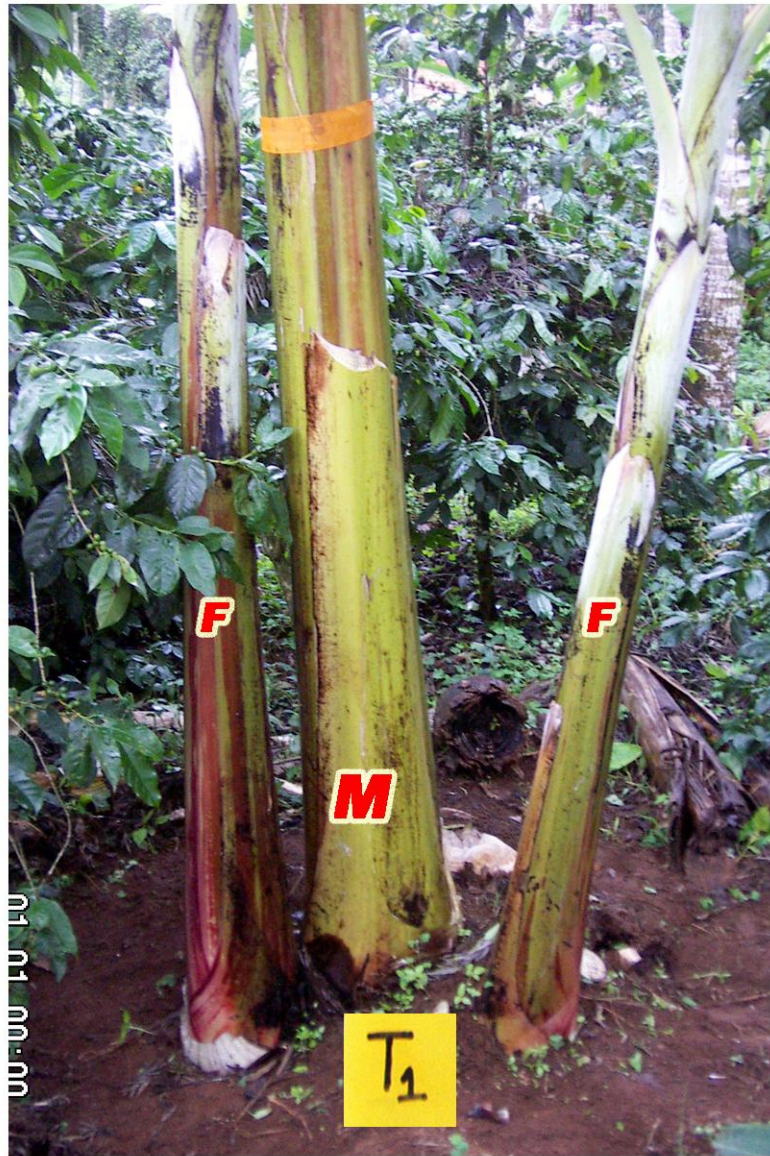


Plate .2.Planting of one sucker per pit and allowing two suckers at shooting stage of the main crop

M - Main Crop **F - Followers**

Plate . 3



Plate . 1 Experimental field view

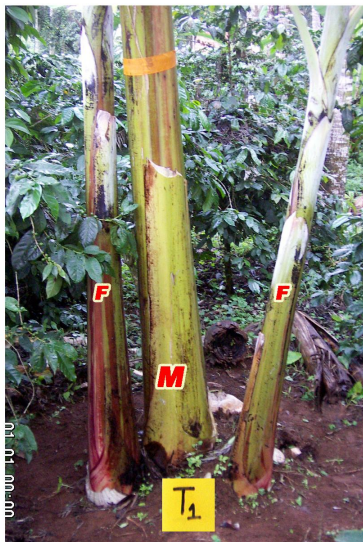


Plate . 2. Planting of one sucker per pit and allowing two suckers at shooting stage of the main crop
M - Main Crop F - Followers



Plate . 3. Planting of one sucker per pit and allowing three suckers at shooting stage of the main crop

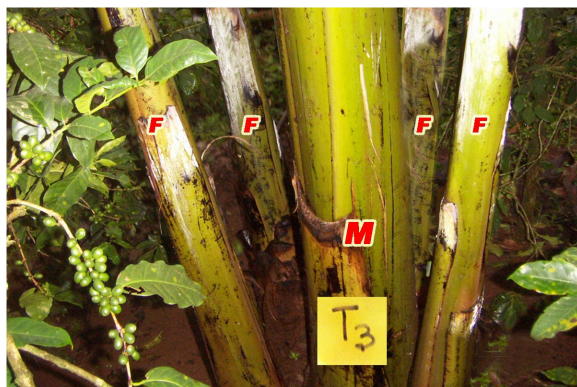


Plate.4.Planting of one sucker per pit and allowing four suckers at shooting stage of the main crop

M - Main Crop

F - Followers



Plate .5.Planting of two suckers per pit and allowing two suckers at shooting stage of the main crop



Plate .6.Planting of two suckers per pit and allowing three suckers at shooting stage of the main crop

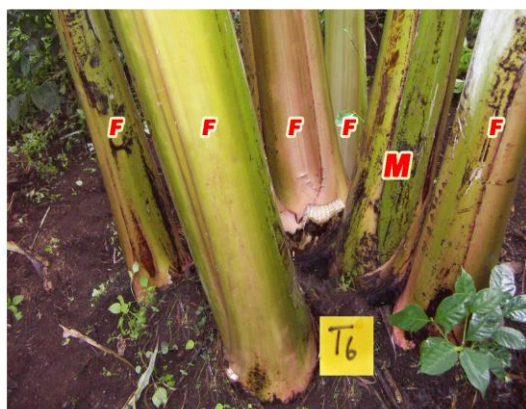


Plate .7.Planting of two suckers per pit and allowing four suckers at shooting stage of the main crop

M - Main Crop

F - Followers



Plate .8. Effect of clump management on bunch weight of hill banana cv. Virupakshi

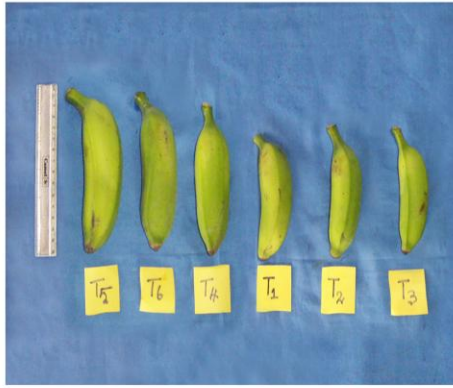


Plate .11. Comparison of individual finger length (cm)

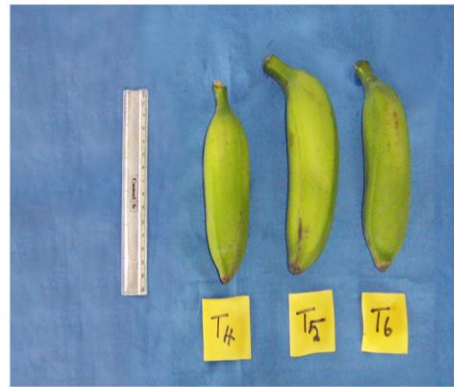


Plate .12. Comparison among single planting treatments

Plate .13. Comparison among double planting treatments

ANNEXURES

ANNEXURE I

Metrological data during the experimental period (2006 – 08).

| Month | Average temperature (° c) | | Rain fall (mm) | Relative humidity(%) | |
|----------------|----------------------------|------|-------------------|----------------------|------|
| | Max | Min | | Max | Min |
| August, 2006 | 36.3 | 19.8 | 93.5 | 93.5 | 50.0 |
| September,2006 | 31.0 | 17.9 | 92.8 | 92.8 | 50.8 |
| October, 2006 | 30.3 | 17.3 | 89.8 | 89.8 | 65.1 |
| November, 2006 | 29.0 | 14.0 | 90.1 | 90.1 | 70.3 |
| December, 2006 | 26.3 | 12.0 | 93.5 | 93.5 | 68.2 |
| January, 2007 | 29.2 | 13.8 | 91.4 | 91.4 | 60.3 |
| February, 2007 | 31.0 | 13.4 | 78.2 | 78.2 | 41.5 |
| March, 2007 | 35.8 | 16.1 | 84.0 | 84.0 | 30.0 |
| April, 2007 | 38.2 | 17.5 | 83.4 | 83.4 | 28.4 |
| May, 2007 | 37.6 | 18.7 | 80.2 | 80.2 | 25.9 |
| June, 2007 | 37.0 | 19.4 | 85.8 | 85.8 | 35.3 |
| July, 2007 | 36.7 | 20.1 | 88.7 | 88.7 | 49.4 |
| August, 2007 | 35.4 | 20.1 | 95.3 | 89.7 | 61.1 |
| September,2007 | 32.6 | 18.3 | 93.2 | 93.0 | 71.0 |
| October, 2007 | 29.8 | 18.1 | 76.0 | 90.9 | 67.0 |
| November, 2007 | 30.0 | 14.6 | 65.9 | 88.9 | 58.8 |
| December, 2007 | 27.3 | 12.7 | 78.0 | 81.0 | 64.0 |
| January, 2007 | 30.1 | 13.5 | 98.7 | 90.3 | 56.8 |

ANNEXURE II

Physical and chemical properties of soil

| | |
|-----------------------|----------------------------|
| Soil type | Sandy clay loam |
| Bulk density | 1.763 g cc ⁻¹ |
| Particle density | 3.05 g cc ⁻¹ |
| Porosity | 42.00 % |
| PH | 5.78 |
| EC | 0.19 dsm ⁻¹ |
| Available nitrogen | 243.54 kg ha ⁻¹ |
| Available phosphorous | 16.98 kg ha ⁻¹ |
| Available potassium | 423.34 kg ha ⁻¹ |

ANNEXURE III

LIST OF ABBREVIATIONS USED

| ABBREVIATIONS | | EXPANSIONS |
|-------------------|---|--------------------------|
| Kg | - | Kilogram |
| ⁰ brix | - | Degree brix |
| g | - | Gram |
| mg | - | Milligram |
| cm | - | Centimetre |
| m | - | Metre |
| <i>i.e.</i> , | - | that is |
| Fig. | - | Figure |
| % | - | Per cent |
| <i>Viz.</i> , | - | Namely |
| CV | - | Coefficient of variation |
| SD | - | Standard Deviation |
| SE | - | Standard Error |
| TSS | - | Total soluble solids |