STANDARDIZATION OF MACROPROPAGATION TECHNIQUE IN BANANA

(*Musa* (AAB) 'NENDRAN')

By

Amal Premachandran

(2016-12-025)

THESIS

Submitted in partial fulfilment of the

Requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"Standardization of macropropagation technique in banana (*Musa* (AAB) 'Nendran')"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Date: 07-09-2018

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CERTIFICATE

Certified that the thesis entitled **"Standardization of macropropagation technique in banana (*Musa* (AAB) 'Nendran')"** is a record of research work done independently by **Mr. Amal Premachandran.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Professor of Horticulture,
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CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Amal Premachandran. (2016-12-025)**, a candidate for the degree of **Master of Science in Horticulture**, with major field in **Fruit Science**, agree that the thesis entitled **"Standardization of macropropagation technique in banana (*Musa* (AAB) 'Nendran')"** may be submitted by **Mr. Amal Premachandran.** in partial fulfilment of the requirement for the degree.

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"This is my simple religion.

There is no need for temples; no need for complicated philosophy.

Our own brain, our own heart is our temple; the philosophy is kindness."

Dalai Lama

The eternal power what we presume as god is present in ourselves. Our act, thinking and perception, create our way ahead. The duties which sprouts in our mind should be fruitful and pose less harm to others and above all, patients and kindness form the basic philosophy of our life. I believe in god and karma, the god which we see among us, who helped me in the difficult times, who cared me, who directed me, who shared my feelings. Hence here I submit my Master of Science degree to the gods I met and who helped me, with immense pleasure. My research work and thesis would be incomplete if I fail to acknowledge them. I express my gratefulness towards each and every member of my Advisory Committee and I consider myself fortunate to have being guided by them during my course and research programme.

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Amal Premachandran

DEDICATED TO

MY PARENTS

MY ADVISOR

TEACHERS

FRIENDS

FARMERS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

1. INTRODUCTION

Banana (*Musa* spp.) is the most important of all the world traded tropical fruits. About 70 million people directly depend on *Musa* fruits particularly for their daily carbohydrate requirement (Swennen and Wilson, 1983). Moreover, it is the staple food of most of the African countries. All parts of the crop find some use or the other; the male bud is used for culinary purposes, its leaf is used as a plate, its underground corm is used for religious rituals and rites and processing, the pseudostem finds extensive use both in culinary and medicinal preparation and for extraction of fine quality fiber. A critical look on the area under banana cultivation will reveal that the data has never displayed a retrogression, the present global area under the crop is 154.94 lakh ha with an annual production of 1132.8 lakh MT (FAOSTAT,2016). In India 8.46 lakh ha of land is confined to banana cultivation that stretches from southern Tamil Nadu and Kerala to Madhya Pradesh in central India and from Maharashtra and Gujarat in the West to Bihar, Assam and North Eastern state on the other side, and the annual production of 291.24 lakh MT (FAOSTAT, 2016). In Kerala the crop occupies an area of 1. 29 lakh ha with an annual production of 89.87 lakh MT (AGRISTAT,2017).

Nendran (*Musa* spp. AAB) belongs to the French plantain group and is the most preferred cultivar in Kerala due to its ideal blend of sugar and acid that makes it a unique choice both as a fresh fruit and as a boiled fruit for breakfast all over the state. Kerala is well known for its great diversity of *Musa* spp and the home gardens of Kerala are a natural gene pool particularly of 'AAB' types that showcases the rich biodiversity in its natural form. Nendran has a unique place in a Keralite's life right from the beginning as a culinary weaning food (baby food), in the unripe form as a vegetable and in the ever-expanding chips industry and finally in the ripened form both for table consumption and as banana figs.

Edible bananas are both sterile and parthenocarpic (Heslop-Harrison and Trude, 2007). Hence, they are seedless and propagated repetitively using suckers. Shortage of healthy and improved planting material is a major constraint for the increased expansion of area under banana cultivation. Several rapid multiplication techniques including *in vitro* propagation protocols have been standardized in banana. While *in vitro* methods provide a

rapid means of propagation, it is capital intensive, skill oriented, cumbersome and there is also natural occurrence of soma clonal variation (Kasyoka *et al.*, 2010). The prohibitive cost of production makes it also beyond the reach of small and marginal farmer. Another major deficiency of tissue culture plant was that it is sensitive to biotic and abiotic stresses. Tissue culture derived plantlets lack the natural protective mechanisms like the epiculticular wax, a properly developed epidermal layer of the leaf and a very poorly developed basal corm which makes it wind prone besides, the practical difficulty of establishment in marginal and poor soils.

Farmers generally rely on natural regeneration of existing mats/clumps for suckers (Kasyoka *et al.*, 2010; Ocimati *et al.*, 2013) which is a relatively slow process and most often do not yield adequate number of suckers from the desired mother clump (Manzur, 2001; Kasyoka *et al.*, 2010).

In vivo macropropagation is an alternative technique for rapid multiplication of bananas, plantains which is relatively simple, cost effective and provides pest and disease free true to type planting materials in a short period. Further in this genus some varieties are not that responsive to the *in vitro* method of propagation thus leaving a threat to its very existence. The only way to overcome this is by *in vivo* macropropagation.

The quality of the planting material is of paramount importance in successful crop production (Tenkouano *et al.*, 2006). The high demand of the Nendran planting material in Kerala is often met from the flow across the borders from neighboring state often forsaking quality aspects and even overlooking quarantine issues. Different techniques have been attempted for activation of new suckers. However, a comprehensive macropropagation technique to produce quality planting material in Nendran is of utmost importance and the imperative need of the hour.

Hence, this study was undertaken with the prime objective of standardizing the bud activation/ invigoration technique leading to efficient sucker production. Another objective is to identify the ideal potting/ grow bag media preferably using locally available materials and favoring multiplication of the sucker at a rapid rate. The third objective was to study the

efficacy of the application of biofertilizers particularly *Glomus fasciculatum* and *Azospirillum* in macropropagation as this has already been proven to have positive effect on the growth and yield of banana. The fourth aspect of the investigation was to study the effect of micronutrients boron and zinc in macropropagation and this was based on the concept that these two are the important elements in the bud growth.

The final outcome of this project will be in terms of standardization of a cost-effective mass multiplication macropropagation technique in Nendran banana, without any compromise on quality aspects.

Review of Literature

2. REVIEW OF LITERATURE

Vegetative propagation techniques can broadly be classified into two major groups namely a) Macropropagation and b) micropropagation or *in vitro* techniques. Within macropropagation there are many methods that are commonly adopted depending on the crop, ease of applying the technique and the success rate.

Banana is commercially propagated using both macro and micropropagation methods. In case of the former the suckers or more precisely the "sword suckers" are the best and most accepted type of planting material. Production of healthy, disease free suckers has been an aspect of focus in *Musa* research. Analysis of the available literature reveals that the large chunk of the research work carried out have been skewed towards *in situ* regeneration of suckers from mother clump. In all these works decapitation or false decapitation techniques at various physiological stages was carried out followed by adoption of various physical, cultural, hormonal and manurial methods for sucker initiation and activation. Another area which has received adequate attention is both the internal and external factors governing sucker production. These aspects have extensively been reviewed recently by Bhende and Kurien, (2016). However, this review chapter does not dwell on the above aspects as it falls outside the realm and scope of the present investigations.

Two methods are generally followed in case of macropropagation or in the case of detached method of propagation in Banana. They are a) Excised bud techniques- i.e. planting the excised buds in grow bags and raising them to the level of good planting material (Lopez,1994) and b) the detached corm multiplication techniques.

The focus of this research project is on the detached corm multiplication technique which has almost become synonymous to macropropagation in banana.

2.1. Macropropagation

Macropropagation is a practical method of plantlet production that was first initiated in Africa to address the huge demand for quality planting material of bananas. The initial works on macropropagation done in Cameroon and Nigeria gained the farmers approval and confidence and of later has spread to other West African nations including Ghana and Ivory Coast, and to Uganda, Rwanda and Tanzania in East Africa (Lefranc *et al.*, 2010). The International Institute of Tropical Agriculture (IITA) is currently on the lookout for elective methods of producing planting material for wide-scale distribution of improved banana and plantain cultivars.

. Reports from the early publication shows that the terminology 'Macropropagation' is not used but similar kind of work have been preceded. Propagation of bananas is difficult because of the absence of seeds, strong apical dominance and the prevention of bud emergence by tightly pressed leaf bases. Position in the pseudostem and the number of leaves exposed were the most reliable guides for the location of the concealed terminal bud. Destroying the terminal bud with a modified core borer increased the sprouting of suckers useful for multiplication. The number of suckers was also influenced by the time of bud removal, the number of functional leaves exposed, and competition for light and nutrients (Ortiz and Fierro, 1976).

A well- developed banana or plantain corm contain several axillary buds, which essentially host meristem of different ages and stage of development (Kwa, 2003). Sword-sucker- corm as well as corm from prior to flowering and harvested plants could be used in detached corm multiplication technique (Faturoti *et al.*, 2002; Tenkouano *et al.*, 2006).

Detached corm multiplication technique could be using whole-corm or split corm. In split corm technique the roots of the dugout corm are removed and overlapping leaf sheath are removed to expose lateral buds, the corm is split into several pieces (bits). These bits are placed face down in an organic matter. Bonte *et al.,* (1995) performed similar experiments to yield 20 new suckers from a single corm weighing 4 Kg. In whole corm technique apical meristem are scarified either by making two cross wise incision on the bud (Kwa, 2003; Tenkouano *et al.*, 2006) or by mechanical removal by screwing up with sharp knife in other

words called as macropropagation (Baiyeri and Aba, 2005). Scarification of lateral buds have full potential to increase the sucker production by a factor of 12- 20 (Tenkouano *et al.*, 2006).

In macropropagation, the apical dominance is suppressed mechanically to stimulate lateral bud development and thereby increase suckering rate (Farouti *et al.*, 2002). This leads to production of plantlets of high quality and at affordable rates. The technique is inexpensive and materials for constructing the growth chambers, if at all necessary can be sourced locally. Such plantlets have uniform size and they tolerate post establishment stress much better than tissue culture plants (Tenkouano *et al.*, 2006). Different methods of macropropagation have been utilized around the world for bananas. Many of these methods use some form of technique that basically break the apical dominance of the banana in order to promote axillary growth. Disrupting the apical meristem suppresses the production of auxin at this point, thereby allowing the growth of the axillary buds (Arinaitwe *et al.,* 1999). Apical dominance exerted by the mother plant, influences control over suckers, regulating both the number of sucker and their development. Hence macropropagation techniques have tended to basically focus on mechanical damage of the apical meristem or application of appropriate growth regulators.

Macropropagation techniques, although genotype dependent, can produce 8-15 new plants/corm within 15 days. Plantlets thus obtained have the uniformity of micropropagated plantlets while being less prone to post-establishment factors in the field. This method is simple and cheap, although it requires some minimum investment to set up propagators with good training and weaning facilities, so it is suitable for small- and medium-scale enterprises Further it has the potential to increase access to affordable high-quality seedlings (Njukwe *et al.*, 2013). A study conducted for improving multiplication and sucker growth of French plantain cv. 'Itoke Sege' through *in vivo* micropropagation resulted in giving more number of suckers by combining macropropagation with BAP at 1.5 mg L^{-1} (Kindimba and Msogoya, 2014).

The PIBS (*plants issus de bourgeons secondaires*) (plants production from secondary buds) is the latest *in vivo* technology developed to optimize sucker production (Kwa, 2002). Like all other plants each plantain leaf bears an axillary (primary) bud at the

point of overlapping of the leaf sheath. However, the architecture of the plant is such that several secondary buds occur along the entire length of the base of a leaf sheath (Kwa, 2002). Most of these buds remain dormant and never become suckers in the lifetime of the plant. These dormant buds have the potential to be activated to produce healthy planting materials within a short time. The whole capability of the corms and suckers could in this manner be exploited to deliver huge amounts of solid planting materials within a brief period. However, information on the amount of healthy planting materials that could be produced from an average sucker is scanty. A close morphological observation of sucker shows that each leaf scar on the corm, in addition to carrying a primary bud, also has several latent secondary buds that will never have developed into daughter suckers (Swennen and Oritz.,1997). Dzomeku *et al.*, (2014) showed that four varieties in South Africa namely French plantain cultivar (Oniaba), Apantu (False Horn), FHIA-21 and Asamienu (True Horn) produced an average number of 20 ,75, 85 and 90 healthy planting materials respectively through PIBS. Further results also revealed that the leaf scar carries a primary bud at the intersection of each leaf sheath and several eyes along the entire length of the leaf sheath which could not have developed into suckers. However, with this technique the eyes could be activated to sprout as healthy planting materials. The technique proved as an efficient method of multiplying healthy planting materials for plantain and could thus be recommended for adoption not only by peasant farmers but also to others who could become commercial plantlet producers. In a study coupling macropropagation with BAP (Benzyleaminopurine) applications to the corm at different concentration revealed that 40.0 mg L^{-1} gives maximum number of suckers at minimum number of days (Thiemele *et al.*, 2015).

Multiplication from stems (*multiplication sur souches décortiquées* MSD) is one of the *in vivo* macropropagation technique. This method exploits the entire potential of the corms to produce large quantities of healthy planting materials within a short period from secondary buds (Kwa, 2003; Njukwe *et al.*, 2005; Msogoya and Mwakisitu, 2014). The MSD method was considered of great potential to contribute to improved quantity and quality of planting material. This method is very useful in making more planting material

available of newly introduced cultivars or for increasing the planting material of superior mother plants of preferred local cultivars. (Lefranc *et al.*, 2010).

Langford *et al.*, (2017) made studies on the effectiveness of macropropagation with the objective of generating supply of pseudostem as a source of food for pigs suggested that temperature and time of year may play a crucial role in the macropropagation of bananas. Macropropagation technique increases seedling availability and the propagation method is farmer friendly. It relies on simple cost-effective methodology that could be easily implemented with good training and fewer resources than are required with other propagation methods. The nurseries can be located near the farmers thus eliminating transport costs and reducing cost of seedlings significantly (Sengendo *et al.*, 2006). Therefore, research is needed to assess the effectiveness of the technology in producing healthy seedlings to enhance its adoption by farmers.

Another striking feature of the macropropagation is that banana plantlets produced through macropropagation benefit from the endophytes in the corm. Tenkouano, *et al.*, (2006) found that such plantlets are less prone to post-establishment stress and loss in the field. This beneficial aspect of the presence of this microorganism is not observed in Tissue culture plantlets. Thus, they are sensitive to pathogenic attack. Studies of Njau *et al.*, (2011) revealed that less than one per cent of the corms in all the study sites rotted and thus support the above contention.

2.2. Hormones and macropropagation

Hormonal activity is the key feature in the sucker initiation and development. GA_3 has been reported to influence the formation of conical shoots, whereas bud initiation depended on a high cytokinin/auxin ratio. Root initiation and variable root growth around the stock could affect bud distribution and subsequent bud development in the cv. Agbagka (De Langhe *et al.*, 1983). Further studies performed by Barman and Das, (2002) reported that GA_3 at 200 ppm had increased sucker production. Sucker growth rate is regulated by GA_3 and GA_3 production is regulated *Ad* gene. Apical dominance in plantain is controlled by major recessive *ad* gene. While *Ad* gene improve the suckering behavior of the plantain-banana hybrid. The *Ad* allele has genetic specificity, incomplete penetrance and variable

expressivity which effect the height of the tallest sucker at both flowering and harvest of the mother plant (Ortiz and Vuylsteke, 1994).

Another class of growth regulator used for macropropagation is the cytokinins. Cytokinins are substances which, in combination with auxin, stimulate cell division in plants and which interact with auxin in determining the direction that differentiation of cells takes (Wareing and Phillips, 1970). Macropropagation coupled with BAP (Benzyleaminopurine) application to the corm at different concentration found that 4 ml of 40 ppm resulted a bud proliferation and obtained 4 bud average in first and second cycle while an average of 13 obtained in third generation (Thiemele *et al.*, 2015).

In an interesting field study conducted by Kurien, (2008) to reduce the height of the sucker by using different hormone though a stem injection to psudostem found that BA, among many other hormone and combination (GA and IAA at 250, 500 and 750 ppm), gave more number of sucker but unfortunately all remained underdeveloped.

2.4. Genomic influence in macropropagation

The genomic groups also show the difference in their yield to the macropropagation. The ABB 'beer' types generally had lower yields, while the plantains had the highest yields of suckers (Ntamwira *et al.,* 2017). In a study of cultivar effects on harvested plantlets obtained through macropropagation, conducted by Kwa, (2003), showed difference in dessert cultivars and plantain cultivars 'Grande Naine' (dessert AAA) which produced lower number of plantlets compared with that of plantain (AAB) cultivars. There is strong evidence that cultivars with a high apical dominance (e.g., most AAB plantains) and corresponding inhibited suckering (i.e., very few large suckers are produced before flowering of the mother plant) produce a larger number of plantlets under macropropagation compared with *Musa* cultivars that have an un-regulated suckering ability after the removal of the apical meristem (Swennen and Vuylsteke, 1991; Ortiz and Vuylsteke, 1994). One study available on Cavendish group proved that this method is effective by giving more suckers (Njau *et al.,* 2011).

Though there exist different banana macropropagation techniques, there are still many questions and challenges regarding the science and practicality of these various methods, especially regarding climatic conditions, the feasibility of properly suppressing the meristem, and premature rotting of corms (Njukwe *et al.,* 2013).

2.5. Anatomical studies on the genesis of sucker

The true stem of the banana plant is either somewhat or entirely underground, and hence is often technically referred as a 'tuberous rhizome'. Bananas do not have extended horizontal growth like most rhizomatous crops but, nevertheless, suckers grow successively outwards. Suckers themselves make little beginning even development before they turn upwards. Accordingly, there is much misjudging here on the grounds that the term 'corm' is being utilized as a part of regular speech or on the other hand openly, while others have utilized both the terms rhizome and corm together, essentially trading from one to the next (Bhende and Kurien, 2016). Simmonds, (1987) used the term 'short rhizome' in the botanical description which is now generally accepted.

A critical review of available literature on the sucker origin reveals that research work on the subject is scanty, if not meagre except of a passing mention that its genesis can be in the cortex of the corm (Simmonds, 1960).

The rhizome has very short internodes lined outwardly by closely packed leaf scars. Internally, it's differentiated into the central cylinder and cortex, and the ground tissue is starchy parenchyma. Thus, the rhizome is an important storage organ for sustaining growth of the bunch and also the developing sucker. before flowering, the rhizome accounts for forty-five per cent of the entire dry matter of the whole plant, however this drops to about thirty per cent at fruit maturity, as reserves are redistributed for fruit growth. Bhende, (2016) in their work observed a group of intense mitotic cells in the cortex region which is the genesis or the primordial origin of the sucker. This mitotic activity intensifies and takes a particular shape with one end pointed and the lower end in a convex shape and lies embedded in the cortex. This activity of the cell gets further intensified in a 'U' shape with

the bottom of 'U' embedded in the cortex and upper part making its way into the sub cortex region and gradually is pushed out to the exterior of cortex.

2.6. Grow bag/Potting Media used in macropropagation

The use of soil less media has great advantages. It provides better multiplication of plantlet coupled with better root growth. Sawdust and coir pith alone and in combination could give good pore space and moisture retention capacity. Baiyeri and Aba, (2005) did however showed that sucker corm is the major nutrient reserve for the development of primary plantlets. Parallel results from the study revealed that use of FYM plus VAM as growing media resulted in increasing the primary, secondary and tertiary bud regeneration. The time taken for emergence of primary, secondary and tertiary buds was also earlier in the treatment with FYM plus VAM in the macropropagation of banana (Esakkimuthu and Shakila, 2012). Reports of Rahman *et al.* (2005) and Ali *et al.* (2011) confirmed higher number of banana plantlet production in the potting mixture containing soil and FYM. Study conducted by Geetha *et al.*, (2005) showed that by applying Nitrogen source as coir pith compost along with 75% recommended dose for banana cv. Nendran resulted in maximum sword sucker production.

Selection of an ideal media is of paramount importance as it forms the basic step on which the entire macropropagation technique has to rely on. In the studies Oselebe *et al.,* (2008) using rice hull plus sawdust yielded more number of plantlets and 84per cent got survived in the nursery stage. The use of organic substrate offers a great advantage over conventional soil (Akanbi *et al.*, 2002; Adams *et al.*, 2003). Organic substrates provide better root substrate relation than conventional soil mix, adequate nutrients for the seedlings, less pre-disposal the seedling to soil born pests and diseases, assures better moisture and nutrient management (by minimizing leaching losses) and as well as maintain optimum pH. The nutrient value of nursery mixture could be further improved by incorporating inorganic salt such as rock phosphate, lime and nitrogenous fertilizers during composting (Matthew and Karikari, 1990). Coconut coir dust, commercially known as coco-peat, is an easily affordable growth medium for raising vegetable seedlings in the tropics. Coco-peat is an agricultural byproduct obtained after extraction of fiber from the coconut husk (Abad *et al.*,

2002; Yahaya *et al.*, 2009). Coco-peat has good waterholding capacity, acceptable electrical conductivity and other chemical attributes. It has a pH of 5.2–6.8 which is neutral to slightly acidic. Coco-peat has the ability to store and release nutrients to plants for extended periods of time. It also has great oxygenation properties which is important for healthy root development. The coco-peat is reusable and hence preferred by nursery growers for raising seedlings. It can be combined with any of the normal ingredients and used as a mixer or a stand-alone product. It is available at an affordable price. Decomposed coir pith can also substitute soil or sand in conventional nursery. In Black Pepper the study confirmed that composted coir pith with vermicompost and Trichoderma is an ideal potting medium for nursery (Prasath *et al.,* 2014).

Bunt, (1988) is of the view that nursery substrate must be composted for at least 8 weeks before use. Composting ensures breaking down of large particles and making the availability of nutrients to the plants. Sajith *et al.*, (2014) in his study confirmed that application of biofertilizer (AMF, *Trichoderma viride, Azospirillum, Pseudomonas fluorescen* and *Bacillus subtilis*) and sawdust as media was the best medium for rapid multiplication of banana suckers. However, decomposition of sawdust caused nitrogen deficiency as microflora deplete available nitrogen in the decomposition process (Woolton *et al.*, 1981).

As media development continues world over, a wide range of crop residues, organic wastes and other industrial by-products could be used as nursery potting medium: preference of any should largely be determined by consideration of availability, economics, physical and chemical characteristics (Akanbi *et al.*, 2002)

The physical composition of media also has a profound effect on the supply of water and air to the growing plants (Beardshell and Nichols, 1982), besides anchorage, nutrient and water holding capacity of medium. These physical characteristics of growing medium affect the emergence and vigor of seedling with consequent effect on quality of seedling produced.

In a comparative study with the existing method of macropropagation (wooden plank, nails, thick polythene sheets and sawdust) with the simple and cost-effective technique (garden soil sticks, reeds and mulch) conducted by Ntamwira *et al.,* (2017) showed that both techniques were on par in case of number of plantlets produced and cost of production. The result showed with the technique with soil is a breakthrough in this study comparing with standard method use of saw dust. The media as the soil give same amount of sucker as that of sawdust gave. Soil is easily accessible and available which reduce the production cost in the multiplication, further no marked differences were observed between the plantlet yields and profits obtained from the manure and manure less treatments. The result also showed that new method negatively influences the increasing altitude while positively by increasing temperatures, number of scarified plantlets and corm circumference.

2.7. Biofertilizers in sucker production

2.7.1. Arbuscular mycorrhizal fungi interaction

Arbuscular mycorrhizal fungi (AMF) play a key role in plant performance and nutrition due to their capacity to improve soil mineral uptake (Smith and Read, 2008), particularly enhancing the uptake of the relatively immobile and insoluble phosphate ions in soil, due to interactions with soil bi- and trivalent cations, principally Ca^{2+}, Fe^{3+}, and Al^{3+} (Tinker and Nye, 2000). Soil pH also has great influence on the AMF species diversity in region and it also depend on the availability of phosphorous and it is irrespective of crop and cultivation practices (Vásquez *et al.,* 2017). However, Co-inoculation of *B. subtilis* and *P. fluorescens* have been reported to stimulate plant growth by virtue of rapid colonization in the rhizosphere and better nutrient uptake (Marcia *et al.*, 2010). Further AMF are shown to boost plant nutrition (biofertilizers), however they also interfere with the phytohormone balance of the plant, thereby influencing plant development (bioregulators) and assuaging the effects of environmental stresses (bioprotector). This leads not only to increases in biomass and yield, but also to changes in varied quality parameters (Antunes *et al.*, 2012). One limitation is that AMF can only be grown in the presence of host plants i.e. obligate symbionts (Owen *et al.*, 2015).

A study conducted for improving multiplication and sucker growth of French plantain cv. 'Itoke Sege' through *in vivo* micropropagation resulted in more number of suckers by combining macropropagation with BAP at1.5 mg L^{-1} (Kindimba and Msogoya, 2014). Similar results were also obtained by Sajith *et al,* (2014) during his study on macropropagation in combination with bio-fertilizers, AMF, *Trichoderma, B. subtilis* and BAP that promoted better auxiliary bud regeneration. The study that was continued up to three ratoons of the same crop revealed that AMF and *T. viride* combination recorded the earliest bud regeneration in a short time span of 28.3 days, followed by BAP plus *B. subtilis* in 29.70 days and AMF in 30 days. *Bacillus subtilis* in combination with *P. fluorescens* and *B. subtilis* in combination with BAP and AMF alone or in combination with *T. viride* increased the regeneration efficiency of secondary bud in cv. Bangladesh Malbhog. Similar results have also been reported in wild bananas *Musa laterita* (Dayarani *et al.*, 2013). Co-inoculation of *B. subtilis* and *P. fluorescens* have been reported to stimulate plant growth by virtue of rapid colonization in the rhizosphere and better nutrient uptake (Marcia *et al.*, 2010).

In a field study conducted in Nendran with IBA plus *Bacillus subtilis* and Saw dust plus AMF plus BAP plus *Bacillus subtilis* along with micronutrient, pseudostem height, girth and number of leaves has shown an increase. Production of suckers in macropropagation using biofertilizer (AMF plus *T viride*) and IBA only have been reported to be increased in banana CV. Bengal Malbogh (Sajith *et al.,* 2014). Manivannan and Selvamani (2014) showed that 100 per cent RDF through inorganic fertilizers plus biofertilizers found to increase the psudostem girth and height. A combined application of bio-fertilizers and bio-control agents with organic manures and inorganic fertilizers (100per cent Recommended dose of fertilizers plus Arbuscular mycorrhizal fungi plus *Azospirillum* plus phosphorous solubilizing bacteria plus *T. harzianum*) on tissue cultured banana cv. Grand Naine resulted in maximum sucker production (Hazarika *et al.*, 2015). In an experiment with plant growth promoting rhizobacteria (PGPR) strain *sp7* and UPMB 10 with minimal nitrogen source has shown the positive effect on the nutrient absorption and act as bioenhancer growth and yield of banana plant (Baset *et al.*, 2010).

2.7.2. Azospirillum interaction

Application of nitrogen fixers enhance the growth and development of the plant. Azospirillum will be metabolically versatile and can grow vigorously in the presence of nitrogenous compounds in the soil, but as soon as the external nitrogen supply is exhausted the bacteria switch to diazotrophy (Rivera-Cruz *et al.,* 2008). Research conducted at NRC Banana Trichy show that AMF alone or in combination with *T. viride*, *Azospirillum* in combination with IBA and *B. subtilis* in combination with BAP were the suitable treatments for better bud regeneration in primary, secondary and tertiary ratoon stages of banana. Further combined inoculation of *Azospirillum* plus *Phosphobacterium* (*Bacillus megaterium* var phosphoticum) plus AMF (*Glomus fasciculatum*) showed higher root length. It was also noted that tertiary buds derived from the treatment combination of IBA and *Azospirillum* showed better root system and survived better during the acclimatization stage (Sajith *et al.,* 2014). These results are in line with the earlier reports indicating that mycorrhizal symbiosis significantly improved banana nutrition even under low fertile soil conditions as the mycorrhizal hyphae are more efficient than roots alone in nutrient uptake and ability to change the root architecture (Uma *et al.,* 2010: Sajith *et al.,* 2014). Study conducted by Rivera-Cruz, *et al.,* (2008) showed that usage of strains of *Azospirillum*, *Azotobacter* and P-solubiliser bacteria along with poultry manure or banana waste as a carrier under greenhouse condition for banana *M. paradisiaca (*AAA) revealed an increase in nitrogen content in shoot. A study conducted by Kavitha *et al*., (2013) showed that combined application of vermicompost, *Azospirillum* (10g) and chemical fertilizer is superior in enhancing the growth and development of the green leafy vegetable specifically *Amaranthus tristis.* A study conducted by Kuppurajendran, (2012) on *Erythrina indica* L, revealed that the individual inoculation of *Azospirillum* (*Azospirillum brasilense)* to the seedlings was found to be the most effective in increasing the growth and biomass.

2.8. Micronutrient and sucker production

Micronutrients are key elements in plants growth and development. These elements play very important role in various enzymatic activities and synthesis. Their acute deficiencies some time poses problems of incurable nature (Kumar and Kumar, 2002).

Micronutrients also help in the uptake of major nutrients and play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity hormone synthesis, nitrogen fixation and reduction (Das, 2003). Among the micronutrients required by banana, iron, zinc and boron are found to be major yield limiting factors in India. Nearly, 5.9, 4.7 and 1.27 kg of Fe, Zn and B, respectively are absorbed per hectare for optimum production of banana based on the total uptake of these micronutrients (Lahav, 1995). In the study of Mandal *et al.*, (2002) a combined spray of Zn (one per cent) and B (0.5 per cent) gave maximum number of suckers in cv. Giant Governor.

2.8.1. Boron and sucker production

Micronutrients are required by plants in minute quantities, although these are very effective in regulating plant growth as they form a part of the enzyme system and thus regulate plant life. Micronutrients like Cu, Zn, Mo, B and Mn are necessary for healthy growth of banana (Srivastava, 1964). Deficiencies of Zn, Cu, Fe and Mo affect the growth and production in Banana in a big way (Charpentier and Martin, 1965). Mandal *et al.,* (2002) observed the beneficial effect of micronutrients and their combination on pseudostem girth over control. The banana plant has rapid growth and requires for its proper development and production, appropriate amounts of nutrients and water in readily available form (Borges and Mallarino, 2006). Improvement in growth of banana plant might be due to enhancement of photosynthetic and other metabolic activities which lead to an increase in various plant metabolites responsible for cell division and cell elongation. Boron increases photo synthetic activity and respiration in plants and thus improves the growth (Lal and Rao, 1954). The low productivity in banana crop can be explained in part due to micronutrient deficiencies. Among the micronutrients, boron (B) stands out in banana cultivation because its functions are linked to the growth of the apical bud and the side (tillers), root formation, the inflorescence emission and fruit filling (Moreira, 1999). Due to this reason only, small amounts of B are normally recommended for the operational ease and efficiency of fertilizer absorption, Moreira, (1999) recommend applying to the rhizome of the "mother plant" of recently harvested or buffed tiller. However, there are no safe doses and recommendations as irrational use by applying below the demand of culture or

overcritical limits can lead to problems related to nutritional imbalance. Nóbrega *et al.*, (2010) reported that for production of sucker of 'Pacovan' it is recommended to prune the mother plant pseudostem with elimination of the rhizome apical meristem and then go in for application of Nitrogen and Boron.

2.8.2 Zinc application and sucker production

The micronutrient commonly found to be deficient in Indian soil is Zn. Beneficial effects on height and girth which may be due to Zinc enhanced the synthesis of auxins in the plants (Bose, 2000). Similar findings have been reported by Ghanta and Mitra, (1993) and Subramanian and Pillai, (1997) in banana, Haque *et al*, (2000) in mandarin orange and Babu and Singh, (2002) in litchi. Further Zinc stimulates photosynthetic activity and its presence is important for protein synthesis. Similar results have also been made in case of banana and other fruit crops by Das and Mohan, (1993), Ghanta and Mitra, (1993), Singh and Rajput, (1976) and Supriya and Bhattacharyya, (1993). Higher sucker production in banana nine months after planting was attained with 40g Zn EDTA along with Manganese, Copper and Borax in the studies of Yadav *et al.,* (2010). Borax along with Manganese, Copper and Zinc treated plants have also been found to reduce flowering and maturity duration in banana by Ghanta and Mitra, (1993) which could be attributed to enhancing effect of zinc in enzymatic reaction, cell division as well as in growth (Supriya and Bhattacharyya, 1993). Another study conducted by Pathak *et al.*, (2011) showed that combined application of Fe (0.5 per cent) and Zn (0.5 per cent) yielded the best response on plant growth in terms of plant height, basal girth of pseudostem, number of leaves produced per plant and minimum duration between emergences of two succession leaves.

Materials and Methods

3. MATERIALS AND METHODS

The study on standardization of macropropagation technique in banana (Musa (AAB) 'Nendran') was carried out at the Department of Fruit Science, College of Horticulture and Banana Research Station (BRS) during 2016 - 2018. Four separate experiments but one as a continuation of the other formed the entire research project. The broad details are as follows.

3.1. Experimental site

The experimental site was at BRS, Kannara. The locale of the study area was situated at 10.53^0 North latitude and 76.32^0 East longitude at an altitude of 60m above mean sea level (MSL). The soil belongs to order Ultisol, Kannara series with pH of 5.5 organic carbon content of 0.9 per cent and electrical conductivity of 0.145 (dS m^{-1}). The first two experiments were with separate potting media and this has been explained in detail under each experiment. The area enjoys a warm humid tropical climate. The experiment was started during 2016.

3.1.1. Experiment I: Standardization of physical aspect of sucker initiation and activation.

3.1.1.1. Experimental details

The experimental material used were corms of healthy sword sucker (3-4-month old) of Nendran (AAB) weighing 1.5 ± 0.1kg that were selected and prepared as per the standard Package of Practices Recommendation of Kerala Agricultural University (KAU, 2016). They were then planted in grow bag containing media of coir pith + sawdust + soil in a common fixed ratio of 2:1:1. The dry weight of media was 20 Kg per grow bag and uniform for all treatments.

3.1.1.2. Treatments of experiment

After removing the debris and roots, suckers were thoroughly washed to remove all plant and soil debris. The outer leaf sheaths were removed, one by one, 2 mm above the corm and from the leaf base with a sharp knife so as to expose all the buds and/or the

meristem. The prepared material was then surface-sterilized for 20 minutes in Carbendazim (0.1 to 0.2 per cent). The buds were then scarified, and the planting material was further air dried for two hours. The meristem was then scooped out and destroyed by using a clean knife or machete by removing the 5 cm diameter growing part in the middle of the pseudostem (IITA, 2012). The sucker was then subjected to incision of 1/4, 1/2, 3/4 depth of the corm as per the envisaged treatment. Further incisions were given at four levels of longitudinal cuts i.e. single cut, double cuts, three cuts, four cuts close to the center of the sucker. Thus, the total number of treatments are a combination of three incision depths and four different number of cuts, which along with an acid treatment and control treatment of no cuts and cutting of apical meristem add up to fifteen treatments in all. Thus, the treatment details were

T_1: single cut of incision up to $1/4^{th}$ of depth of sucker.

T_2: single cut of incision up to 1/2 depth of sucker.

T_3: single cut of incision up to $3/4^{th}$ depth of sucker.

T_4: Two cuts of incision up to $1/4^{th}$ depth of sucker.

T_5: Two cuts of incision up to 1/2 depth of sucker.

T_6: Two cuts of incision up to $3/4^{th}$ depth of sucker.

T_7: Three cuts of incision up to $1/4^{th}$ depth of sucker.

T_8: Three cuts of incision up to 1/2 depth of sucker.

T_9: Three cuts of incision up to $3/4^{th}$ depth of sucker.

T_{10}: Four cuts of incision up to $1/4^{th}$ depth of sucker.

T_{11}: Four cuts of incision up to 1/2 depth of sucker.

T_{12}: Four cut of incision up to $3/4^{th}$ depth of sucker.

T_{13}: Acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion.

T_{14}: Cutting of apical meristem at the base of growing portion.

T_{15}: Control (without any cut).

The treatment was replicated thrice in a completely randomized design (CRD). The study was carried out for a calendar of year (12 months) from the date of planting i.e. 08/10/2016. The newly formed suckers that reached a collar girth of 10cm at 5 cm height above the media or mother corm were detached and planted out in the same media with

same respective treatment enforced. This formed the basis of study of Ratoon-2 (R-2) or cycle-2 studies

From the first experiment the combination of depth of incision and number of cuts or the physical activation of buds are expected to be standardized which ought to form the basis for all further studies.

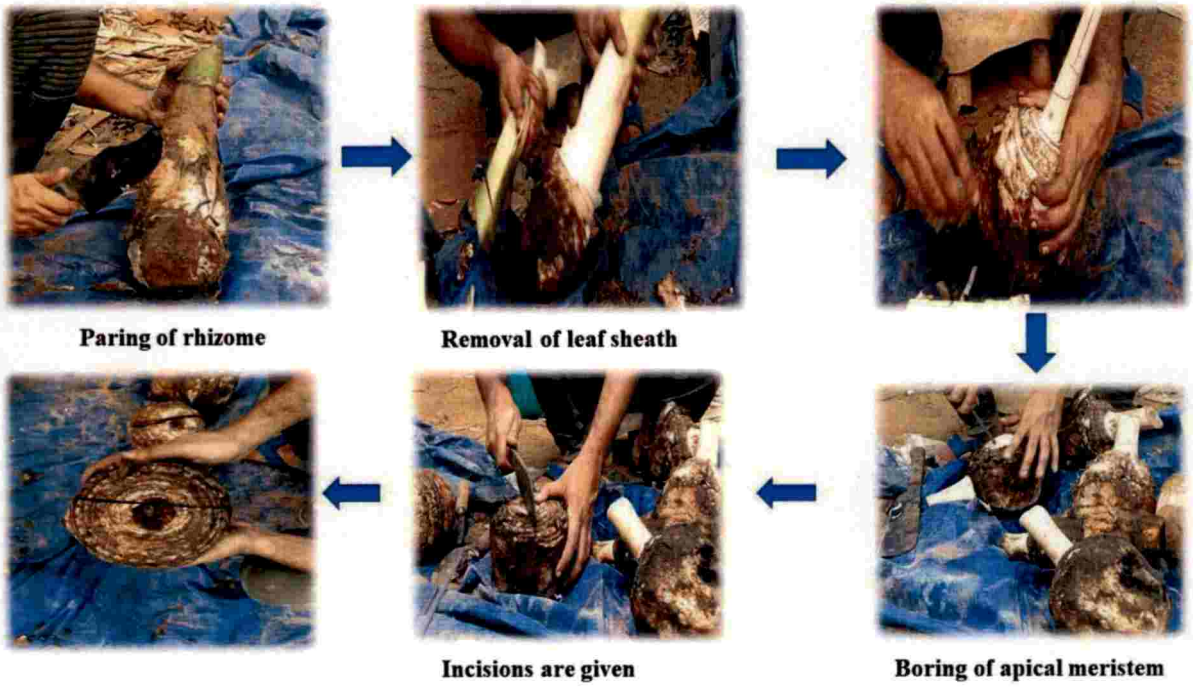


Plate. 1 Preparation of suckers used in macropropagation

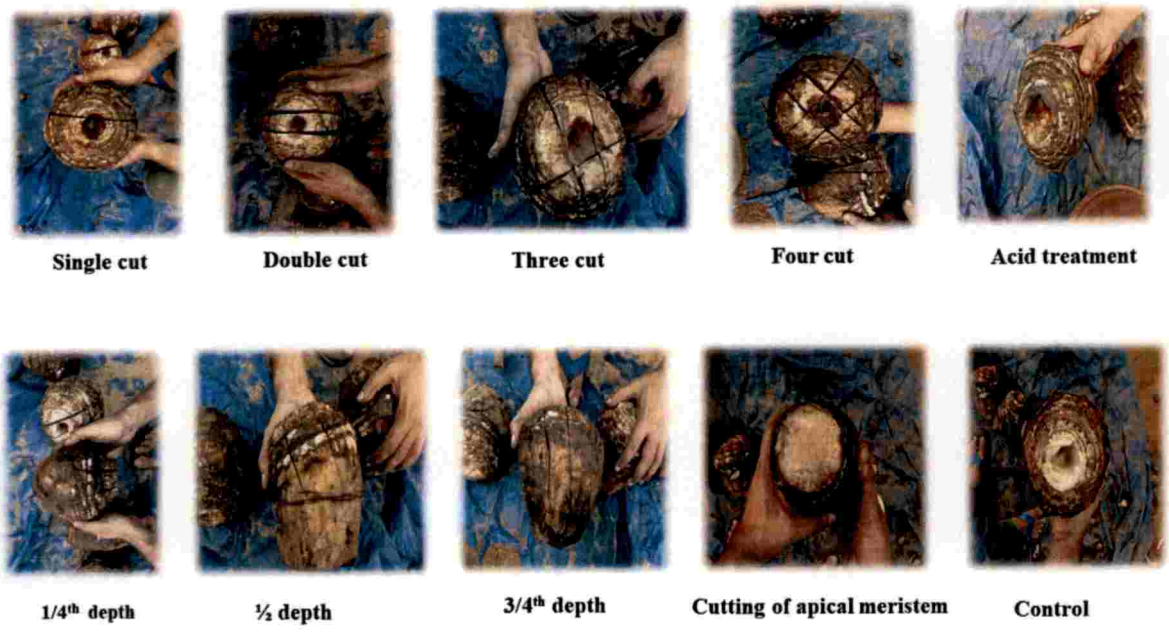


Plate 2. Enforcement of treatments of the first experiment

Plate 3. General view of the first experiment

3.1.2. Experiment- II; Standardizing the grow bag media for macropropagation.

3.1.2.1. Experimental details

The experimental material used were corms of healthy sword sucker (3-4-month old) of Nendran (AAB) weighing 1.5 ± 0.1kg which were selected and prepared as per the standard Package of Practices Recommendation of Kerala Agricultural University (KAU, 2016).

3.1.2.2. Treatments in the experiment

Seven different media combinations plus two treatments of acid treatment and cutting of apical meristem in Red soil media alone along with a control of no cut formed the ten treatments.

The treatment details are as follows (Coir pith: Sawdust: Soil).

T_1: Media composition in proportion as 1:1:1

T_2: Media composition in proportion as 1:2:1.

T_3: Media composition in proportion as 1:1:2.

T_4: Media composition in proportion as 2:1:1.

T_5: Media composition in proportion as 2:2:1.

T_6: Media composition in proportion as 2:1:2.

T_7: Media composition in proportion as 1:2:2.

T_8: Acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion (Red soil only).

T_9: Cutting of apical meristem at base (on growing point on corm) (Red soil only).

T_{10}: Control (Red soil only).

These ten combinations were further tried in a holding potting media of two graded size of 15 Kg and 20 Kg dry weight which thus added up to a total of twenty treatments. From the first experiment the standardized physical activation technique or the best treatment after six months of start of the first experiment *i.e.* acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion and scooping of apical meristem were

uniformly applied to the corm of all the suckers selected for the study except the local control treatment of cutting of apical meristem (T_9 and T_{19}) and control (T_{10} and T_{20}).

The pH and EC (dS m^{-1}) of coir pith were 5.6 and 0.05 respectively and that of saw dust was 6.88 and 0.04 respectively.

The suckers were planted in 10/03/17. The treatments were replicated thrice in completely randomized design. The time period of the study was six months. The newly formed suckers that reached a collar girth of 10cm at 5 cm height above the media or mother corm were detached and planted out in the same media with same respective treatment enforced. This formed the basis of study of Ratoon-2 (R-2) or cycle-2 studies.

From this experiment the best potting media and most effective weight of media were expected to be standardized and which ought to form the basis for the further studies.

Plate 4. General view of the second experiment

3.1.3. Experiment III; Effect of *Glomus fasciculatum* and *Azospirillum. spp* on macropropagation by using banana sucker (Nendran AAB).

3.1.3.1 Experimental details

The materials used were healthy sword suckers (3-4-month old) of Nendran (AAB) weighing 1.5 ± 0.1kg which were selected and prepared as per the standard Package of Practices Recommendations of Kerala Agricultural University (KAU, 2016). The standardized physical activation techniques from the first experiment and the best potting media from the second experiment were taken uniformly taken as a common practice prior to enforcing the treatments in this experiment.

3.1.3.2. Treatments details

Glomus fasciculatum and *Azospirillum. Spp* obtained from Agricultural Microbiology department of Kerala Agricultural University and Biocontrol Lab of Banana Research Station respectively were used as treatments in the study. Before planting the corm of the suckers, the biofertilizers were applied in the polybag 15 cm deep at the time of planting of suckers. The quantity of *Glomus fasciculatum* and *Azospirillum. spp*/ sucker were applied as per the treatments. Three level of input (10g, 20g and 30 g each) of *Glomus fasciculatum* and *Azospirillum. spp* individually (i.e. 6 treatments) and three level each of *Glomus fasciculatum* (10g, 20g and 30 g each) and *Azospirillum. Spp* (10g, 20g and 30 g each) in combination (i.e. Nine treatment) which along with the control formed the sixteen treatments. The treatment details are as follows

T_1: 10g of *Glomus fasciculatum* application per sucker.
T_2: 20g of *Glomus fasciculatum* application per sucker.
T_3: 30g of *Glomus fasciculatum* application per sucker.
T_4: 10g of *Azospirillum. spp* application per sucker.
T_5: 20g of *Azospirillum. spp* application per sucker.
T_6: 30g of *Azospirillum. spp* application per sucker.
T_7: 10g of *Glomus fasciculatum* + 10g of *Azospirillum. spp* per sucker.
T_8: 10g of *Glomus fasciculatum* + 20g of *Azospirillum. spp* per sucker.
T_9: 10g of *Glomus fasciculatum* + 30g of *Azospirillum. spp* per sucker.

42

T_{10}: 20g of *Glomus fasciculatum* + 10g of *Azospirillum. spp* per sucker.

T_{11}: 20g of *Glomus fasciculatum* + 20g of *Azospirillum. spp* per sucker.

T_{12}: 20g of *Glomus fasciculatum* + 30g of *Azospirillum. spp* per sucker.

T_{13}: 30g of *Glomus fasciculatum* + 10g of *Azospirillum. spp* per sucker.

T_{14}: 30g of *Glomus fasciculatum* + 20g of *Azospirillum. spp* per sucker.

T_{15}: 30g of *Glomus fasciculatum*+30g of *Azospirillum. spp* per sucker.

T_{16}: Control (without microbial inoculum)

The suckers were planted on 09/09/17. The treatments were replicated thrice in completely randomized design. The time period of the study was 6 months. The newly formed suckers that reached a collar girth of 10cm at 5 cm height above the media or mother corm were detached and planted out in the same media with same respective treatment enforced. This formed the basis of study of Ratoon-2 (R-2) or cycle-2 studies

Plate 5. General view of the third experiment

3.1.4. Experiment- IV: Standardization of macropropagation technique using micronutrients in Banana Musa (AAB) 'Nendran'.

3.1.4.1 Experimental details

The materials used were healthy sword suckers (3-4-month old) of Nendran (AAB) weighing 1.5 ± 0.1kg were selected and prepared as per the standard Package of Practices Recommendation of Kerala Agricultural University (KAU, 2016). The standardized physical activation techniques from the first experiment and the best potting media from the second experiment were taken uniformly taken as a common practice prior to enforcing the treatments in this experiment.

3.1.4.2. Treatments in the experiment

The micronutrients envisaged in the study were Zn and B. Zn ($ZnSO_4$ $7H_2O$) in concentrations of 0.1%, 0.25% and 0.5%, and B ($Na_2B_4O_7$ $10H_2O$) in concentrations of 0.1%, 0.25 % and 0.5% individually and their combinations which along with a control formed the formed the sixteen treatments. The method of application was by application of the 5 ml nutrient solution directly in to the corm of the sucker by boring 4 holes of 5cm depth adjacent to the center or growing point.

The treatments applied (as nutrient solution) were as follows.

T_1: Application of Zn (0.1%) to the sucker.

T_2: Application of Zn (0.25%) to the sucker.

T_3: Application of Zn (0.5%) to the sucker.

T_4: Application of B (0.1%) to the sucker.

T_5: Application of B (0.25%) to the sucker.

T_6: Application of B (0.5%) to the sucker.

T_7: Application of Zn (0.1%) + B (0.1 %) to the sucker.

T_8: Application of Zn (0.1%) + B (0.25%) to the sucker.

T_9: Application of Zn (0.1%) + B (0.5%) to the sucker.

T_{10}: Application of Zn (0.25%) + B (0.1%) to the sucker.

T_{11}: Application of Zn (0.25%) +B (0.25%) to the sucker.

T_{12}: Application of Zn (0.25%) + B (0.5%) to the sucker.

T_{13}: Application of Zn (0.5%) +B (0.1%) to the sucker.

T_{14}: Application of Zn (0.5%) +B (0.25%) to the sucker.

T_{15}: Application of Zn (0.5%) +B (0.5%) to the sucker.

T_{16}: Control (without micronutrient).

The experiment was laid out in a Completely Randomized Design (CRD) with three replications.

The suckers were planted on 09/09/17. The time frame of the study was six months the newly formed suckers that reached a collar girth of 10 cm and at 5 cm height above the media or mother corm were detached and planted out in the same media and the same respective treatment was enforced. This formed the basis of study of Ratoon-2 (R-2) or cycle-2 studies.

Plate 6. General view of the fourth experiment

3.2. Observations

In all the four experiment the following observation were taken.

a. Number of days to first sprout

Daily observations were taken to correctly quantify the days from planting to first visible emergence of sprout.

b. Number of sprouts retained

Sprouts which were left on the sucker after the removal of quality sucker. Initially daily observation was recorded, which was expressed as number of sprouts emerged per fortnight.

c. Mean of total sucker production

Mean number of total suckers produced from three replication, accounted at the end of the experiments.

d. Total number of new suckers produced

Total number of suckers produced from three replication, accounted at the end of the experiment.

e. Number of new sprouts produced

Initially daily observation was recorded, which was expressed as number of sprouts emerged per fortnight.

f. Number of plantlets planted out

Initially daily observation was recorded, which was expressed as number of sprouts planted out per fortnight.

The observations mentioned below were made on a monthly basis starting from first month and continued till twelfth month.

g. Height of sucker

Height of the plant was recorded from the top of mother corm to the base of the unopened leaf and expressed in centimeters (cm).

h. Collar girth of sucker

The girth of the plant was measured at 5 cm height above from base of pseudostem and expressed in centimeters (cm).

f. Number of leaves

The number of leaves produced were taken at monthly basis.

g. Number of quality suckers produced

The number of quality suckers were based on a visual appearance of sucker and by observing collar girth which.

In additional to the above morphological observations were made at the end of twelfth month.

h. Weight of sucker produced

The weight of the newly developed suckers was weighed by removing the roots and leaving the pseudostem of 5 cm from the base and expressed in grams (g).

I. **Volume of sucker**

The volume of newly developed suckers was calculated by water displacement method and expressed in cubic centimeters (cc).

j. No of roots produced

The number of roots on the suckers were taken by counting of number of primary roots that were from the base of the sucker.

k. Number of under developed suckers at six-month stage and twelve -month stage

Number of under developed suckers at the end of sixth month and twelfth month stage. (in Experiment II, III and IV) were taken.

l. Number of dead suckers

The dead suckers and totally necrotic ones were counted from the beginning of the experiment and were expressed as number of dead suckers.

The Incidence of infestation of banana weevils and virus diseases were also recorded based on the incidence.

In case of first experiment the following additional was taken.

47

m. Carbohydrate content in Mother sucker, Ratoon -1, Ratoon- 2 and Dead sucker

The carbohydrate content of mother corm was analyzed, at the start of the experiment and the end of the experiment. Hundred mg of the sample was weighed into a boiling tube. This was hydrolyzed by keeping it in boiling water bath for 3 hours with 5mL of 2.5 N-HCl and cooled to room temperature. This solution was neutralized with solid sodium carbonate until the effervescence was ceased. Then volume was made up to 100ml and centrifuged. Supernatant was collected and 0.5 and 1mL were taken as aliquots for analysis. Standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1ml of the working standard. 0 serves as blank. Volume was made up to 1mL in all the tubes including the sample tubes by adding distilled water. Then 4 mL of anthrone reagent was added, this was heated for eight minutes in a boiling water bath, and then cooled rapidly and read the green to dark green color at 630 nm. A standard graph by plotting concentration of the standard on the *X*-axis versus absorbance on the *Y*-axis. From the graph the amount of carbohydrate present in the sample were calculated.

In the 3rd experiment on biofertilizer application in additional to the above, following observations were taken.

n. Root length

The length of the root was measured at the 6-month stage of the crop. The length was taken from the base of corm to tip of root and measured in centimeters (cm).

o. Spore count of *Glomus fasciculatum Tul. & C. Tul* in media.

The spore of the AMF inoculated in the soil at the start of the experiment (i.e. 09/09/17) and 6 months after were isolated by modified sieving method as per Gerdemann and Nicolson, (1963). For this, 100 g rhizosphere soil was initially suspended in 1000 ml of tap water in a measuring cylinder and after the heavier particles had settled. The supernatant liquid was passed through a set of sieves of B.S.S No:8 (2000 micron), 16 (1000 micron), 30 (500 micron), 36 (425 micron), 60 (250 micron), 150 (150 micron), and 350 (45 micron). The residue left behind on the measuring cylinder thereafter was resuspended in 1000 ml of fresh tap water and passed through the same set of sieves. This procedure was repeated three

to four times to collect maximum number of spores from the soil. Finally, the materials present on each sieve was transferred to 100 ml beaker in a small volume of water and filtered through Whatman No. 1 filter paper. The content of each filter paper was carefully examined under microscope for the typical spore of *Glomus fasciculatum* and expressed as number of spores per gram of sample.

p. Percentage root colonization for *Glomus fasciculatum Tul. &C.Tul.*

The AMF per cent root colonization was assessed using the method described by Phillips and Hayman (1970). The roots were washed in tap water to remove all the adhering soil particles and cut into bits of 1cm length. The washed root bits were softened by simmering in 10 per cent KOH solution at 90°C for 90 minutes in water bath. After cooling, the excess KOH was washed – off in tap water and then neutralized with two per cent HCl. The root bits were stained with 0.05 per cent tryphan blue for five minutes. Then the root bits were examined under digital microscope for *Glomus fasciculatum* colonization. The *Glomus fasciculatum* colonization percentage was determined using the following formula

$$\text{Per cent root colonization} = \frac{\text{Number of infected root segments}}{\text{Total number of root segments observed}} \times 100$$

q. Population count of *Azospirillum. spp.*

The test tube containing 5. 0 ml Nfb (Nitrogen free bromothymol blue) semi- solid media (Okon *et al.*, 1977) was inoculated with 100µl of appropriate dilution (10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}) of soil suspension and enumeration was performed using the Most Probable Number (MPN) method (De Man, 1975). White pellicle formation and blue colour development in the media were taken as positive for *Azospirillum. spp.* After 30± 2°C, 10 µ of pellicle forming culture was spread of Nfb- solid medium supplemented with ammonium chloride as nitrogen source. Morphologically divergent colonies were picked from the plates and transferred to fresh Nfb semi- solid medium. Colonies that showed white undulation pellicle formation with blue colour development were further purified and preserved and the population was recorded as MPN per gram of sample.

r. Major available nutrient analysis of the media

Composite soil samples were collected before filling in the polybag and they were air dried. The pH, EC (Jackson, 1958) and organic carbon (Walkley and Black, 1934) of the soil was recorded. Analysis of available nutrient (Nitrogen, phosphorous and potassium) were analyzed as per standard procedure. The available nitrogen was estimated by method of Subbiah and Asija, (1956). The available Phosphorus was estimated by Bray and Kurtz method (Bray and Kurtz, 1945). The available potassium was estimated by Neutral normal ammonium acetate method (Jackson, 1958).

In case of 4th experiment in addition to the common observation of plant characters the plant tissue analysis of newly developed sucker (Ratoon -1 or cycle - 1), ratoon- 2 sucker and dead sucker were carried out for major (N, P, and K), Secondary (Mg and S) and Micronutrients (Mg, B, Zn and Fe).

s. Plant tissue analysis of newly developed sucker, ratoon sucker and dead sucker

The plant samples were collected from the third opened leaf from the apex at 6 months after planting. The samples were then dried at 70^{o} C and then it was powdered and subjected to Microwave digestion using nitric acid. The total nitrogen in the plant sample was determined by the Kjeldahl distillation method (Jackson, 1958). The total phosphorus in plant sample was determined by vanadomolybdo phosphate yellow colour method (Bray and Kurtz, 1945). The total potassium was determined by flame photometry (Jackson, 1958). The total sulfur in plant sample was determined by turbidimetry method (Olsen. 1917). The total boron in plant sample was determined using the, inductive coupled plasma - optical emission spectrometry (Perkin Elmer Optima 8000® ICP-OES Spectrometer). The total zinc, magnesium and iron in plant samples were determined with the Atomic absorption spectrometry (Perkin Elmer PinAAcle 500® Flame Atomic Absorption Spectrometer)

t. Statistical Analysis

All the four experiments were in Completely Randomized Design and data after appropriate transformation using square root transformation were analyzed using analysis of variance technique (IARI, Web Agri Stat package (WASP 2.0)) except in number of new suckers produced, planted out and total number of suckers produced.

Results

4. Results

The results of the study on "Standardization of macropropagation technique in banana (*Musa* (AAB) 'Nendran')" are presented aspect wise under each experiment. The findings in all the four individual experiments after imposing the treatments are given for Ratoon-1 or Cycle -1 and Ratoon -2 or Cycle-2 separately given below.

4.1. Experiment I Standardization of the number of cuts and depth of incision for activation of new banana sucker.

4.1.1. Ratoon-1

4.1.1.1. Days taken to first sprouting

The data presented in Table 1 revealed that there are significant differences between means of the treatments T_9 (Three cut of incision up to 3/4 depth of sucker.) followed by treatments T_2, T_3 and T_7 were the earliest to sprout. T_9 took 16 days to sprout whereas treatment T_2 took 18 and T_3 and T_7 took 18.33 days each. The maximum number of days to sprout was recorded in treatment T_{13} and T_8.

4.1.1.2. Number sprouts retained at fortnightly intervals

Analysis of the data in Table 1 revealed that no sprouting occurred in the first fortnight in all the treatments. However, in second fortnight treatment T_9 (Three cut of incision up to 3/4 depth of sucker) followed by treatments T_2, T_3 T_6 and T_7 recorded maximum mean number of suckers retained which were statistically at par and significantly superior over other treatments. In the 3rd fortnight, treatment T_{13} (Acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) followed by treatments T_2 and T_{12} recorded the maximum number of suckers retained. In the 4th fortnight treatment T_{12} followed by T_{13} recorded maximum number of suckers whereas in the 5th fortnight it was treatment T_{13} and T_{12} which retained the maximum and equal number of 5.5 suckers each. In the sixth fortnight treatment, T_{11} (Four cuts of incision up to 1/2 depth of sucker) recorded a mean number of 5.75 suckers which was followed by T_{13} recording 5.5 suckers. Though the maximum number of suckers were recorded in treatment T_{13} from 7th fortnight to the 15th fortnight. the results were statistically significant only in 11th and 12th fortnight. In the 13th

to 18th fortnight another wave of sucker production was observed (Fig 1), and the maximum suckers retained was again in treatment T_{13} followed by treatments T_{10} and T_3. The mean number of suckers retained from 16th to 22nd fortnight did not differ significantly, and mean number of suckers retained was only in the range of 0.5 to 1. However, a third wave of sucker production was observed almost exactly in 23rd and 24th fortnight again (Fig 1) and the treatment T_{13} recorded maximum number of suckers retained, though the differences were not statistically significant.

4.1.1.3. Mean of total sucker production

A critical analysis of the Table 1 again pointed to the superiority of treatment T_{13} (Acid treatment by pouring 5 ml of 1 % H_2SO_4 acid on the apical meristem portion) which recorded maximum of 26.0 suckers followed by treatments T_1, T_{11} and T_{12} which recorded 24.0 number of suckers. The lowest sucker production was observed in treatment T_6. The results were statistically not significant.

Table. 1 Influence of number of cuts at different depth on corm of mother sucker on various aspects of sprouting at R-1 stage.

Treatments			fortnightly interval																					
	No. of days to 1st sprouting	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21th	22nd	23rd	24th	Mean of total No. of suckers
T_1	33 (5.73)	0 (0.7)	5.75 (2.13)	5.25 (2.06)	3.25 (1.93)	3.5 (1.85)	3.75 (1.84)	2.5 (1)	1.75 (1.41)	2.25 (1.54)	2 (1.23)	1 (1.66)	1.25 (1.44)	1.25 (1.05)	1 (1.34)	1 (1.44)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.5 (1.22)	2.75 (1)	2.25 (1)	8 (2.81)
T_2	18 (4.23)	0.75 (1.18)	6.25 (2.15)	5.75 (2.07)	5 (2.04)	3.5 (1.67)	3.5 (1.67)	2.5 (1.38)	2.5 (1.24)	2.5 (1.24)	1.5 (1.22)	2 (2.33)	2.25 (1.34)	0.75 (1.56)	2 (1.56)	1 (1.65)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.75 (1.34)	0.5 (1.22)	2.25 (1.24)	2 (1.24)	6.66 (2.57)
T_3	18.33 (4.26)	0.5 (1.05)	3.5 (1.71)	3.75 (1.71)	3 (1.64)	2.75 (1.64)	2.75 (1.64)	2.5 (1.33)	3.25 (1.72)	3.25 (1.72)	1 (1.17)	1.25 (1.33)	2.5 (1.88)	1 (1.25)	1.25 (1.25)	0.5 (1.17)	0.5 (0.99)	0.5 (0.99)	0.5 (1.18)	0.5 (0.99)	0.5 (0.99)	0.5 (0.99)	2.5 (1.33)	2.25 (1.24)	4.66 (2.15)
T_4	31 (5.56)	0 (0.7)	4.5 (1.98)	4.75 (1.98)	4 (2.03)	3.5 (1.85)	3.25 (1.88)	2.25 (1.38)	1.5 (1.27)	1.5 (1.271)	1 (1.34)	1 (1)	1.75 (1.34)	1 (1.23)	1 (1.34)	0.75 (1.23)	0.75 (1.18)	0.5 (1.18)	0.5 (1.17)	0.5 (0.99)	0 (0.7)	0 (0.7)	2.25 (1.38)	2 (1.38)	4.66 (2.13)
T_5	36 (5.99)	0 (0.7)	5.25 (2.3)	5.25 (2.22)	3.75 (2.41)	3.5 (1.88)	3.5 (1.88)	2.75 (1.55)	0.75 (1.09)	2.25 (1.48)	1 (0.87)	1 (0.7)	2 (1.41)	0.75 (1.17)	1 (1.17)	0.5 (1.09)	0.4 (0.99)	0.5 (0.87)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)	2.25 (1.41)	2 (1.41)	6.66 (2.53)
T_6	20.66 (4.55)	0.5 (0.99)	4.75 (2)	4.5 (1.82)	3.5 (1.76)	3 (1.56)	2.75 (1.56)	2.75 (1.38)	1.75 (1.13)	2.75 (1.27)	1.75 (1.23)	1.25 (1.33)	1.75 (1.23)	1.25 (1.23)	1.25 (1.23)	1.25 (1.23)	1.25 (1.23)	1.5 (1.23)	1.25 (1.23)	1.25 (1.23)	1 (1.05)	1 (1.05)	2.75 (1.38)	2 (1.13)	4.33 (2.06)
T_7	18.33 (4.26)	0.5 (1.05)	5.25 (2.06)	4.75 (1.88)	3.75 (1.84)	4 (1.71)	4 (1.71)	4 (1.55)	2.75 (1.24)	3.25 (1.33)	1.75 (1.59)	2 (3.33)	2.25 (1.46)	1.75 (1.46)	2 (1.71)	1.75 (1.46)	1 (1.44)	1 (1.34)	0.75 (1.34)	0.5 (1.18)	0.25 (0.99)	0.25 (0.99)	4 (1.47)	3.5 (1.47)	7 (2.64)
T_8	36.66 (6.05)	0 (0.7)	5 (2.06)	4.5 (1.9)	2.75 (2.018)	3.75 (2.03)	3 (1.71)	2.75 (1.55)	1.75 (1.33)	1.25 (2.33)	1.5 (1.52)	1.25 (1.34)	1.75 (1.33)	1 (1.44)	1.25 (1.44)	1 (1.44)	0.75 (1.34)	1 (1.44)	1 (1.44)	1 (1.44)	1 (1.44)	1 (1.44)	2.5 (1.47)	1.75 (1.33)	5 (2.2)
T_9	16 (3.97)	1.25 (1.46)	4.25 (1.9)	4 (1.91)	3.25 (1.86)	3.25 (1.85)	3.25 (1.86)	3 (1.57)	1.75 (1.27)	1.75 (1.27)	1.5 (1.58)	1.5 (2)	1.5 (1.46)	1.25 (1.68)	1.5 (1.58)	1.25 (1.58)	1.25 (1.46)	1.75 (1.46)	1.25 (1.34)	1.25 (1.46)	1.25 (1.46)	1 (1.46)	2.75 (1.57)	2.75 (1.57)	5 (2.2)
T_{10}	36 (5.99)	0 (0.7)	4.75 (2.03)	4.5 (1.95)	3.5 (1.74)	3 (1.58)	3.25 (1.76)	2 (1.64)	2 (1.13)	2.5 (1.24)	2 (1.76)	2 (2)	2.75 (1.41)	1.75 (1.76)	2 (1.76)	1.25 (1.76)	1 (1.38)	1 (1.28)	1 (1.28)	1.25 (1.29)	1.25 (1.29)	1.25 (1.28)	2.5 (1.27)	2.5 (1.27)	6 (2.43)
T_{11}	31 (5.56)	0 (0.7)	5.25 (2.42)	5.25 (2.36)	5 (2.42)	5.75 (2.47)	5.25 (2.34)	4 (1.86)	2 (1.33)	2 (1.33)	1 (1.38)	1 (0.33)	1 (1.29)	0.4 (1.29)	0.4 (1.29)	0.5 (0.87)	0.5 (0.99)	0.5 (0.99)	0.5 (0.994)	0.5 (0.99)	0.5 (0.99)	0.5 (0.99)	4 (1.86)	3.25 (1.66)	8 (2.83)
T_{12}	20.66 (4.55)	0.25 (0.99)	6.25 (2.66)	6.5 (2.62)	5.5 (2.44)	5.25 (2.44)	4.25 (2.24)	4 (1.95)	2.25 (1.48)	2.25 (1.48)	1.5 (1.52)	2 (1.33)	2.25 (1.46)	1.25 (1.66)	2 (1.66)	1.25 (1.44)	1 (1.44)	1.5 (1.44)	1.25 (1.27)	1 (1.44)	1 (1.44)	0.75 (1.44)	2.75 (1.62)	2.25 (1.55)	8 (2.83)
T_{13}	38.66 (6.21)	0 (0.7)	6.5 (2.48)	6.25 (2.39)	5.5 (2.21)	5.5 (2.21)	5.5 (2.21)	5.5 (2.07)	4 (1.95)	4.5 (2)	4 (2.38)	3.25 (3.33)	4 (1.89)	2.5 (2.18)	3.25 (2.18)	1 (1.95)	1 (1.34)	1 (1.34)	0.25 (1.34)	0.5 (0.88)	0.5 (0.87)	0.5 (0.87)	5 (2.076)	4.75 (2.02)	8.66 (2.93)
T_{14}	35 (5.91)	0 (0.7)	3 (2.30)	2.75 (2.23)	2.5 (1.79)	2.25 (1.72)	2 (1.64)	2 (1.48)	1 (1.13)	1.25 (1.27)	0.25 (0.87)	0.25 (0.7)	1.25 (1.27)	1 (1.58)	0.4 (0.87)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.87)	0 (0.7)	0 (0.7)	0 (0.7)	1.75 (1.48)	1.25 (1.27)	6 (2.39)
T_{15}	32.33 (5.68)	0 (0.7)	5.25 (2.22)	4.5 (2)	3.75 (1.77)	3.25 (1.66)	3.5 (1.88)	4 (1.38)	2 (1.57)	2.75 (1.33)	1.25 (1.26)	1.25 (1.26)	1.25 (1.26)	1 (1.35)	1.25 (1.26)	0.75 (1.35)	0.5 (1.18)	0.5 (1.18)	0.25 (1.05)	0.25 (1.05)	0 (0.7)	0 (0.7)	2.5 (1.38)	2.75 (1.38)	6.33 (2.49)
F value	27.22	3.12*	0.69^{NS}	0.75^{NS}	0.59^{NS}	0.71^{NS}	0.45^{NS}	0.57^{NS}	0.48^{NS}	0.36^{NS}	20.7*	2.28*	1.66^{NS}	1.30^{NS}	1.09^{NS}	1.89^{NS}	1.05^{NS}	1.42^{NS}	0.91^{NS}	1.55^{NS}	1.46^{NS}	1.2^{NS}	0.54^{NS}	0.5^{NS}	1.82^{NS}
CD (0.01)	0.60																								
CD (0.05)	0.45	1.91									0.67	1.98													

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.1.4. Number of new suckers produced at fortnightly intervals

The data regarding the total number of new suckers (total of all replicates) produced presented in Table 2 revealed that there was no sucker production in the first fortnight. However, in the second fortnight treatment T_9 (three cuts of incision up to 3/4 depth of sucker) followed by treatment T_2 produced more number of suckers. Among the fortnights, the 3rd fortnight showed the most vigorous suckering tendency in all the treatments. The treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) recorded the highest number of 19.0 suckers from 3 replication followed by treatments T_{15}, T_{10} and T_7. In the 4th fortnight also vigorous suckering was observed in treatments T_{12} (four cuts of incision up to 3/4th depth of sucker) and T_{11} (four cuts of incision up to 1/2 depth of sucker). In the 5th ,6th ,7th ,8th ,9th ,10th, 11th and 12th fortnight practically no suckering was observed in most of the treatments, but isolated cases of suckering were observed in 6th and 8th fortnight in case of treatmentsT_{10}, T_5 and control and 12th fortnight in treatments T_3 and control. In case of 13th, 14th, and 16th fortnight a second wave of suckering was observed in almost all treatments except in control, treatments T_{11} and T_3. In the 17th fortnight also suckering was observed to maximum of 2.0 in treatment T_2 followed by T_5, T_{13}, T_{11}, T_{10}, T_8, T_9 and T_{14} which recorded one sucker each. In the 18th fortnight suckering was observed only in treatments T_7 and control whereas in 19th fortnight suckering was observed in treatments T_1 and T_2 and in 20th fortnight it was only in treatment T_1 and T_{11}. From the 23rd to the 24th fortnight again suckering was observed which ranged from 1.0 to 2.0

4.1.1.5. Number of plantlets planted out

The data regarding the number of plantlets planted out presented in Table 2 revealed that the planting out was first recorded in treatment T_7 (three cuts of incision up to 1/4th depth of sucker) in the 4th fortnight. In the 5th fortnight except in four treatments (T_3, T_4, T_9, T_{11}) planting out of either 1.0 or 2.0 plantlets could be done, but it was in the control (without any cut) that the maximum number of 3.0 plantlets were planted out. In the 6th fortnight maximum number of 5.0 plantlets were planted out in treatment T_{14} (cutting of apical meristem at the base of growing portion) which was followed by T_{12}, T_{10} and control.

In the 7th fortnight treatment T_5 (two cuts of incision up to 1/2 depth of sucker) yielded 6.0 plantlets for planting out which was followed by T_2. In the 8th and 9th the maximum number of 3.0 plants were planted out. In former fortnight it was treatments T_{12} and T_8 whereas in latter fortnight treatments T_4, T_5 and control yielded 3.0 plantlets. In the 10th fortnight 6.0 plantlets were planted out in treatments T_{11} (Four cuts of incision up to 1/2 depth of sucker) and 4.0 in case of T_{12}. In case of 11th fortnight, 2.0 plantlets were planted out in treatments T_{14} (cutting of apical meristem at the base of growing portion) and T_{11} whereas in the 12th fortnight it was 5.0 followed by 3 in 13th fortnight. Treatments T_{13} and T_6 had 2.0 plantlets each for planting whereas in 14th fortnight treatment T_5 yielded 7.0 plantlets for planting out. In 16th fortnight maximum number of 5.0 plantlets were planted out in treatment T_7 (three cuts of incision up to 1/4th depth of sucker) followed by 3.0 in treatment T_8. In 17th fortnight treatments T_3 and T_6 and in 18th T_4, T_6 and T_9 one plantlet each were planted out. In 19th fortnight maximum number of 3.0 plantlets that were planted out was in treatments T_7, T_{11}, T_{12} and T_{13} respectively. In case of 20th fortnight the maximum number of 6.0 plantlets that were planted out was in treatment T_{13}. From 22nd to 24th fortnight again more number of plantlets were planted out with the maximum in treatment T_{13} (3.0) and one each in treatments T_1, T_3, T_4, T_5, T_6, T_7, and T_{14}.

A critical analysis revealed that suckering habit started by the 2nd fortnight which was intense in 3rd and 4th fortnight and thereafter there was practically no suckering observed till 13th fortnight. From 13th to 18th fortnight again a spurt in sucker production was noticed and in 23rd and 24th fortnight again another wave of suckering occurred. The first wave of suckering was more intense, and second wave occurred after plantlets produced in the first wave were detached for planting out (Fig 1).

4.1.1.6. Total number of new suckers produced

From the Table 2 it is very clear that the maximum number of 26.0 suckers in a calendar year was produced in treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) followed by 24.0 each in case of treatments T_{11}, T_{12} and T_1 with the control (T_{15}) and local control (T_{14}) recording 19.0 and 18.0 plantlets each. The

lowest number of plantlets (16) were produced in treatment T_6 (two cuts of incision up to $3/4^{th}$ depth of sucker).

Figure 1. Waves of suckering at R-1 stage in calendar year of selected treatments as influenced by number of cuts given at different depth.

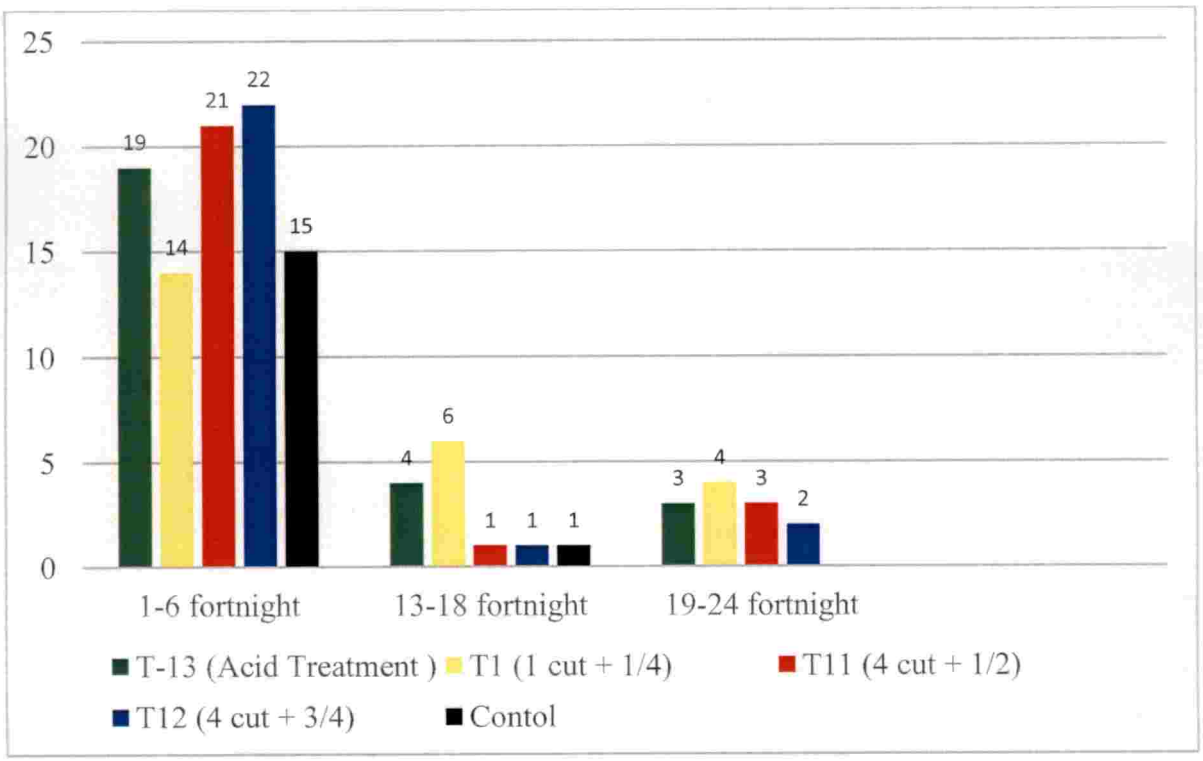


Table 2. Effects of number of cuts at different depths on corm of mother sucker on total sucker production, sucker production and detachment of suckers at fortnightly intervals at R-1 stage.

Treatments	Total number of suckers produced at fortnightly intervals																					
	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	Total No. of suckers
T_1	0	9	5	0(1)	0(3)	0(1)	0	0(5)	0	0	0	2	2	0(5)	2	0	0(3)	1	1	0(2)	0	2	0(1)	24
T_2	3	11	0	0(1)	0(2)	0(3)	0	0(1)	0(1)	0	0	0	0(2)	2	0(3)	2	0	1	0(1)	0(1)	0	2	0	20
T_3	2	6	1	0	0(2)	0	0	0(1)	0	0(1)	3	0	0	0(6)	0	0(1)	0	0(1)	0(1)	0	0	2	1(1)	14
T_4	0	11	1	0	0(1)	0(2)	0	0(4)	0	0	1	0(4)	0(1)	1	0(1)	0	0(3)	0	0	0	0	1	0(1)	14
T_5	0	12	4	0(1)	1	0(4)	1	0(2)	0(1)	0	0	1	0(3)	0(1)	1	1	0	0(1)	0(1)	0(1)	0	2	1(1)	20
T_6	2	8	1	0(1)	0(2)	0	0	0	0(1)	0	1	0(2)	0(1)	0	0	0	0(1)	0	0	0	0	1	0(1)	13
T_7	2	13	0(2)	0(2)	0(2)	0(1)	0	0	0(1)	0	0(2)	1	1	1	0(3)	0	2	0(3)	0	0(1)	0	2	0	21
T_8	0	8	3	0(2)	0	0	0(3)	0	0(1)	0(1)	0	0	0	1	0(6)	1	0	0	0(4)	0	0	2	0	15
T_9	5	5	1	0	0(6)	0	0	0(1)	0	0	0(5)	0	1	0	0(1)	1	0(1)	0	0(2)	0	1	1	0	15
T_{10}	0	13	0	0(1)	0(4)	0(2)	2	0(2)	0(1)	0	0(1)	1	1	0(2)	1	1	0	0	0(3)	0	0	2	0(1)	18
T_{11}	1	12	8	0	0(1)	0	0(1)	0(1)	0(6)	0(2)	0(2)	0	0	0(3)	0	1	0	0(3)	1	0	1	1	0	24
T_{12}	0	9	13	0(1)	0(4)	0	0(3)	0(1)	0(3)	0(1)	0	0	0(2)	1	0(2)	0	0	0(3)	0	0	0	2	0	24
T_{13}	0	19	0	0(1)	0(3)	0	0	0	0	0(1)	0(2)	1	0	2	0(6)	1	0	0(3)	0(4)	0	0	3	0(3)	26
T_{14}	0	12	2	0(1)	0(5)	0(1)	0(1)	0(1)	0	0(2)	0(1)	1	0(2)	0(1)	0	1	0	0(1)	0	0	0	2	2(1)	18
T_{15}	0	15	0	0(1)	0(2)	0	1	0(1)	0	0	1	0(1)	0(1)	0	0(1)	0	1	0	0(1)	0(1)	0	1	0	19

Values in the parenthesis show the number of detached suckers

4.1.1.7. Height of the sucker retained

The mean height of the plantlet actually retained are presented in the Table 3 and was measured to give an idea of the quality of plantlet produced. However, the detachment of the quality plantlets (suckers) as and when they reached a planting out stage caused a dip in mean height in case of some treatments as the data was of only the remaining retained plants. In the first month sucker was observed only as peepers with only treatments T_3 (single cut of incision up to $3/4^{th}$ depth of sucker) and T_2 (single cut of incision up to 1/2 depth of sucker) showing mean height of 6.5 and 5.0 cm which was statistically significant. Thereafter up to 120 days there was progressive growth in height which was significant only at the end of 4^{th} month. This data is of no significance as detachment of the sucker started after two and half months of planting. However, the range of average height varied from 22.0 to 40.0 cm showing that plantlets produced were healthy. Thereafter a progressive growth in height was observed up to 210 days. During this phase there were detachment but those that retained showed more growth but after 210 days there was a total reduction in height as the plantlets due to the retained suckers from the second wave of suckering were in their initial phase of sprouting. The results from 270 days to 360 days show that differences in the treatment mean were explicit and significant. Treatment T_6 recorded maximum height in 270 days, treatment T_9 at 300 days and treatment T_8 at 330 and 360 days after planting.

Table 3. Influence of number of cuts at different depths on height of retained plantlets produced at R-1 stage.

Treatments	Height (cm) of the retained plantlets at monthly intervals											
	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days	360 days
T_1	0 (0.7)	11.25 (3.29)	17.33 (4.09)	35.96 (5.97)	37.13 (6.14)	74.23 (8.61)	77.97 (8.79)	36.7 (5.97)	42.47 (6.55)	40.267 (6.37)	50.33 (7.11)	51.6 (7.20)
T_2	5 (2.12)	11.2 (3.31)	19.5 (4.34)	33.9 (5.82)	39.5 (6.31)	64.4 (7.98)	73.93 (8.51)	49.4 (7.01)	42.47 (6.50)	36.33 (6.05)	57.4 (7.38)	54.33 (7.041)
T_3	6.47 (2.29)	20.58 (4.44)	32.73 (5.71)	34.6 (5.86)	44.57 (6.50)	45.83 (6.47)	72.37 (8.18)	13.67 (3.26)	3.67 (1.61)	4 (1.64)	6 (1.90)	17.66 (3.69)
T_4	0 (0.7)	6.13 (2.56)	19.5 (4.86)	25.5 (5.01)	46.46 (6.77)	40.3 (6.10)	62.87 (7.67)	43.4 (6.51)	29.03 (5.22)	30.07 (5.35)	22.93 (4.09)	8 (2.12)
T_5	0 (0.7)	8.23 (2.92)	18.83 (4.28)	22.33 (4.69)	23.73 (4.50)	29.833 (4.63)	43.87 (5.94)	11 (2.41)	14.83 (20.7)	10.93 (2.40)	15.43 (2.76)	0 (0.7)
T_6	0 (0.7)	6.9 (2.68)	25.47 (5.04)	29.4 (5.41)	67.2 (8.23)	67.9 (8.24)	68.13 (8.13)	54.2 (7.38)	58.63 (7.67)	50.33 (7.12)	63 (7.97)	47.67 (6.47)
T_7	1.43 (1.20)	8.87 (3.06)	18.33 (4.25)	21.53 (4.61)	39.03 (6)	58.16 (7.61)	123.63 (11.11)	25.03 (4.91)	28.33 (5.16)	17.3 (4.16)	36.67 (5.75)	22 (4.09)
T_8	0 (0.7)	9.64 (2.8)	12.6 (3.27)	17.53 (4.14)	25.43 (4.65)	55.93 (7.49)	64.3 (7.94)	49.2 (7.03)	58.9 (7.69)	49.86 (7.12)	74.8 (8.63)	77.67 (8.77)
T_9	1.77 (1.46)	8.33 (2.96)	25.97 (5.05)	29.87 (5.44)	60.5 (7.79)	59.2 (7.64)	97.73 (9.88)	39.77 (6.31)	56.27 (7.44)	56.36 (7.53)	65.33 (8.10)	65 (8.07)
T_{10}	0 (0.7)	16.05 (3.99)	28.43 (5.28)	35.8 (5.96)	41.13 (6.04)	64.33 (7.99)	74.87 (8.26)	28.7 (4.99)	26.46 (4.91)	28.26 (5.13)	38.5 (5.32)	34.67 (5.06)
T_{11}	0 (0.7)	12.80 (3.13)	23.86 (4.58)	34.53 (5.83)	23.63 (4.41)	31.87 (4.86)	29.8 (5.26)	26.93 (4.50)	11.13 (2.41)	11.13 (2.41)	12.67 (2.53)	12 (2.48)
T_{12}	0.77 (1.02)	8.17 (2.94)	21.03 (4.55)	29.5 (5.39)	41.83 (6.36)	62.66 (7.61)	64.7 (7.86)	35.5 (5.89)	39.23 (6.24)	40.93 (6.41)	47.33 (6.845)	45.33 (6.69)
T_{13}	0 (0.7)	3.63 (1.99)	17.13 (4.09)	37.6 (6.11)	52.5 (7.26)	82.06 (9.06)	88.87 (9.40)	55.97 (7.484)	48.5 (6.99)	52.9 (5.1)	51.667 (7.194)	18.33 (2.96)
T_{14}	0 (0.7)	7.43 (2.77)	28.53 (5.18)	39.47 (6.26)	32.7 (4.92)	45 (5.73)	69.06 (8.04)	19.566 (3.031)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_{15}	0 (0.7)	9.73 (3.02)	23.23 (4.71)	40.5 (6.36)	45.36 (6.66)	67.86 (8.08)	92.06 (9.49)	29.366 (4.66)	26.67 (4.45)	29.27 (4.64)	26.33 (4.44)	26.67 (4.44)
F value	2.376*	0.83 ^{NS}	0.858^{NS}	3.113**	0.989^{NS}	0.99 ^{NS}	1.465 ^{NS}	1.674^{NS}	4.663**	3.673**	3.59**	3.267**
CD (0.01)				1.44					4.101	4.322	5.160	5.600
CD (0.05)	1.006			1.073					3.040	3.216	3.830	4.152

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.1.8. Collar girth of retained suckers

The data on collar girth of suckers is presented in Table 4. At 30 days the collar girth measurement at 5 cm above from the base could be observed for treatment T_2 (single cut of incision up to 1/2 depth of sucker) and recorded maximum collar girth which was followed by treatments T_3 and T_7. The results were statistically significant. At 60 days the mean collar girth varied from 5.16 cm to 8.36 cm, however, at this stage the first set of detached new suckers which have reached 10.0 cm had already been planted out. At 90 days there is a progressive increment in the mean collar girth with range varying from 7.46 cm to 12.56 cm. Maximum collar girth was recorded for treatment T_3 which coincided with the stage wherein sucker had reached the stage of planting out. At 120 days there was a progressive dip in the mean collar girth of the treatment due to the detachment of quality plantlets. At 150 days, treatment T_1 recorded maximum collar girth followed by treatments T_{10} and T_3. At 180 days the range varied from 2.66 in T_5 to 10.77 in T_{13}. The results were not statistically significant. At 120 days the mean collar girth is again a reflection of the means of attached suckers as a sizable amount had already removed, and this is the reason as to why it was statistically not significant. At 240 and 270 days there was no much change in collar girth observed except in case were the detachment was done and the range varied from 1.73 in T_3 to 8.93 in treatment T_6 which recorded maximum and was significantly superior to all the treatments except T_8, T_9 and T_2. At 300 days and 330 days treatment T_9 followed by treatments T_8 and T_{13} recorded maximum collar girth which was significantly superior to other treatments and on par with each other. At 360 days, treatment T_8 followed by treatments T_9, T_6, T_2, T_1, and T_{13} recorded maximum collar girth which were at par with each other and superior to other treatments.

Table 4. Influenced by number of cuts at different depths on collar girth of retained plantlets at R-1 stage.

Treatments		Collar girth (cm) of retained plantlets at monthly interval										
	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days	360 days
T_1	0 (0.7)	6.1 (2.54)	7.46 (2.45)	9 (3.07)	9.3 (3.13)	5.83 (2.27)	7.6 (2.75)	7.36 (20.78)	6.13 (2.49)	7.1 (2.75)	7.66 (2.85)	9.4 (3.13)
T_2	2.36 (1.35)	6.23 (2.59)	9.4 (3.06)	8.06 (2.91)	7.066 (2.74)	7.46 (2.80)	6.8 (2.58)	7.9 (2.78)	7.83 (2.88)	6.93 (2.71)	6.6 (2.66)	9.76 (3.17)
T_3	0.66 (0.78)	8.36 (2.97)	12.56 (3.55)	8.7 (3.03)	8.83 (3.056)	10.26 (3.27)	7.6 (2.74)	6.33 (2.51)	1.13 (1.12)	1.73 (1.26)	1.8 (1.28)	1.4 (1.19)
T_4	0 (0.7)	6.7 (2.67)	8.93 (2.96)	5.36 (2.4)	5.43 (2.25)	6.86 (2.69)	5.76 (2.36)	6.13 (2.45)	6.3 (2.61)	6.93 (2.69)	7.03 (2.74)	5.23 (2.16)
T_5	0 (0.7)	6.46 (2.59)	8.63 (2.9)	1.9 (1.30)	0.66 (0.77)	2.66 (1.52)	8.3 (2.87)	6.46 (2.52)	2.16 (1.35)	3.03 (1.50)	3.233 (1.54)	3.23 (1.54)
T_6	0 (0.7)	5.16 (2.37)	9.53 (3.08)	8.16 (2.94)	7.36 (20.78)	8.1 (2.93)	7.03 (2.64)	7.76 (2.78)	8.93 (3.07)	11.23 (3.43)	9.06 (3.09)	10.33 (3.29)
T_7	0.66 (0.77)	8.56 (3.01)	12.03 (3.47)	7.8 (2.87)	7.5 (2.81)	9.6 (3.17)	6.83 (2.60)	4.8 (2.14)	6.73 (2.67)	7.26 (2.78)	7.8 (2.86)	6.13 (2.53)
T_8	0 (0.7)	9.63 (3.16)	8.83 (2.97)	6.03 (2.54)	5.43 (2.25)	6.66 (2.65)	7.13 (2.67)	5.43 (2.25)	8.83 (3.05)	9.9 (3.22)	9.3 (3.13)	12.63 (3.62)
T_9	0 (0.7)	6.06 (2.53)	12.23 (3.49)	7.36 (2.79)	7.73 (2.71)	8.1 (2.87)	8.26 (2.86)	6.36 (2.50)	8.16 (2.94)	10.93 (3.37)	9.43 (3.14)	11.46 (3.45)
T_{10}	0 (0.7)	6.9 (20.76)	11.13 (3.28)	9.33 (3.12)	9.03 (3.06)	9.03 (3.06)	9.13 (2.99)	5.93 (2.43)	5.26 (2.16)	4.9 (1.54)	5.13 (2.14)	6.13 (2.31)
T_{11}	0 (0.7)	7.53 (2.5)	11.9 (3.43)	4.53 (2.)	2.7 (1.45)	4.63 (2.04)	5.36 (2.29)	4.6 (2.13)	4.766 (2.07)	2.4 (1.39)	2.06 (1.33)	2.26 (1.37)
T_{12}	0 (0.7)	5.63 (2.48)	9.7 (3.08)	5.56 (2.45)	4.46 (2.09)	7.76 (2.83)	7.46 (2.69)	5.83 (2.37)	7.5 (2.81)	7.83 (2.87)	8.26 (2.96)	9.46 (3.15)
T_{13}	0 (0.7)	5.6 (2.47)	8.33 (2.85)	5.3 (2.36)	6.06 (2.53)	10.7 (3.33)	7.73 (2.71)	4.46 (2.09)	7.3 (2.79)	8.33 (2.96)	8.8 (3.04)	9.33 (3.13)
T_{14}	0 (0.7)	8.63 (2.99)	11.56 (3.35)	5.93 (2.27)	6.23 (2.59)	7.16 (2.75)	7 (2.61)	7.13 (2.66)	2.7 (1.45)	0 (0.7)	0 (0.7)	0 (0.7)
T_{15}	0 (0.7)	7.06 (2.74)	9.86 (3.12)	7.133 (2.76)	7.5 (2.82)	5.9 (2.48)	6.7 (2.53)	5.76 (2.37)	5 (2.12)	5.2 (2.15)	5.73 (2.27)	5.7 (2.23)
F value	2.468*	0.579^{NS}	0.815^{NS}	1.877^{NS}	1.781^{NS}	1.565^{NS}	0.514^{NS}	0.948^{NS}	2.046*	3.887**	3.626**	3.609**
CD (0.01)										10.78	1.634	1.876
CD (0.05)	0.859								1.289	1.267	1.211	1.392

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.1.9. The number of leaves of the retained suckers

The data on number of the leaves are present in the Table. 5 At 30 days small sized leaves unfurled in treatments T_2 (single cut of incision up to 1/2 depth of sucker), T_3 (single cut of incision up to $3/4^{th}$ depth of sucker), T_7 (three cuts of incision up to $1/4^{th}$ depth of sucker), T_9 (three cuts of incision up to $3/4^{th}$ depth of sucker) and T_{11} (four cuts of incision up to 1/2 depth of sucker). Maximum number of leaves were recorded by treatment T_2 which is 1.5 followed by treatments T_{11} and T_7 and rest of the treatment showed no leaf production. From 60 days the number of leaves progressively increased up to 90 days and in some case up to 120 and 150 days depending on the fortnight at which the detachment of plantlets that sprouted were affected. An introspection into the data presented in the Table 5 revealed that the number of leaves up to 120 days varied from 1.0 to 5.0. Beyond 150 days it is evident from the data that the number of leaves ranged from 1.0 to 3.0 up to 270 days wherein the number of detachments had slowed down. The second cycle of detachment occurred at these stages and hence the number of leaves retained by the plants again varied from 0 to 3.0. These zero values were observed in treatment T_{14} were almost all suckers were detached. At 330 and 360 days the maximum number of leaves was in treatment T_8 which was significantly superior to all other treatments except treatments T_9 and T_6.

Table 5. Effect of number of cuts at different depths on number of leaves of retained plantlets of R-1 stage at monthly intervals.

Treatments	Number of leaves retained at monthly interval											
	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days	360 days
T_1	0 (0.7)	2 (1.56)	2.83 (1.81)	2.66 (1.77)	3.66 (1.97)	1.33 (1.28)	1.66 (1.38)	2 (1.49)	1.66 (1.38)	2.33 (1.56)	2 (1.47)	1.66 (1.38)
T_2	1.5 (1.40)	2 (1.56)	3.16 (1.89)	3.5 (1.99)	3.83 (2.06)	2.83 (1.82)	2 (1.47)	2 (1.42)	2 (1.468)	3 (1.72)	2.33 (1.56)	2 (1.47)
T_3	0.66 (1.05)	2.5 (1.72)	3.33 (1.93)	2.83 (1.68)	3.66 (1.96)	2.16 (1.63)	1.16 (1.13)	0.83 (1.04)	1 (1.09)	1.33 (1.17)	1.166 (1.13)	0.66 (0.99)
T_4	0 (0.7)	1.66 (1.39)	2.66 (1.77)	3 (1.86)	3 (1.85)	2.16 (1.63)	2.33 (1.49)	1.83 (1.42)	2.33 (1.54)	2.33 (1.54)	1.66 (1.25)	2.33 (1.64)
T_5	0 (0.7)	1.66 (1.39)	3.16 (1.91)	1.16 (1.13)	1.5 (1.22)	2.66 (1.77)	0.66 (0.99)	1 (1.09)	0.66 (0.99)	0.33 (0.87)	0 (0.7)	0.33 (0.87)
T_6	0 (0.7)	2.16 (1.63)	3.5 (1.99)	4.33 (2.19)	4.33 (2.18)	2.83 (1.81)	3.33 (1.94)	3.33 (1.95)	3.33 (1.95)	3.33 (1.88)	3.33 (1.93)	3 (1.86)
T_7	1 (1.18)	2.5 (1.72)	3.83 (2.07)	2.66 (1.65)	3.33 (1.94)	2 (1.47)	1.66 (1.38)	2.33 (1.54)	1.33 (1.26)	1.83 (1.42)	2.5 (1.73)	2.16 (1.63)
T_8	0 (0.7)	1 (1.18)	3.83 (2.09)	2 (1.47)	2.56 (1.61)	3.33 (1.94)	3.33 (1.79)	3.66 (1.86)	3.16 (1.75)	3.83 (1.89)	5 (2.33)	3.33 (1.93)
T_9	0.5 (0.95)	2.33 (1.67)	3.9 (2.09)	3.83 (2.07)	3.16 (1.91)	2.16 (1.6)	2 (1.49)	3 (1.72)	2.16 (1.53)	3.16 (1.76)	4.16 (2.14)	4 (2.11)
T_{10}	0 (0.7)	2.33 (1.65)	4.16 (2.15)	2.83 (1.68)	2.46 (1.58)	1.5 (1.34)	1.66 (1.35)	1.83 (1.42)	2.16 (1.5)	2.66 (1.74)	2.16 (1.52)	2.5 (1.6)
T_{11}	1 (1.09)	1.66 (1.25)	5 (2.33)	1.16 (1.13)	0.83 (1.05)	3.33 (1.94)	0.83 (1.05)	1.33 (1.17)	1 (1.09)	1 (1.09)	1.16 (1.13)	1.16 (1.13)
T_{12}	0 (0.7)	2.16 (1.63)	3.33 (1.95)	3.66 (2.04)	4.16 (2.15)	3 (1.84)	4.66 (2.25)	4.5 (2.23)	3.66 (2.038)	3.66 (2.04)	3.33 (1.89)	3 (1.82)
T_{13}	0 (0.7)	1.33 (1.28)	3.33 (1.95)	4 (2.11)	2.5 (1.60)	3 (1.86)	2.16 (1.5)	2.5 (1.59)	1.66 (1.38)	1.5 (1.34)	1 (1.09)	1.33 (1.26)
T_{14}	0 (0.7)	1.16 (1.23)	2.4 (1.59)	2.83 (1.68)	1.66 (1.35)	1.66 (1.46)	0.33 (0.87)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_{15}	0 (0.7)	1.66 (1.45)	3.33 (1.951)	3.5 (1.97)	2.83 (1.78)	1.33 (1.34)	0.33 (0.87)	0.33 (0.87)	0.66 (0.99)	0 (0.7)	1 (1.18)	0.33 (0.87)
F value	1.019	0.674	1.165	0.985	1.007	1.211	1.122	1.124	1.066	1.283	2.166*	2.357*
CD (0.05)											0.952	0.815

** Significant at 1 per cent,*Significant at 5 per cent, NS- Non significant, Figures in parenthesis indicate square root transformed value

4.1.1.10. Number of quality suckers

From the Table 6 it can be inferred that maximum number of quality suckers that was planted out successfully is in treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) followed by treatments T_{11} (four cuts of incision up to 1/2 depth of sucker), T_{12} (four cut of incision up to $3/4^{th}$ depth of sucker.) and T_1 (single cut of incision up to $1/4^{th}$ of depth of sucker) which is significantly superior to all other treatments except treatments T_{11}, T_{12} and T_1 with which was statistically at par. However, there was an average one plantlet more production in treatment T_{13} which from both numerical and economical terms is certainly an improvement.

Plate 7. Most effective treatment in R-1 at six-month stage T_{13} (acid treatment)

4.1.1.11. Number of under developed suckers

The results presented in Table 6 revealed that there was no statistical significance between the treatments. However, a close scrutiny of the data revealed that maximum number of under developed sucker was observed in treatment T_{15} ((control) without any cut).

4.1.1.12. Number of dead suckers

Results presented in Table 6 revealed that highest number of dead suckers were observed in the control treatment (T_{15}, without any cut). followed by treatments T_{12}, T_2 and T_5 which recorded same number of dead suckers.

Table 6. Influence of number of cuts at different depths on sucker production at R-1 stage.

Treatment	Number of quality suckers	Under developed suckers	Number of dead suckers	Mean of total no of sprouts
T_1	6.66(2.57)	0.67(1.05)	0.67(0.99)	8(2.81)
T_2	5(2.22)	0.33(0.87)	1.33(1.29)	6.66(2.57)
T_3	4(1.98)	0(0.7)	0.67(1.05)	4.66(2.15)
T_4	4.33(2.06)	0(0.7)	0.33(0.87)	4.66(2.13)
T_5	5.33(2.26)	0(0.7)	1.33(1.34)	6.66(2.53)
T_6	3(1.714)	0.33(0.87)	1(1.23)	4.33(2.06)
T_7	6(2.45)	0.33(0.87)	0.67(1.05)	7(2.64)
T_8	4(1.98)	0.66(0.99)	0.34(0.87)	5(2.21)
T_9	4(1.95)	0.33(0.87)	0.67(1.05)	5(2.22)
T_{10}	5.33(2.26)	0(0.7)	0.67(1.05)	6(2.43)
T_{11}	6.67(2.58)	0.33(0.87)	1(1.18)	8(2.82)
T_{12}	6.66(2.57)	0(0.7)	1.33(1.29)	8(2.82)
T_{13}	7.66(2.75)	0.33(0.87)	0.67(1.05)	8.66(2.93)
T_{14}	5(2.21)	0.33(0.87)	0.67(1.05)	6(2.39)
T_{15}	3(1.71)	1(1.18)	2.33(1.67)	6.33(2.49)
F value	2.441*	0.752^{NS}	1.081^{NS}	1.822^{NS}
CD (0.05)	0.593			

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.1.13. Mean weight, volume and number roots of corm of the plantlets

The data on the weight and volume of corm and number of roots of sucker are presented in Table 7. It is evident from the table that treatment T_9 (three cuts of incision up to 3/4th depth of sucker) yielded maximum weight of corm (212g) followed by treatments T_8, T_5 and T_2 which were on par with each other and significantly superior to the other treatments. A similar trend was observed in the case of volume of corm and the results were also statistically significant.

However, in case of number of roots in treatment T_9 (three cuts of incision up to 3/4th depth of sucker) excelled over others followed by treatments T_5, T_2 and T_{12}, but there were no significant differences observed between the treatment means.

Table 7. Corm weight, volume and number of roots produced R-1 stage as influenced by number of cuts given at different depth.

Treatment	Weight (g)	Volume (cc)	No. of. roots
T_1	95.33	94.66	10.33
T_2	130	131.33	20.66
T_3	8.33	9	7.33
T_4	13	14	2.66
T_5	130	131.33	20.66
T_6	103	110	13.33
T_7	21.33	21	6.33
T_8	175	158	15.33
T_9	212	210.33	22.66
T_{10}	85.33	87.33	12.66
T_{11}	23.33	20.66	5.66
T_{12}	63.66	84.33	18.66
T_{13}	31.33	32	12
T_{14}	85.33	87.33	12.66
T_{15}	24	23.33	2.33
F value	8**	8.2**	1.717^{NS}
CD (0.01)	85.631	84.921	
CD (0.05)	63.599	64.1	

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

4.1.2. Ratoon-2

The results of the study after imposing the same treatment on the corm of R-1 suckers were planted and the results are as follows

4.1.2.1. Number of sprouts retained and mean of total number of sprouts

The data of number of sprouts retained and mean of total number of sprouts are presented in Table 8. A critical analysis of data revealed that maximum number of sprouts were produced in treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) at all the 5 stages of the observation from first month to fifth month. The results were also statistically significant at fifth month, second month and the mean of total number of sprouts.

Plate 8. Most effective treatment in R-2 at 60 days stage T_{13} (acid treatment)

Table 8. Number of suckers retained in R-2 at monthly intervals as influenced by number of cuts at different depth.

Treatments	No. of suckers retained at monthly interval					
	30 days	60 days	90 days	120 days	150 days	Mean of total No. sprouts
T_1	1.33(1.26)	1(1.05)	0.66 (0.99)	0.66(0.99)	0(0.7)	3.6(2.02)
T_2	0.66(0.99)	1(1.05)	1 (1.265)	1(1.265)	0.66(0.99)	4.33(2.16)
T_3	0.33(0.87)	0.66(0.99)	0.66(0.99)	0.66(0.99)	0.33c	2.6(1.79)
T_4	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	0.66(0.99)	0.33(0.87)	1.3(1.49)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66 (0.99)	0.33(0.99)	0 (0.7)	0(0.7)	0 (0.7)	1.6(1.4)
T_9	0(0.7)	0 (0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	0 (0.7)	0(0.7)	0.33(0.87)	0.33(0.87)	0.33(0.87)	1.03(1.2)
T_{11}	0(0.7)	0(0.7)	0 (0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0.33(0.87)	0.33(0.87)	0.33(0.87)	1.3(1.1)
T_{13}	1.33 (1.34)	1(1.46)	0.66(0.99)	0.66(0.99)	1(1.34)	4.66(2.1)
T_{14}	0 (0.7)	0 (0.7)	0 (0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0.33 (0.87)	0.33 (0.87)	1.33(1.1)	1.33(1.1)	0.33(0.87)	3.3(1.892)
F value	2.368*	2.255*	1.821^{NS}	1.421^{NS}	2.087*	4.35**
CD (0.01)						0.102
CD (0.05)	0.405	0.441			0.469	0.081

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.1.2 Height of the suckers

The data presented in Table 9 revealed that the treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) produced plantlet with maximum height followed by treatments T_1, T_2 and T_3. At all the five stages of the observation the difference in treatment means between the four treatment were statistically at par but was significantly superior over the means of other treatments.

Table 9. Influenced of number of cuts at different depth on height of retained plantlets at R-2 stage.

Treatments	Height (cm) at monthly intervals				
	30 days	60 days	90 days	120 days	150 days
T_1	4.76 (2.08)	5.33(2.17)	6.46(2.37)	9.06(2.73)	9.2(2.75)
T_2	3.7(1.87)	5.33(2.17)	6.23(2.33)	7.56(2.52)	7.9(2.57)
T_3	2.7(1.45)	3.23(1.54)	3.5(1.58)	5.06(1.79)	5.33(1.82)
T_4	0 (0.7)	0(0.7)	0 (0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	1.6(1.24)	3.8(1.62)	3.83(1.62)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	1.7 (1.26)	2.13(1.35)	2.73(1.45)	3.3(1.54)	3.33(1.55)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	0(0.7)	0(0.7)	2.96(1.49)	2.96(1.49)	3.1(1.52)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{13}	4.966(2.30)	6.3(2.58)	8(2.89)	10.7(3.30)	11.033(3.37)
T_{14}	0(0.7)	0(0.7)	0 (0.7)	0(0.7)	0(0.7)
T_{15}	1.43(1.21)	2.1(1.35)	2.63(1.43)	4.56(1.72)	0(0.7)
F value	2.435*	2.452*	1.877^{NS}	1.732^{NS}	2.174*
CD (0.05)	1.052	1.217			1.751

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.2.3. Collar girth of the suckers

A more or less similar trend was observed in case of collar girth. The data presented in Table 10 reveal that there was no statistical significance in the difference between the treatment means. It was also very evident that collar girth was drastically decreased in cycle 2 or ratoon- 2.

Table: 10. Influence of number of cuts at different depth on collar girth of retained plantlets at R-2 stage.

Treatments	Collar girth at monthly intervals				
	30 days	60 days	90 days	120 days	150 days
T_1	0.733(1.01)	0.76(1.02)	1.13 (1.12)	1.7 (1.26)	1.66(1.29)
T_2	0 (0.7)	1.36 (1.29)	1.43(1.24)	1.9 (1.44)	1.933(1.45)
T_3	0(0.7)	0.66 (0.99)	0.66(0.99)	1.53 (1.22)	1.66 (1.29)
T_4	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0.766(1.02)	0.66(1.05)
T_6	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)
T_8	0(0.7)	0.76 (1.02)	1.2 (1.14)	1.2 (1.143)	1.2 (1.14)
T_9	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)
T_{10}	0(0.7)	0(0.7)	0(0.7)	0.33(0.87)	0.33 (0.87)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0(0.7)
T_{13}	0(0.7)	1.13 (1.22)	1.5 (1.35)	2.9 (1.69)	3.6 (1.84)
T_{14}	0(0.7)	0.76 (1.02)	0.9 (1.06)	1.6 (1.24)	1.93 (1.45)
T_{15}	0(0.7)	0.63 (0.98)	0(0.7)	0.266(0.85)	0.266(0.85)
F value	1^{NS}	1.053^{NS}	1.171^{NS}	0.95^{NS}	0.993^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.2.4. Number of leaves produced

There was a marked reduction in the number of leaves produced in second ratoon 2 or cycle 2 as is clear from Table 11. Treatment T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion) retained maximum number of leaves at 30^{th}, 60^{th}, 90^{th} and 120^{th} day after planting followed by treatment T_2. After 120^{th} day there was reduction in number of leaves retained. This reveals that irrespective of size and collar girth the plantlets must be planted out by 120 day after planting of mother corm.

Table 11. Influence of number of cuts given at different depth on number of leaves of retained plantlets at R-2 stage.

Treatments	Number of leaves retained at monthly intervals				
	30 days	60 days	90 days	120 days	150 days
T_1	1.33 (1.28)	1 (1.18)	1 (1.18)	1.66 (1.38)	0.66 (1.05)
T_2	1 (1.18)	0.66 (1.05)	1.33 (1.26)	1.33 (1.26)	1.66(1.38)
T_3	1 (1.09)	0.66 (0.99)	0.33 (0.87)	1.33 (1.17)	0.66(0.99)
T_4	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_5	0(0.7)	0 (0.7)	0.66 (0.99)	1.33 (1.17)	0.66 (0.99)
T_6	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)
T_8	0.66(0.99)	0.66(0.99)	0.66(0.99)	1 (1.09)	0.33 (0.87)
T_9	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_{10}	0(0.7)	0(0.7)	0 (0.7)	0(0.7)	0 (0.7)
T_{11}	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_{12}	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0(0.7)
T_{13}	21.526	1.66 (1.46)	1.33 (1.34)	2 (1.56)	1.33 (1.34)
T_{14}	0(0.7)	0(0.7)	0 (0.7)	0 (0.7)	0 (0.7)
T_{15}	1 (1.09)	0.66 (0.99)	0.33 (0.87)	0.66 (0.99)	0.33 (0.87)
F value	1.776^{NS}	2.255*	1.821^{NS}	1.421^{NS}	2.087*
CD (0.05)		0.441			0.469

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.1.18. Carbohydrate content observed in corm mother sucker ratoon- 1, ratoon-2 and dead sucker

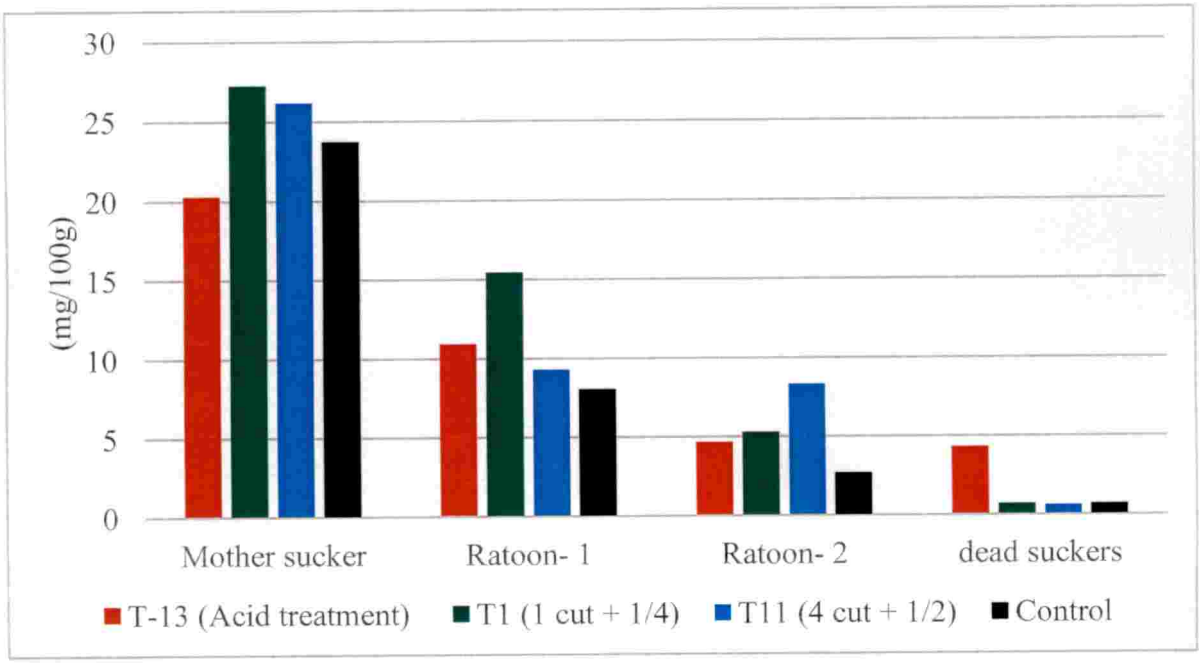
The levels of carbohydrate in the mother plant, first ratoon (cycle1) and second ratoon (cycle-2) are presented in Table.12 The data revealed that the carbohydrate content of mother plant was much higher than that in the first ratoon which is again much higher than second ratoon. The depleting levels of carbohydrate should be seen as the reason for the low sucker production in the second ratoon and also the low crop span in ratoon-2. The treatment means of the ratoon-1, ratoon-2 and dead sucker were statistically significant at one percent level. The levels in the mother sucker is not significant which also reveals the uniformity in sucker selection or in other words the precision of the experiment.

Table 12. Carbohydrate content in corm of mother sucker ratoon- 1, ratoon-2 and dead sucker

Treatment	Carbohydrate mg /100ml			
	Mother sucker (initial)	Ratoon – 1	Ratoon – 2	Dead sucker
T_1	27.26(5.12)	15.46 (3.92)	5.3(2.3)	0.7(0.83)
T_2	22.66(4.748)	7.86 (2.81)	4.1(2.02)	0.2 (0.43)
T_3	23.8(4.875)	12.73(3.56)	5.933 (2.43)	0.233 (0.46)
T_4	25.03(5.002)	9.2 (3.023)	2.97 (1.58)	0.433 (0.61)
T_5	24.2(4.91)	10.6 (3.24)	0.5 (0.77)	1.7(1.3)
T_6	22.86(4.76)	16.13 (4.01)	4.7(2.17)	0.766 (0.87)
T_7	21.33(4.56)	12.066 (3.37)	4.566 (2.13)	1(0.99)
T_8	24.43(4.95)	10.26 (3.19)	4.333 (2.08)	1.7(1.3)
T_9	24.73(4.97)	17(4.12)	5.4(2.33)	4.7(2.17)
T_{10}	24.96(4.99)	19.86 (4.45)	4.366 (2.08)	4.12(2.21)
T_{11}	26.2(5.11)	9.33 (3.04)	8.366 (2.89)	0.633 (0.79)
T_{12}	22.43(4.71)	9.33(3.03)	8.2(2.86)	0.8(0.89)
T_{13}	20.3(4.47)	10.933 (3.29)	4.466 (2.12)	4.366 (2.11)
T_{14}	23.83(4.88)	7.4(2.72)	3.566 (1.84)	5(2.24)
T_{15}	23.73(4.86)	8.06(2.84)	2.7(1.65)	0.7(0.83)
F value	0.403^{NS}	6.323**	1.203**	12.95**
CD (0.01)		0.815	2.142	0.237
CD (0.05)		0.605	1.596	0.170

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

Figure 2. Carbohydrate content (mg/100g) in corms of selected treatments of mother sucker, R-1, R-2 and dead suckers.



4.2. Experiment II: Standardizing the grow bag media constitution for macropropagation.

4.2.1. Ratoon-1

The best treatment of pouring 5 ml of 1 per cent H_2SO_4 acid on the apical meristem portion was uniformly adopted in all the media treatments except in local control (T_9 and T_{19} in soil media 15 Kg and 20 Kg respectively) and control where cutting of apical meristem was given in soil media (T10 and T20 in soil media of 15 and 20 Kg respectively)

4.2.1.1 Days taken to first sprout

According to the data presented in Table 13 the treatment T_1 (15 kg media composition in the proportion 1:1:1), recorded earliest sprouting followed by treatments T_9, T_8 and T_2. Treatment T_1 took a mean of 16.3 days, T_9 took 17 days, treatment T_8 took 17.33days and treatment T_2 took 17.66 days for first sprouting. The treatment T_5 took maximum time to record first sprouting (49 days) and recorded 20 and 22.66 (T_{10} and T_{20}) days to first sprouting. The treatments T_{18}, T_2, T_8 and T_1 are statistically at par with each other. The result was statistically significant at one percent level.

4.2.2 Number of sprouts retained

Mean number of sprouts retained in different grow bag media composition is presented in Table 13. In the first fortnight sprouting was not observed. But the data clearly showed that in the second fortnight maximum sprouting occurred in treatmentT_{18} (20 kg of red soil only) and T_9 (local control in 15 Kg red soil only) followed by T_{20} and T_{12}. In the third fortnight treatment T_{10} followed by treatments T_{18}, T_9, T_{20} excelled over the others and the treatment means of treatment T_{10} was significantly superior over rest of the treatments. In the 4th fortnight best treatments were treatments T_{19}, T_{10}, and T_{13} but the results were not statistically significant. In the 5th fortnight treatment T_{18} followed by treatments T_{13}, T_{10} and T_{11} were the best treatments with the latter three treatments recording identical values. though treatment T_{18} showed explicitly higher values the result was not significant. In the 6th to 12th fortnight again relative superiority of treatmentT_{18} followed by treatment T_{10} was evident but in all the case the result was statistically not significant.

4.2.3. Mean of total number of sprouts

The data regarding the mean of total number of sprouts presented in Table 13 revealed that among all the treatments, treatment T_{18} (20 Kg red soil alone), yielded the best results with mean production of 6.0 plantlets which could be carried over to the next ratoon cycle followed by treatment T_{19} which yielded an average of 5.2 suckers. T_{18} was on par with all treatment that yielded a mean number of 4 platelets or more but the mean of 6 plantlets (T_{18}) is a big difference and hence the result are of immense practical importance.

Table: 13. Number of days to first sprout, sprouts retained at fortnightly intervals and mean of total number of sprouts produced in R-1 in different combination of potting media

Treatments		Fortnightly											
	Days to 1st sprout	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Mean of total No. of sprouts
T_1	16.3 (4.04)	0.33 (0.87)	0.33 (0.88)	0.66 (0.99)	0.33 (0.87)	0.66 (0.994)	0.66 (0.994)	0.66 (0.99)	0.66 (0.99)	1 (1.09)	0.66 (0.99)	0(0.7)	1.3 (1.26)
T_2	17.66 (4.21)	0.33 (0.88)	0.33 (0.87)	1.33 (1.26)	2.66 (1.663)	3 (1.723)	3.33 (1.783)	3 (1.72)	2.66 (1.66)	3 (1.72)	3.333 (1.783)	2.33 (1.49)	4 (2.09)
T_3	35.66 (5.97)	0 (0.7)	0.33 (0.87)	0.33 (0.87)	0.66 (0.994)	0.66 (0.994)	1 (1.18)	1.33 (1.26)	1.66 (1.38)	1.66 (1.38)	2 (1.56)	0.66 (0.99)	3 (1.81)
T_4	20.33 (4.50)	0.33 (0.88)	0.66 (0.99)	0.66 (0.99)	1.66 (1.38)	1.66 (1.38)	2.33 (1.564)	2 (1.47)	1.66 (1.38)	1 (1.18)	1.33 (1.34)	0.33 (0.87)	3.33 (1.95)
T_5	49.6 (7.05)	0 (0.7)	0 (0.7)	1 (1.09)	0.66 (0.99)	1 (1.18)	1 (1.18)	0.66 (0.994)	0.66 (0.99)	2 (1.58)	2 (1.56)	0.66 (0.99)	3.66 (2.02)
T_6	37.33 (6.11)	0 (0.7)	1 (1.18)	1.33 (1.26)	2 (1.56)	1.33 (1.287)	1.33 (1.287)	1.33 (1.29)	1.33 (1.29)	1.66 (1.44)	2 (1.56)	1.66 (1.38)	2 (1.58)
T_7	32 (5.65)	0 (0.7)	0.33 (0.87)	1.33 (1.34)	2 (1.56)	2 (1.55)	2 (1.56)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.66 (0.99)	1.33 (1.34)	3.33 (1.89)
T_8	17.33 (4.17)	0.33 (0.87)	0.66 (0.99)	2 (1.56)	2.33 (1.67)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	2 (1.55)
T_9	17 (4.13)	1 (1.18)	2 (1.56)	3 (1.85)	3 (1.85)	2.33 (1.68)	3.333 (1.953)	2.33 (1.65)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	4.6 (2.245)
T_{10}	22.66 (4.76)	0.33 (0.87)	3.66 (2.004)	4 (2.09)	3.66 (2.004)	3.66 (2.004)	4 (2.09)	3.66 (1.654)	3.33 (1.93)	2.66 (1.76)	2.66 (1.76)	2.66 (1.76)	4 (2.09)
T_{11}	24.33 (4.93)	0.66 (0.99)	2 (1.56)	3 (1.86)	3.66 (2.04)	2.33 (1.68)	2.66 (1.761)	2.33 (1.67)	2.33 (1.67)	1.66 (1.46)	1.66 (1.46)	1.33 (1.34)	4.66 (2.27)
T_{12}	22 (4.68)	1.66 (1.46)	2.66 (1.77)	3.33 (1.95)	3.66 (2.04)	3.66 (2.04)	4 (2.123)	4 (2.123)	3.333 (1.95)	3 (1.88)	2.66 (1.77)	2 (1.58)	4.66 (2.24)
T_{13}	25 (4.99)	0.66 (1.05)	3 (1.82)	4 (2.11)	4 (2.11)	4 (2.11)	3.66 (2.03)	3 (1.86)	3 (1.86)	2.66 (1.77)	3 (1.86)	2.66 (1.76)	4 (2.11)
T_{14}	24 (4.89)	0.33 (0.87)	2 (1.47)	2.66 (1.65)	2.66 (1.65)	2.33 (1.56)	3 (10.7)	2 (1.47)	1.66 (1.38)	2 (1.56)	2.33 (1.64)	1.66 (1.38)	3 (1.85)
T_{15}	24 (4.89)	0.33 (0.87)	0.66 (0.99)	3 (1.67)	2.66 (1.61)	3.66 (1.79)	3.66 (1.79)	3.33 (1.73)	2.33 (1.54)	3 (1.78)	3 (1.78)	2 (1.47)	4.33 (2.19)
T_{16}	35.33 (5.94)	0 (0.7)	1 (1.18)	2 (1.42)	2 (1.42)	2 (1.42)	1.66 (1.25)	2 (1.526)	1.66 (1.35)	1.66 (1.44)	2 (1.52)	1.33 (1.27)	4.3 (2.19)
T_{17}	23 (4.79)	1 (1.23)	1 (1.23)	1.33 (1.34)	1.33 (1.34)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	1 (1.2)	1 (1.22)	0.66 (1.05)	2.66 (1.76)
T_{18}	18.33 (4.27)	2 (1.56)	2.66 (1.77)	4 (2.06)	4.33 (2.16)	4.33 (2.12)	5 (2.237)	5 (2.23)	4 (2.06)	3.66 (2.004)	4 (2.029)	3 (1.84)	6 (2.53)
T_{19}	18 (4.24)	2 (1.56)	2.66 (1.76)	2.33 (1.67)	2.66 (1.76)	2.66 (1.76)	3.33 (1.91)	2.33 (1.67)	2.33 (1.67)	2.66 (1.77)	2.33 (1.68)	2.66 (1.77)	5.33 (2.41)
T_{20}	20 (4.47)	1.66 (1.44)	2.66 (1.77)	2.66 (1.77)	2.66 (1.77)	2.66 (1.77)	3 (1.85)	2 (1.58)	2.33 (1.68)	2.33 (1.68)	2.33 (1.68)	2.33 (1.68)	4.66 (2.25)
F value	97.436**	2.501**	3.606**	1.759^{NS}	1.711^{NS}	1.24^{NS}	1.153^{NS}	1.2^{NS}	1.211^{NS}	1.113^{NS}	0.948^{NS}	1.63^{NS}	4.37**
CD(0.01)	0.317	0.697	0.817										0.775
CD(0.05)	0.235	0.512	0.616										0.576

** Significant at 1 per cent,*Significant at 5 per cent, NS- Non significant, Figures in parenthesis indicate square root transformed value

4.2.4. Total number of suckers produced

The data presented in the Table 14 revealed that in the second fortnight maximum number of new suckers produced was in treatments T_{18} (in 20 kg red soil only), and T_{19} followed by treatments T_{20} and T_{12} which was followed by treatments T_9. In the third fortnight treatment T_{10} (control in 15 kg red soil alone) produced a total of 10.0 new suckers followed by treatment T_{13}. In the fourth fortnight treatment T_{15} produced maximum number of 7.0 suckers followed by treatment T_8. In general, there was a decrease in sucker production after the fourth fortnight. In the fifth fortnight maximum production was observed in treatment T_1 whereas in the sixth fortnight maximum production was in treatment T_5 and in the seventh it was in treatment T_9. Another wave of sucker production was observed in 10^{th} and 11^{th} fortnight but the number of new suckers produced were sizably low except in case of treatment T_5. In the 10^{th} in 11^{th} and 12^{th} fortnight there was very low production of suckers the maximum recorded was just 4.0 suckers.

4.2.5 Total number of new suckers produced

The total number of new suckers produced at the end of half yearly (Table 14) was maximum for treatment T_{18} (20 Kg of red soil alone), which produced 18.0 suckers followed by treatments T_{19} (16.0 suckers) and then by treatments T_{20}, T_{11} and T_9 which recorded an equal total number of 14.0 suckers. Thus, it is evident from the data that the treatment T_{18} is the best. A critical analysis revealed that the treatment soil alone as media excelled over all other treatments and only minor difference was observed at the quantity of media 20 and 15 kg with the former yielding more number of plantlets.

4.2.6. Planted out plantlets

The data presented in the Table 14 revealed that the planting out started in the fifth fortnight and one plantlet each in treatments T_{10}, T_{15} were planted. In sixth fortnight a maximum of 4 plantlets in treatment T_{11} followed by treatments T_{17} (3.0), T_6, T_8 and T_9 respectively was recorded. The fifth fortnight to sixth fortnight to be regarded as first wave of production of quality suckers. At seventh fortnight there were no plantlets ready for

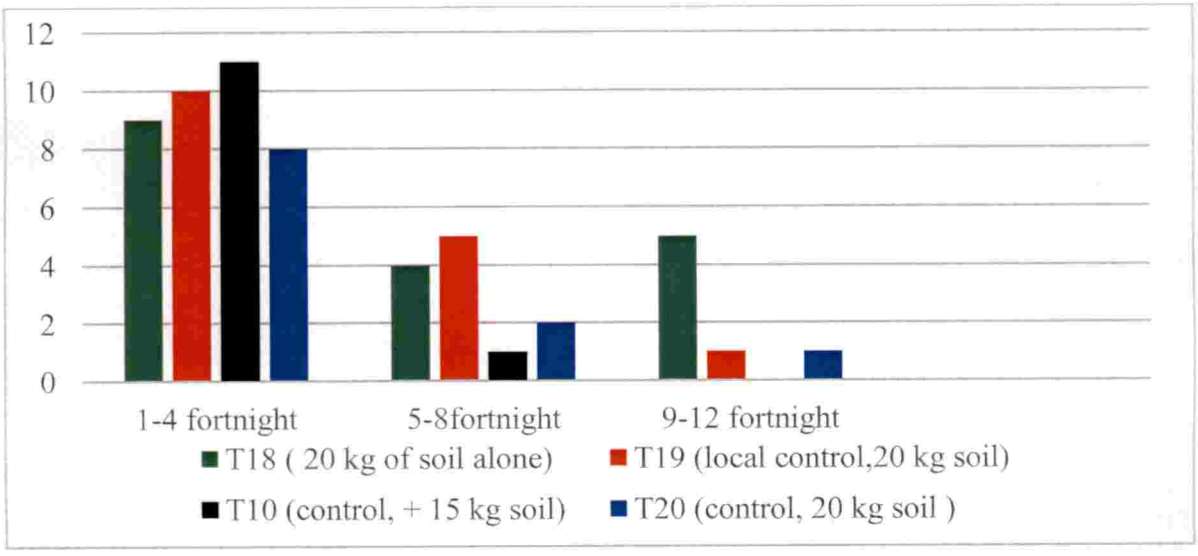
planting out. At eighth fortnight 3.0 plantlet each were planted out in treatments T_9 and T_{14} and 2.0 in case of treatment T_7. At ninth fortnight maximum of 6.0 plantlets were planted out in T_{19} followed by 2.0 each in treatment T_{12}, and T_{13}. At tenth fortnight treatment, T_{19} recorded a maximum of 4.0 plantlet which was followed by .0 each in case of treatments T_{10}. Only in three cases a single plantlet was planted out in the eleventh fortnight whereas in the twelfth fortnight, 4.0 plantlets each were moved out for planting in treatments T_2, T_3, T_5 and T_{19}.

Table 14. Total number of new suckers produced, total number of suckers detached (shown in brackets) at fortnightly interval and total number of suckers produced in R-1 in different potting media.

Treatments	Fortnightly interval											
	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Total No. of suckers
T_1	1	0	1	0	1	0	0	0	1	0(1)	0(1)	4
T_2	1	0	3	4	1	1	0(1)	0(1)	1	1	0(4)	12
T_3	0	1	0(1)	1	0	1	2(1)	2(1)	0	1	0(4)	9
T_4	1	1	0	3	0	3	0(2)	0(1)	0(2)	2	0(3)	10
T_5	0	0	3	0(2)	2	0	0(3)	0	4	0	0(4)	11
T_6	0	3	1	2	0(2)	0	0	0	1	1	0(2)	6
T_7	0	1	3(1)	3	0(2)	0	0(2)	0	0	2	0(1)	10
T_8	1	1	4	1	0(2)	0	0	0	0(2)	0	0(2)	6
T_9	3	3	3(1)	0	0(5)	4	0(3)	0(4)	0	0(3)	0	14
T_{10}	1	10	1	0(1)	0	1	0(1)	0(1)	0(3)	0	0	12
T_{11}	2	4	3	3	0(4)	1	0(3)	0	0(2)	0	0(2)	14
T_{12}	5	3	2	1	0	2	0	0(3)	0(2)	0(3)	0(2)	14
T_{13}	2	7	3	0	0	0	0(2)	0(2)	0	0(3)	0(2)	12
T_{14}	1	4	2	0	0(2)	2	0(3)	0(1)	1	1	0(2)	9
T_{15}	1	2	7	0(2)	3	0	0(1)	0(3)	2	0	0(3)	13
T_{16}	0	3	3	0	0	0	0(4)	1	0(2)	1	0(3)	12
T_{17}	3	0	2	0	0(3)	0	0(2)	0	0	3	0(3)	8
T_{18}	6	3	0(5)	1	0(4)	3	0(5)	0	3	0(3)	2	18
T_{19}	6	2	2	2	0	3	0	0(6)	0(4)	1	0(6)	16
T_{20}	5	3	0(4)	0	0	2	0(2)	1	0	0(4)	0	14

Values in the parenthesis show the number of detached suckers

Figure 3. Waves of suckering under observed at first ratoon stage in different combinations of potting media.



4.2.7 Height of retained suckers

A critical analysis of data in Table-15 revealed that the plants started putting on height only after 60 days even though the sprouting started in 30days in many of the treatments they remained as only peepers. At 60 days treatment T_{20} the control treatment of 20 Kg red soil only, recorded maximum height (61.6cm) followed by treatments T_{17}, T_{18} T_{19}, T_9, T_{12}, T_{10}, T_8, and T_{13} which were statistically on par with each other. The results were also statistically significant. At 90 days the height showed considerable increase and treatment T_{20} followed by treatment T_8 recorded maximum height. In the 120^{th} day all the treatments showed increasing trend and maximum was recorded again in treatment T_{20} followed by treatment T_{19}, T_{10} and T_8. At the 150^{th} day treatments showed a dip in the reading due to the detachment of the plantlets except treatment T_4 and maximum was in T_{11} followed by treatments T_{19} and T_{20}. From 90^{th} day to 150^{th} days the results were not statically significant. In 180^{th} days, the trend also reverted, and maximum was recorded in treatment T_{18} followed by treatments T_8, T_{20} and T_{10}. Further the results were also statistically significant.

Table: 15. Influence of different combination of potting media on height of retained plantlet at R-1 stage

Treatment	Height of retained plantlets produced at monthly intervals				
	60 days	90 days	120 days	150 days	180 days
T_1	9.46(2.26)	19.1(3.64)	49(5.97)	8.1(2.13)	10.5(2.35)
T_2	16.66(3.84)	28.03(5.33)	54.96(7.41)	11.83(3.07)	6.16(1.92)
T_3	9.66(2.29)	18.5(3.67)	27.33(4.47)	16.93(3.56)	26.5(4.46)
T_4	14.46(3.04)	23.66(3.96)	37.33(5.16)	43.26(5.61)	27.5(4.55)
T_5	5.4(1.83)	17.66(2.9)	37.13(5.83)	15(2.72)	14.33(2.67)
T_6	20.26(3.58)	32.33(4.91)	42.16(6.37)	20.6(3.97)	26.86(4.49)
T_7	20.23(4.42)	37.06(6.06)	61.4(7.82)	25.3(5.03)	29.2(5.39)
T_8	25.73(5.02)	59.36(7.72)	80.6(8.99)	64.5(8.05)	68.66(8.32)
T_9	32.7(5.73)	57.93(7.58)	79.03(8.91)	43.96(6.48)	49.33(7.02)
T_{10}	32.36(5.60)	50.66(7.04)	81.5(9.04)	41.06(6.44)	59.33(7.72)
T_{11}	19.93(4.44)	41.5(6.45)	43.6(6.63)	44.1(6.35)	43.33(6.45)
T_{12}	31.66(5.66)	35.63(5.99)	78.16(8.85)	31.13(5.63)	43.36(6.62)
T_{13}	25.46(4.89)	44.7(6.55)	57.5(7.44)	33.13(5.76)	19.33(4.35)
T_{14}	25.06(4.14)	36.93(5.21)	40.5(6.18)	19.93(4.42)	35.96(5.16)
T_{15}	17(2.83)	30(4.71)	42.6(6.42)	28.76(4.60)	18.53(3.77)
T_{16}	10.06(3.62)	18.4(2.95)	36.33(4.89)	16.5(3.57)	13.66(2.61)
T_{17}	44.33(6.514)	42.66(5.58)	53.63(6.24)	16(3.33)	16.23(2.80)
T_{18}	42.66(6.55)	62.46(7.92)	75.5(8.67)	14.83(20.74)	69.36(8.34)
T_{19}	37.2(6.11)	45.16(6.73)	84.66(9.185)	60.66(7.79)	56.7(7.55)
T_{20}	61.7(7.89)	72.1(8.5)	77.46(8.77)	58.83(7.66)	66(8.12)
F value	1.997*	1.292^{NS}	1.2^{NS}	1.801^{NS}	2.504*
CD (0.05)	3.31				3.902

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.1.8. Collar girth of retained suckers

It can be inferred from Table 16 that treatment T_9 (local control in 15 Kg red soil only,) produced maximum collar girth followed by treatment T_{10}, T_{18}, T_{19}, T_{20}, T_{13}, and T_{11} respectively which were statistically at par with each other in 60 days. At 90 days the control treatment and treatment T_{17} excelled followed by treatments T_{19}, T_8 and T_9 respectively and the results showed statistical significance. At 150^{th} day treatments T_8 and T_{19} yielded plants with maximum girth, but the results were not statistically significant. At

the half yearly stage there were significant differences in treatment means with treatment T_{19} followed by treatments T_8 and T_{18} which yielded plants with highest collar girth.

Table 16. Influence of different combination of potting media on collar girth of retained plantlets at R-1 stage.

Treatment	Collar girth of attached sucker produced at monthly intervals				
	60 days	90 days	120 days	150 days	180 days
T_1	2.5(1.41)	2.73(1.45)	2.933(1.49)	2.7(1.45)	2.73(1.45)
T_2	0.86(1.05)	5.8(2.48)	4(2.09)	3.93(1.9)	1.86(1.29)
T_3	2.7(1.45)	4.23(1.97)	3.86(1.90)	3.63(1.86)	5.33(2.72)
T_4	3.36(1.81)	7.2(2.47)	7.6(2.539)	6.83(2.41)	5.4(2.18)
T_5	1.26(1.16)	2.53(1.42)	8.33(2.98)	2.9(1.48)	2.7(1.47)
T_6	3.43(1.81)	5.43(2.19)	7.2(2.76)	4.8(2.09)	5.16(2.15)
T_7	1.93(1.47)	8.2(2.94)	13.63(3.89)	6.2(2.57)	6.53(2.63)
T_8	0(0.7)	10.03(3.24)	12.66(3.76)	11.03(3.39)	12.06(3.54)
T_9	9.4(3.13)	9.83(3.21)	9.86(3.17)	8.33(2.96)	10.1(3.25)
T_{10}	7.13(2.72)	8.66(3.03)	10.2(3.27)	7.5(2.82)	9.03(3.07)
T_{11}	5.06(2.32)	5.96(2.51)	8.56(2.95)	7.76(2.85)	9.16(3.09)
T_{12}	4.5(2.18)	7.76(2.83)	7.033(2.73)	9.26(3.11)	9.93(3.21)
T_{13}	5.26(2.35)	3.26(1.77)	6.76(2.64)	6.7(2.65)	8.16(2.92)
T_{14}	3.76(1.88)	3.5(1.82)	7.26(2.78)	5.93(2.27)	7.7(2.55)
T_{15}	2.3(1.56)	2.73(1.45)	5.13(2.35)	3.73(1.87)	5.466(2.20)
T_{16}	1.2(1.14)	5.36(2.18)	4.2(2.35)	3.53(1.59)	2.2(1.35)
T_{17}	5.03(2.12)	11.46(3.45)	7.9(2.88)	2.83(1.47)	3.16(1.52)
T_{18}	6.63(2.62)	8.86(3.06)	8.5(2.98)	9.86(3.22)	11.16(3.41)
T_{19}	6.23(2.58)	11.1(3.40)	12.36(3.59)	10.96(3.38)	12.46(3.59)
T_{20}	6.2(2.59)	11.46(3.46)	9.5(3.17)	7.56(2.83)	9.7(3.16)
F value	2.134*	2.013*	2.344*	1.493^{NS}	2.095*
CD (0.05)	1.281	1.413	1.125	-	1.552

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.1.9. Number of leaves retained

The data regarding the number of leaves presented in Table 17 revealed that number of leaves at monthly intervals is more a reflection of height, collar girth and number of plants retained. At 60 days treatment T_{20} which is 20 Kg red soil and at 90 and 120 days it was treatments T_{19} and T_{20}, at 150 days it was treatments T_{19} and T_{18} and at end of 6 months it was treatments T_{11}, T_{12}, T_{18}, T_{19} and T_{20} (control, in 20 Kg red soil alone) that recorded

maximum number of leaves. At all the intervals the difference in treatments were not statistically significant

Table 17. Number of leaves in retained plantlets at monthly intervals in different combination of potting media

Treatment	Number of leaves at monthly intervals				
	60 days	90 days	120 days	150 days	180days
T_1	0.66(0.99)	1.16(1.13)	1(1.09)	1(1.09)	1.16(1.13)
T_2	0.33(0.87)	2(1.58)	2.66(1.74)	1(1.56)	1(1.09)
T_3	1(1.09)	1(1.09)	2.16(1.53)	2.33(1.56)	2.33(1.56)
T_4	0.83(1.05)	2.5(1.6)	3.66(2.02)	2.16(1.52)	2(1.49)
T_5	0.33(0.87)	1.16(1.13)	3.83(2.08)	0.83(1.05)	1.16(1.13)
T_6	1.33(1.26)	1.5(1.34)	3.16(1.9)	2.16(1.52)	1.83(1.43)
T_7	1.33(1.28)	3.16(1.9)	4.33(2.18)	2.33(1.68)	2.5(1.72)
T_8	2(1.56)	4(2.12)	4(2.11)	2.66(1.77)	2.33(1.654)
T_9	2.66(1.77)	2.91(1.84)	3.5(1.99)	3.16(1.92)	2.83(1.82)
T_{10}	2.33(1.67)	2.41(10.79)	3.66(2.04)	2.83(1.81)	2.16(1.63)
T_{11}	1.83(1.52)	2.16(1.62)	4.16(2.14)	3.83(2.07)	3.83(2.07)
T_{12}	2.66(1.77)	3.33(1.95)	2.83(1.82)	3.5(2)	3.16(1.91)
T_{13}	2.083(1.59)	3.16(1.89)	3.63(1.99)	3.66(2.02)	3.33(1.95)
T_{14}	2(1.47)	2.7(1.75)	3.06(1.87)	2.33(1.65)	1.33(1.28)
T_{15}	2.16(1.52)	2.416(1.58)	2.83(1.82)	1.66(1.38)	1.33(1.26)
T_{16}	0.91(1.07)	1(1.09)	2.66(1.81)	1.5(1.34)	1.66(1.38)
T_{17}	2(1.49)	2.33(1.56)	2.66(1.71)	1.66(1.25)	1.66(1.251)
T_{18}	2.83(1.82)	4(2.11)	4.23(2.17)	3.5(1.99)	3.16(1.9)
T_{19}	2.66(1.77)	3.5(1.99)	4.16(2.15)	4(2.11)	3(1.85)
T_{20}	3.33(1.95)	3.5(1.99)	4.46(2.22)	2.83(1.82)	3(1.86)
F value	1.631^{NS}	1.508^{NS}	1.775^{NS}	1.469^{NS}	1.102^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.1.10 Number of quality suckers, underdeveloped suckers, dead suckers and mean of total suckers

A critical analysis of data in Table 18 revealed that the number of quality suckers at 6 months was maximum in T_{18} (20 kg of red soil only) followed by treatments T_{19} (control in 20 kg red soil only) and T_9 (control in 15 kg red soil) and treatment T_{12}. The differences in treatment means were also significant.

In case of under developed suckers the number produced were very low with maximum of one in treatments T_2 in 15 kg of coir pith, sawdust and soil in proportion of

1:2:1 and T_{11} in 20 Kg of coir pith, sawdust and soil in proportion of 1:1:1. A similar trend was observed in case of dead suckers also. The total sucker production which included quality, underdeveloped and dead sucker was highest in treatment T_{18} followed by treatments T_{19}, T_{20} and T_9. The result also showed statistical significance at one percent.

Table 18. Number of quality suckers, underdeveloped suckers, dead suckers and mean of total suckers produced at R-1 as influenced by different combination of potting media

Treatment	No. of quality sucker	No. of underdeveloped suckers	No. of dead suckers	Mean of total suckers
T_1	0.66(0.99)	0.33(0.87)	0.33(0.87)	1.3(1.26)
T_2	2(1.56)	1(1.22)	1(1.18)	4(2.09)
T_3	2.33(1.65)	0.33(0.87)	0.33(0.87)	3(1.815)
T_4	2.66(1.76)	0(0.7)	0.66(1.05)	3.33(1.95)
T_5	3(1.84)	0.33(0.87)	0.33(0.87)	3.66(2.02)
T_6	1.66(1.46)	0(0.7)	0.33(0.87)	2(1.58)
T_7	2(1.56)	0.33(0.87)	1(1.18)	3.33(1.89)
T_8	2(1.56)	0(0.7)	0(0.7)	2(1.56)
T_9	4(2.11)	0.33(0.87)	0.33(0.87)	4.66(2.24)
T_{10}	3.33(1.91)	0(0.7)	0.66(1.05)	4(2.09)
T_{11}	2.66(1.77)	1(1.22)	1(1.18)	4.66(2.27)
T_{12}	3.66(2.004)	0.33(0.87)	0.66(1.05)	4.66(2.24)
T_{13}	3(1.85)	0.66(1.05)	0.33(0.87)	4(2.11)
T_{14}	2.33(1.67)	0(0.7)	0.66(1.05)	3(1.85)
T_{15}	3(1.85)	0.66(1.05)	0.66(0.99)	4.33(2.19)
$T1_6$	3(1.88)	0.33(0.87)	1(1.18)	4.3(2.19)
T_{17}	2.33(1.64)	0(0.7)	0.33(0.87)	2.66(1.76)
T_{18}	5.66(2.46)	0(0.7)	0.33(0.87)	6(2.52)
T_{19}	4(2.114)	0.66(1.05)	0.66(1.05)	5.33(2.41)
T_{20}	3.33(1.95)	0.33(0.87)	1(1.18)	4.66(2.25)
F value	2.33*	1.724^{NS}	0.47^{NS}	4.37**
CD (0.01)				0.775
CD (0.05)	0.566			0.576

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.11 Weight and Volume of corm

A thorough examination of the data regarding the Weight and volume of the corm presented in the Table 19 revealed that the mean weight of plantlets produced were highest in treatment T_{19} (control in 20 Kg red soil) followed by treatments T_{11} (media composition

of coir pith, sawdust and soil proportion as 1:1:1), T_{18} (local control in 20 Kg red soil, T_9 (control in 15 kg of red soil). In case of volume it was treatment T_{12} (in 20 kg of coirpith, saw dust and soil in proportion of 1:2:1,) followed by treatments T_9, T_{18} and T_{19}. The best treatment was at par with above treatments and treatments T_8, T_{11}, T_{13} and T_{14}.

4.2.12. Number of roots

The maximum number of roots produced was in the treatment T_{20} (control of 20 Kg Red soil), followed by treatments T_{19}, T_{12}, T_9, T_8 which were statistically at par with each other.

In case of weight, volume and number of roots the differences between the treatment means were statistically significant even at one per cent.

Plate 9. Most effective potting media treatment T_{18} in 20 kg red soil at R-1, 60 days after planting

Table 19. Corm weight, volume of corm and number of roots produced as influenced by potting media at R-1 stage.

Treatment	Weight (g)	Volume (cc)	Number of roots
T_1	52.33	30.33	29.33
T_2	58.66	85.33	9.33
T_3	32	35.66	10
T_4	129.66	142.66	7
T_5	61.66	59.33	3
T_6	69.33	88.66	7.33
T_7	126.33	94	9
T_8	215.66	231.33	36.66
T_9	288.33	264.66	37.33
T_{10}	247.66	159.33	44
T_{11}	317	233	49
T_{12}	268.66	298.333	58
T_{13}	231.66	233	12.33
T_{14}	154	129.66	23.33
T_{15}	96	52.66	15.66
T_{16}	81.66	70	13
T_{17}	86.33	76.66	6
T_{18}	304.33	248	46.333
T_{19}	479.66	246	65
T_{20}	233.33	187	66.66
F value	2.446**	2.532**	3.476**
CD(0.01)	132.23	125.41	46.16
CD(0.05)	98.85	93.79	34.5

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

4.1.2 Ratoon-2

The results of the study after imposing the same treatment on the corm of R-1 suckers were planted and the results are as follows.

4.2.2.1 Number of suckers produced

A critical analysis of number of sprouts at monthly interval presented in Table 20 revealed that suckering was observed only in treatments were the potting media was soil alone. There was only subtle difference that were observed at the level of the weight of potting media. The maximum number of suckers retained in all the treatments beginning from the first month to the fourth month was observed only in soil media. At the first month it was treatment T_8 (15 Kg red soil only). In the second and third month it was treatments

T_{10} and T_9 followed by treatments T_{19} and T_{18} and in the fourth month it was treatment T_{19}. This again reveals that the weight of the potting media is not a matter of very much importance with regard to earliness in sprouting.

4.2.2.2 Mean of total number of sprouts

The data regarding the mean of total number of sprouts produced presented in the Table 20 revealed that maximum number of sprouts were observed in treatments T_8 (15 Kg of red soil alone), T_{18} (20 Kg of red soil alone), 20 kg) and T_{19} the local control in 20 Kg red soil only that produced same number of 4.3 sprouts which was significantly superior over all other treatment means. A significant observation was that there was no plantlet production in the other 14 treatments of study.

Plate 10. Most effective potting media treatment T_{18} in 20 kg red soil at R-2, 60 days after planting

Table 20: Number of suckers produced in R-2 at monthly intervals in different combination of potting media.

	No. of sucker in monthly interval				
Treatments	30 days	60 days	90 days	120 days	Mean of total No. of sprouts
T_1	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_2	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_3	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	1(1.18)	2(1.58)	1.33(1.34)	1.33(1.34)	4.3(2.19)
T_9	0.66(1.05)	1.33(1.34)	2(1.58)	1.33(1.34)	3(1.86)
T_{10}	0(0.7)	1.66 (1.35)	2(1.56)	1.33(1.34)	3(1.86)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{13}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{17}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{18}	0.33(0.87)	1(1.22)	1.33(1.34)	1.66(1.46)	4.3(2.19)
T_{19}	1.66(1.46)	2(1.58)	1.66(1.46)	2(1.58)	4.3(2.19)
T_{20}	0.66(1.05)	1.33(1.34)	1.33(1.34)	1.66(1.46)	3(1.85)
F value	5.24**	9.307**	26.625**	32.781**	78.25**
CD (0.01)	0.352	0.396	0.254	0.221	0.032
CD (0.05)	0.268	0.299	0.191	0.167	0.023

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.2.3. Height of the second ratoon suckers

A perusal of the data presented Table 21 makes it very clear that in the 1st and 2nd month stage maximum height was observed in treatment T_{18} (20 Kg of red soil media), which was followed by treatment T_{11} in first month and treatment T_9 in the second month. In the 3rd month treatment T_8 followed by treatmentsT_{19} and T_{18} recorded maximum height and at the 4th month it was treatments T_{18}, T_{20} and T_{13}. At all intervals the results were statistically significant even at one per cent level in all the months.

Table 21. Height of retained plantlets at R-2 stage in different combination of potting media.

	Height (cm) at monthly intervals			
Treatments	30 days	60 days	90 days	120 days
T_1	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_2	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_3	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	1.83(1.44)	5.03(2.41)	12.96(3.46)	10.93(3.36)
T_9	2.73(1.79)	6.5(2.64)	8.1(2.94)	11.5(3.46)
T_{10}	0(0.7)	2.033(1.48)	9.53(3.16)	12.83(3.63)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{13}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{17}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{18}	3.13(1.9)	8.06(2.92)	12.06(3.53)	16.13(4.06)
T_{19}	2.16 (1.63)	3.2(1.91)	12.43(3.59)	13.6(3.76)
T_{20}	0.6(0.98)	8.06(2.92)	11.5(3.46)	14.33(3.84)
F value	15.004**	69.572**	38.786**	186.34**
CD (0.01)	0.402	0.381	0.764	0.392
CD (0.05)	0.301	0.286	0.571	0.296

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.2.4. Collar girth of the suckers

The data on collar girth present in Table 22 revealed that treatment T_{18}, (20 Kg Red soil only) produced plantlet with good collar girth at 1st month and second month. In the 3rd month it was treatment T_{19} which recorded maximum girth and in the 4th month it was treatments T_{14} and T_{20}. In all the cases the results were significant even at one percent level.

Table 22. Collar girth of retained platelets at R-2 stage in different combinations of potting media.

	Collar girth (cm) at monthly intervals			
Treatments	30 days	60 days	90 days	120 days
T_1	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_2	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_3	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.46(0.96)	2.26(1.66)	3.033(1.87)	3.46(1.98)
T_9	0.73 (1.07)	1.8(1.49)	2.63(1.76)	3.26(1.94)
T_{10}	0(0.7)	1.93(1.46)	3.1(1.86)	3.36(1.94)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{13}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{17}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{18}	2(1.57)	2.66(1.77)	4.06 (2.13)	4.1(2.14)
T_{19}	1.13 (1.22)	1.7(1.473)	3.18(1.87)	4.53(2.24)
T_{20}	0.26(0.85)	1.46(1.39)	2.7(1.785)	3.33(1.95)
F value	7.121**	14.393**	74.007**	136.514**
CD (0.01)	0.33	0.401	0.246	0.207
CD (0.05)	0.246	0.303	0.18	0.158

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.2.2.5 Number of leaves retained in second ratoon suckers

The data on the number of leaves retained which is presented in Table 22 revealed that in the first month and second month treatment T_{18} (20 Kg of red soil alone) and treatment T_9 (local control in 15 Kg of Red soil) recorded maximum number of leaves. At 3rd month maximum number of leaves produced in treatment T_{20} and in the 4th month it was in treatments T_{18} and T_{10}. The result was statistically significant at one percent level. In case of ratoon the leaves began to dry, and plant showed symptoms of flaccidity and hence the

study was stopped at 4th month and plantlets planted out. Analysis of the number of underdeveloped suckers also showed that it was prudent to go for planting out at this stage and do not proceed any further.

Table23. Number of leaves in retained plantlet at R-2 stage in different combination of potting media.

	Number of leaves retained at monthly intervals			
Treatments	30 days	60 days	90 days	120 days
T_1	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_2	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_3	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66(1.05)	1.33(1.34)	1.66(1.46)	1.66(1.46)
T_9	0.66(1.05)	1.33(1.34)	2(1.58)	1.66(1.46)
T_{10}	0(0.7)	1(1.18)	1.66(1.46)	2(1.58)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{13}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{17}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{18}	1.66(1.46)	2(1.58)	1.66(1.46)	2(1.58)
T_{19}	1(1.18)	1.66(1.46)	1.66(1.46)	1.66(1.46)
T_{20}	0.33(0.87)	1.33(1.34)	2(1.581)	1.66(1.46)
F value	5.24**	17.101**	49.824**	49.824**
CD(0.01)	0.352	0.292	0.201	0.201
CD (0.05)	0.268	0.221	0.158	0.158

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.3 Experiment III: Effect of AMF (*Glomus fasciculatum)* and *Azospirillum* on macropropagation using banana sucker (Nendran AAB).

The best physical activation technique and the best soil media formed the common practice which was uniformly given in all the treatments.

4.3.1. Ratoon-1

4.3.1.1. Days to first sprout

It can be inferred from the Table 24 that the number of days taken to first sprout ranged from 22-24 days and no significant differences between treatment means were observed.

4.3.1.2. Number of suckers retained

The data regarding the mean number of sprouts retained presented in Table 24 revealed that in the second fortnight after planting maximum sprouts were observed in treatment T_1 (10g of AMF application per sucker) followed by treatment T_2. In the 3rd fortnight after planting it was treatment T_3 (30g of AMF application per sucker) followed by treatments T_{10} and T_1 whereas in the 4th fortnight it was treatments T_1 and T_{12} that recorded the maximum number of retained suckers. In the 5th fortnight after planting maximum suckers were observed in the treatment T_3. At the end of the 3rd month it was treatmentT_{12} which recorded maximum number of plantlets retained. In 7th fortnight, treatment T_3 followed by treatmentT_6 and T_{10}recorded maximum plantlet retained. At the end of 4th month only 2.0 plantlets were observed at treatmentsT_3, T_6 and T_{10}.Similar observation was noticed in the 9th fortnight with treatments T_{10} and T_6 recording the maximum number. At 5th month after planting maximum number of plantlets retained were in treatment T_6 whereas in 11th month it was treatment T_{13}. Analysis of the data at all nine fortnight intervals revealed that there was no significant difference in the treatment means.

4.3.1.3. Mean of total number of suckers

The data presented in the same Table 24 revealed that treatment T_{10} (20g of AMF + 10g of *Azospirillum.* per sucker) produced the highest mean number of five sprouts among

all the treatments followed by treatments T_{14}, T_1, T_{15} and T_3 which were statistically at par with each other.

Table 24. Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum*) on days to first sprout, sprouts retained at fortnightly intervals and mean of total number of sprouts in R-1 stage.

reatments		fortnightly interval (Sprouts retained)										
	Days to 1st sprout	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	Mean of total No. of suckers
T_1	22 (4.69)	3.33 (1.89)	2.33 (1.65)	2.33 (1.65)	1.33 (1.34)	1 (1.22)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	1 (1.22)	1 (1.22)	3.66 (2.03)
T_2	22 (4.69)	2.66 (1.77)	2 (1.58)	2 (1.58)	1.66 (1.46)	2 (1.58)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.33 (1.34)	2.66 (1.77)
T_3	22 (4.69)	2.66 (1.76)	2.66 (1.77)	3 (1.86)	2.33 (1.65)	2 (1.56)	2 (1.56)	2 (1.56)	1.66 (1.46)	1.67 (1.46)	1.33 (1.34)	3 (1.86)
T_4	23.33 (4.82)	1.33 (1.28)	1.67 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.67 (1.46)	1.33 (1.34)	1.66 (1.46)
T_5	22 (4.69)	1.66 (1.44)	1.66 (1.44)	1.67 (1.44)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	1.67 (1.44)	1 (1.22)	1.66 (1.44)
T_6	24.66 (4.97)	0.66 (0.99)	1.66 (1.46)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	1.667 (1.46)	2 (1.56)
T_7	22 (4.69)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.18)
T_8	22 (4.69)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	1.33 (1.29)
T_9	22 (4.69)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.33 (1.34)	1.66 (1.46)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	2 (1.56)
T_{10}	22 (4.69)	1.66 (1.46)	2.33 (1.64)	2 (1.56)	1.66 (1.46)	2 (1.56)	2 (1.56)	2 (1.56)	2 (1.56)	1.67 (1.44)	1.33 1.34)	5 (2.34)
T_{11}	22 (4.69)	1.66 (1.46)	1.33 (1.34)	1.66 (1.46)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	2 (1.56)
T_{12}	22 (4.69)	1.66 (1.46)	2 (1.58)	2.33 (1.65)	2 (1.56)	2.33 (1.654)	1.67 (1.46)	1.66 (1.46)	1.67 (1.46)	1.67 (1.46)	1.3333 (1.34)	2.66 (1.71)
T_{13}	22 (4.69)	1.66 (1.46)	1.33 (1.28)	1.33 (1.29)	1.66 (1.38)	1.67 (1.38)	1.66 (1.38)	1.66 (1.38)	1.67 (1.38)	1.67 (1.38)	1.67 (1.38)	1.66 (1.38)
T_{14}	22 (4.69)	1.66 (1.46)	1.67 (1.46)	1.33 (1.34)	1.66 (1.44)	1.66 (1.44)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	4.33 (2.19)
T_{15}	22 (4.69)	1 (1.22)	1 (1.22)	1 (1.22)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	3.33 (1.94)
T_{16}	23.33 (4.82)	0.66 (1.05)	0.67 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.67 (1.05)	0.67 (1.05)	0.33 (0.87)	0.66 (0.99)
F value	1.777	1.892^{NS}	1.515^{NS}	1.52^{NS}	0.67^{NS}	0.85^{NS}	0.72^{NS}	0.725^{NS}	0.77^{NS}	0.663^{NS}	1.01^{NS}	2.41*
CD (0.05)												0.680

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.1.4. Number of new suckers produced at fortnightly intervals

The data regarding the total number of new suckers (total of all replicates) produced presented in Table 25 revealed that in the 2nd fortnight maximum number of 10.0 plantlets were produced in treatment T_1 (10g of AMF application per sucker) followed by treatment T_3 (10g of AMF application per sucker) and treatment T_{10} (20g of AMF+ 10g of *Azospirillum.* per sucker) which accounted for 8.0 plantlets and 6.0 plantlets respectively. At 2nd fortnight new suckers were only observed in two treatments namely T_6 and T_{15} recording 3.0 suckers each and treatments T_4 and T_{12} that recorded one sucker each. At 4th fortnight again only four treatments produced sprouts and the treatments T_{10}, T_{14} yielded 4.0 plantlets each. From 7th fortnight to 11th fortnight there was practically no of sucker production, except in the 8th fortnight wherein T_{14} produced 4.0 suckers.

4.3.1.5. Total number of new suckers

The data presented in Table 25 revealed that maximum number of suckers produced was observed in treatment T_{10} (20g of AMF+ 10g of *Azospirillum.* per sucker) followed by treatments T_{14}, T_1 and T_{15} respectively.

4.3.1.6. Number of suckers planted out

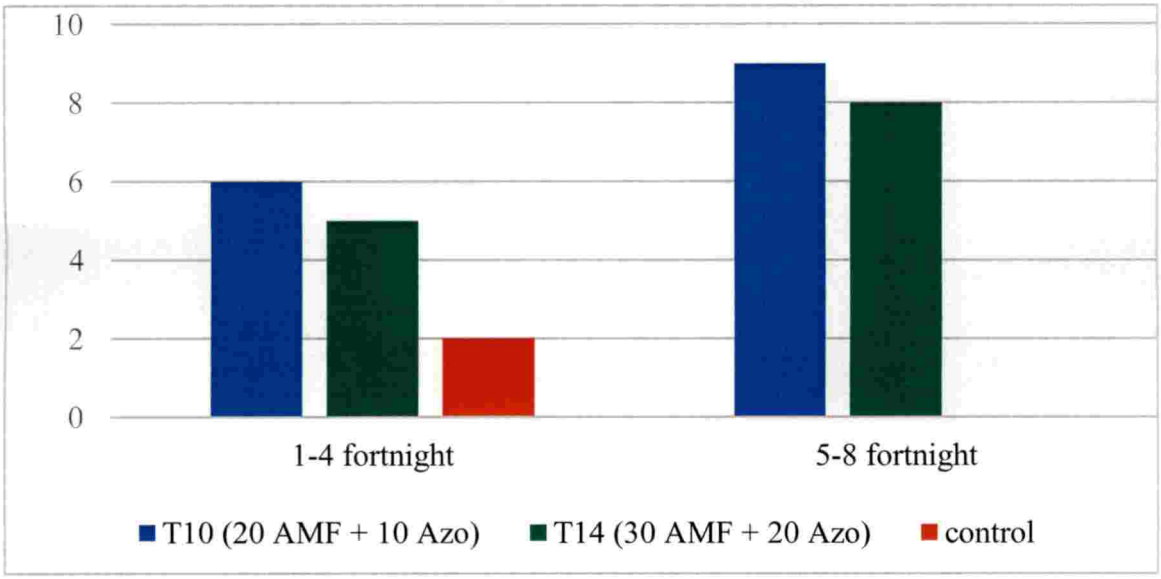
The data presented in Table 25 revealed that the first planting out of plantlets began after 3rd fortnight in treatments T_1 (10g of AMF application per sucker) and T_{13} (30g of AMF + 10g of *Azospirillum* per sucker) with 3.0 and 1.0 plantlet respectively. At 4th fortnight it was 1.0 each in treatments T_2, T_{14} and T_{15}. At 5th fortnight it was 4.0 plantlet that were planted out in treatments T_1, T_2 and T_{15}. In 6th fortnight one each were planted out in treatments T_1, T_2 and T_3. It was more or less the same in the 7th fortnight but the planting out was observed in treatments T_8, T_9 and T_{14}. In the 8th fortnight planting out was carried out only in treatment T_{12}. In the 9th fortnight planting out was done in treatments T_{11} and T_{15} while in the 10th fortnight planting out was done in the treatments T_{11}, T_{12}, T_{13}, T_{14}, T_{15} and T_{16}. In the 11th month it was 2.0 in treatment T_{15} (30g of *Glomus fasciculatum*+30g of *Azospirillum. spp* per sucker) and one each in treatments T_1, T_2, T_3, T_6 and T_{15}. At the end of 11th fortnight plantlets showed flaccidity and less of vigor and hence all the remaining plantlets were carried for next cycle.

Table 25. Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum*) on number of new suckers produced, number of suckers detached (shown in brackets) at fortnightly interval and total number of suckers produced in R-1 stage.

Treatments	Total number of suckers produced at fortnightly intervals										
	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	Total No. of suckers
T_1	10	0(3)	0	0(4)	0(2)	1	0	0	0	0	11
T_2	6	0	0(2)	1	0(2)	0	0	0	0	0(2)	7
T_3	8	0	1	0(2)	0(3)	0	0	0(1)	0	0(1)	9
T_4	4	1	0(2)	0	0	0	0	0	0	0(2)	5
T_5	5	0	0	0	0	0	0	0	0	0(4)	5
T_6	2	3	1	0	0	0	0	0	0	0(4)	6
T_7	3	0	0	0(2)	0	0	0	0	0	0	3
T_8	4	0	0	0	0	0(3)	0	0	0	0	4
T_9	5	0	0	0(2)	1	0(2)	0	0	0	0	6
T_{10}	6	0	0	4(1)	0	0	5	0	0	0(5)	15
T_{11}	5	0	1	0	0	0	0	0(1)	0(1)	0	6
T_{12}	5	1	1	0(2)	1	1	0(2)	0	0(2)	0	8
T_{13}	5	0(1)	0	1	0	0	0	0	0(2)	0	6
T_{14}	5	0	0(3)	4	0	0(4)	4	0	0(3)	0	13
T_{15}	5	3	0(1)	0(2)	2	0	0	0(1)	0(1)	0(1)	10
T_{16}	2	0	0	0	0	0	0	0	0(2)	0	2

Values in the parenthesis show the number of detached suckers

Figure 4. Waves of suckering observed in selected treatments at first ratoon stage due to biofertilizer treatments of *Glomus fasciculatum* and *Azospirillum*.



4.3.1.7. Height of the plantlet retained

The data regarding height of the plantlet retained presented in Table 26 revealed that though there were detachments of the suckers as and when they satisfied the required quality parameters, the mean height increased particularly from first month to fifth month. In the first month, treatment T_9 (10g of AMF + 30g of *Azospirillum* per sucker) recorded maximum height (15.3) followed by treatments T_7, T_8 and control. The lowest was recorded in treatment T_{15} (10g of AMF + 20g of *Azospirillum* per sucker). In the 2nd month, treatment T_8 (30g of AMF +30g of *Azospirillum* per sucker) excelled over treatments followed bytreatmentsT_9, T_7, T_2 and T_{10}. In the 3rd month treatment T_1 recorded the maximum mean height of 61.6 cm followed by treatments T_{11}, T_9, T_3 and T_{12}. In the 4th month, treatment T_4 recorded maximum height of 70.57cm, followed by treatments T_2 (64.6cm), T_9 (63.37cm) and T_5 (56.56cm). At the end of 5th month of planning treatment T_3 recorded maximum height followed by treatment T_1, T_{11}, T_4, T_9, T_5 and T_{14}. There were no significant differences between treatment means.

Table 26. Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum.*) on height of the retained plantlets at R-1 stage.

Treatment	Height of retained plantlets at monthly interval				
	30 days	60 days	90 days	120 days	150 days
T_1	7.43 (2.76)	27.27(5.25)	61.6(7.86)	54.66 (7.26)	84.07(9.13)
T_2	7.86 (2.794)	30.37(5.55)	48.2(6.97)	64.6(8.055)	53(7.26)
T_3	7.56 (2.63)	28.7(5.39)	52(7.12)	57.8(7.57)	86.67(9.33)
T_4	7.03 (2.44)	27.73 (5.14)	41.26 (6.44)	70.57(8.42)	75.67(8.72)
T_5	9.7(3.13)	23.87(4.92)	50.73 (7.16)	56.56 (7.44)	74.67(8.66)
T_6	2.53 (1.42)	17.73 (4.24)	27.36 (5.27)	37.3(6.11)	41.67(6.49)
T_7	14.43(3.79)	33.6(5.8)	45.17(6.75)	55.73(7.49)	53.66 (7.35)
T_8	14.37(3.84)	35.87(5.46)	45.23(6.73)	47.4(6.86)	48.33(6.92)
T_9	15.53(3.96)	34.36 (5.85)	55.9(7.49)	63.37(7.89)	75(8.69)
T_{10}	8.87(3.02)	30.03 (5.46)	44.53 (6.64)	55.13 (7.4)	63(7.95)
T_{11}	9.63 (3.09)	27.2(5.21)	56.37(7.53)	54.033 (7.32)	78.67(8.89)
T_{12}	7.67(2.74)	24.7(4.99)	50.16 (7.1)	49.6(7.064)	47.67(6.89)
T_{13}	8.2(2.6)	18.03 (3.72)	24.33 4.27)	27.033(4.51)	39(5.35)
T_{14}	9.76(3.17)	24.73 (4.99)	36.53(5.97)	49.76 (7.02)	74(8.61)
T_{15}	3.3(1.78)	27.26 (5.26)	43.83 (6.66)	50.63 (7.13)	64.66 (8.01)
T_{16}	12.33 (3.13)	25.67(4.39)	31.93(4.87)	38.63 (5.34)	41.33(5.50)
F value	1.163^{NS}	0.685^{NS}	1.488^{NS}	1.091^{NS}	1.798^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.1.8. Collar girth of the retained suckers

From the data on mean collar girth of the retained suckers presented in Table27, it could be deduced that at the end of first month, treatment T_7 (10g of AMF + 10g of *Azospirillum* per sucker.) recorded the maximum collar girth of 4.66cm followed by treatments T_8 and T_{13}. In the second month collar girth showed an increasing trend and maximum collar girth was observed in treatment T_9 (10g of AMF + 30g of *Azospirillum. spp* per sucker) followed by treatments T_1, T_{14}, T_2, T_{15}, T_{12} and T_7 whereas in the third month contrary to height, collar girth showed a slight decrease particularly in treatments T_5, T_7, T_9, T_{14} and control. This is due to the detachment of the quality suckers. At the end of 3rd month maximum collar girth was observed in treatment T_1 (10g of AMF per sucker) (13.7 cm) followed by treatments T_9 and T_{15}. At 120th day, all treatments showed an increase in collar girth except treatments T_1 and T_{13} and maximum collar girth was observed in treatment T_9 followed by treatments T_2, T_1 and T_{15}. At the fifth month treatmentsT_1 and T_3 recorded maximum collar girth followed by treatments T_9, T_{11} and T_4. In all the cases the data showed no significant differences between the treatment means.

Table:27 Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum.*) on collar girth of the retained plantlets at R-1 stage.

Treatments	Collar girth (cm) of retained suckers at monthly interval				
	30 days	60 days	90 days	120 days	150 days
T_1	3.43 (1.81)	9.9(3.19)	13.7(3.74)	10.43 (3.27)	12.83 (3.64)
T_2	2.13 (1.51)	9.2(3.11)	9.23 (3.11)	11.4(3.45)	10.86 (3.37)
T_3	2.8(1.67)	6.8(2.69)	7.36 (2.77)	8.43 (2.96)	12.83 (3.65)
T_4	2.66 (1.65)	8.1(2.88)	9.13 (3.09)	9.57(3.17)	11.4(3.43)
T_5	3.97(1.92)	8.97(3.06)	8.66 (3.)	9.366 (3.14)	10.4(3.29)
T_6	2.53 (1.42)	5.96 (2.51)	6.57(2.65)	7.067(2.73)	6.76 (2.67)
T_7	4.66 (2.05)	9(3.072)	8.56 (3.02)	9.47(3.15)	9.56 (3.17)
T_8	4.1(2.15)	8.4(2.97)	8.7(3.03)	9.9(3.23)	10.1(3.25)
T_9	3.33(1.79)	10.43 (3.28)	10.16 (3.26)	11.87(3.51)	11.93 (3.52)
T_{10}	1.5(1.22)	7.73 (2.84)	7.86 (2.85)	8 (2.9)	10.66 (3.34)
T_{11}	3.36 (1.8)	8.7(3.023)	9.37(3.13)	9.43 (3.09)	11.63 (3.49)
T_{12}	1.5(1.22)	9.067(3.09)	9.4(3.08)	9.76 (3.19)	9.7(3.16)
T_{13}	4(1.93)	5.26 (2.16)	6.63 (2.39)	5.46 (2.19)	5.27(2.17)
T_{14}	2.13 (1.51)	9.66 (3.17)	9(3.07)	9.13 (3.1)	9.5(3.16)
T_{15}	0(0.7)	9.1(3.09)	9.63 (3.17)	9.9667(3.23)	10.33 (3.29)
T_{16}	2.96 (1.49)	7.17(2.48)	6.97(2.45)	8.066 (2.59)	7.36 (2.51)
F value	0.853^{NS}	0.785^{NS}	0.784^{NS}	0.865^{NS}	1.594^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.3.1.9 Number of leaves retained

The data regarding number of leaves retained is presented in Table 28. It can be inferred that at thirty days after planting, treatment T_1 (10g of *Glomus fasciculatum* application per sucker) recorded maximum number of leaves followed by treatments T_{14}, T_8, T_{15} and T_5, which recorded mean values of 3.66 in the first three treatments, and 3.33 in the latter. In the second month, a mean maximum retention of 6.33 leaves was observed in treatment T_{14} (30g of AMF + 20g of *Azospirillum* per sucker) followed by treatments T_7, T_{15}, T_9, T_{12}, T_{11} and T_8 respectively. In the 3rd month, treatment T_5 (20g of *Azospirillum. spp* application per sucker) recorded maximum retention of leaves followed by treatmentsT_{10} and T_8. In the 4th month a reduction in leaves was observed in many of the treatments except in T_1, T_2, T_6, T_7, T_9, T_{12}. The, treatments T_1 and T_2 recording the maximum. At 150th day, treatmentT_9 recorded maximum number of leaves followed by treatmentsT_{11}, T_{12} and T_{13}. No statistical differences were observed between treatment means.

Table 28. Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum*) on number of leaves of retained plantlets at monthly interval by new suckers in R-1 stage

Treatments	Number of leaves retained at monthly interval				
	30 days	60 days	90 days	120 days	150 days
T_1	4(2.11)	4.83(2.29)	4(2.12)	5(2.34)	3(1.82)
T_2	2.86(1.83)	4.17(2.15)	4(2.11)	5(2.34)	1.33(1.29)
T_3	2.16 (1.63)	4.33(2.19)	4.33 (2.18)	4(2.12)	2(1.47)
T_4	3(1.86)	4.83(2.30)	4.33 (2.18)	3.67(2.03)	2(1.47)
T_5	3.33(1.93)	5(2.32)	5.33 (2.41)	4.16 (2.15)	3.33(1.79)
T_6	2.66 (1.77)	4.83 (2.29)	3.16 (1.92)	3.5(1.99)	3(1.86)
T_7	3(1.88)	5.67 (2.47)	3.33 (1.95)	3.66 (2.03)	2(1.47)
T_8	3.66 (2.04)	5(2.33)	4.66 (2.27)	3.66 (2.04)	2(1.47)
T_9	2.83(1.83)	5.33(2.40)	3.33 (1.95)	3.66 (2.04)	5(2.33)
T_{10}	3.5(1.99)	4.267(2.19)	4.83(2.3)	3.07(1.88)	1.33(1.17)
T_{11}	3.66 (2.04)	5.1(2.37)	4.17(2.15)	3.66 (2.04)	4.66(2.25)
T_{12}	2.16 (1.62)	5.13(2.36)	3(1.72)	3.17(1.88)	3.66(2.02)
T_{13}	2(1.49)	3.5(1.84)	4.33 (2.18)	1.66 (1.38)	3.66(1.86)
T_{14}	3.66(2.04)	6.33 (2.61)	5(2.32)	2.66 (1.76)	3(1.72)
T_{15}	3.66(2.04)	5.5(2.42)	2.66 (1.64)	1.33 (1.29)	2.66(1.76)
T_{16}	2.33 (1.56)	3.33 (1.79)	2.66 (1.64)	2.33(1.56)	1.33(1.17)
F value	1.218 NS	0.809 NS	0.939 NS	2.39 NS	0.821 NS

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.1.10. Number of quality suckers produced

The data presented in Table 29 clearly revealed that the treatment T_{10} (20g of AMF+ 10g of *Azospirillum* per sucker) recorded the maximum mean number of quality suckers followed by treatments T_{14} (30g of *Glomus fasciculatum* + 20g of *Azospirillum* per sucker), T_1 (10g of *Glomus fasciculatum* application per sucker) and T_3 (10g of *Glomus fasciculatum* application per sucker), which were on statistically par with T_{10} but significantly superior over other treatment means. The lowest number of quality suckers were recorded in the control.

Plate 11. T_{10} (20g of *Glomus fasciculatum*+ 10g of *Azospirillum. spp* per sucker) at 60 days (Ratoon-1)

4.3.1.11 Number of underdeveloped suckers

From the Table 29 it is evident that the number of under developed sucker in all treatments were very low. Maximum number of underdeveloped suckers was in treatment T_{15} (1) (30g of *Glomus fasciculatum* + 30g of *Azospirillum* per sucker) followed by treatments T_{11}. Treatments T_2, T_3 T_4, T_5, T_6, T_7 and T_8 did not produce any under developed suckers at all.

4.3.1.12 Mean number of dead suckers

The data regarding mean number of dead suckers are presented in Table.29. The range of dead sucker fall in between 0.33 to 0.66 and treatment means did not exhibit any significant differences.

Table 29: Influence of biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum.*) on number of quality suckers, underdeveloped suckers, dead suckers and mean total suckers produced in R-1 stage.

Treatment	Number of quantity suckers	No. of Underdeveloped suckers	No. of Dead suckers	Mean of total suckers
T_1	3(1.86)	0.33(0.87)	0.33(0.87)	3.66(2.04)
T_2	2(1.56)	0(0.7)	0.66(1.05)	2.66(1.65)
T_3	2.33(1.65)	0(0.7)	0.66(1.05)	3(1.86)
T_4	1.33(1.34)	0(0.7)	0.33(0.87)	1.66(1.46)
T_5	1.33(1.34)	0(0.7)	0.33(0.87)	1.66(1.44)
T_6	1.33(1.34)	0(0.7)	0.66(1.05)	2(1.56)
T_7	0.66(0.99)	0(0.7)	0.33(0.87)	1(1.18)
T_8	1(1.18)	0(0.7)	0.33(0.87)	1.33(1.28)
T_9	1.33(1.29)	0.33(0.87)	0.33(0.87)	2(1.56)
T_{10}	4.33(2.18)	0.33(0.87)	0.33(0.87)	5(2.33)
T_{11}	0.66(1.05)	0.66(0.99)	0.66(1.05)	2(1.56)
T_{12}	2(1.53)	0.33(0.87)	0.33(0.87)	2.66(1.71)
T_{13}	1(1.18)	0.33(0.87)	0.33(0.87)	1.66(1.38)
T_{14}	3.33(1.94)	0.33(0.87)	0.66(1.05)	4.33(2.19)
T_{15}	2(1.56)	1(1.18)	0.33(0.87)	3.33(1.94)
T_{16}	0.33(0.87)	0(0.7)	0.33(0.87)	0.66(0.99)
F value	2.902**	0.904^{NS}	0.2^{NS}	2.41*
CD (0.01)	0.810			
CD (0.05)	0.603			0.680

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.1.13: Weight and volume of the corm.

Analysis of the Table 30 revealed that the mean weight of the corm produced were highest in T_1 (101.6g) (10g of *Glomus fasciculatum* application per sucker) followed by T_5, T_3, T_{15} and T_9. In case of volume it was again T_1 (10g of *Glomus fasciculatum* application per sucker) that recorded the maximum of 98cc followed by T_3 and T_5. However, both weight and volume did not show any statistically significant variation between treatments means.

4.3.1.14: Number of roots produced

The data regarding the number of roots produced are presented in the Table 30. It can be confirmed that treatment T_{10} (20g of *Glomus fasciculatum*+ 10g of *Azospirillum* per sucker) recorded the maximum number of roots followed by treatments T_9, T_7 and T_{15} which were statistically at par. Significant differences over other treatment means were observed even at one per cent level.

4.3.1.15: Length of the of the roots

The data regarding the length of the roots are presented in the Table30. Though the treatment means did not differ significantly it can be observed that treatment T_{10} (20g of *Glomus fasciculatum*+ 10g of *Azospirillum* per sucker) followed by treatments T_9, T_7 and T_{15} showed maximum root length. The treatment T_{13} (30g of AMF + 10g of *Azospirillum. spp* per sucker) recorded the shortest roots.

Table 30. Corm weight, volume of corm and number of roots of retained plantlets at R-1 stage as influence by biofertilizer treatments.

Treatment	Weight (gm)	Volume (cc)	Number of roots	Root length (cm)
T_1	101.66	98.0	11.66	23.4
T_2	60.0	46.67	6.0	11.13
T_3	76.66	85.33	12.66	27.7
T_4	56.66	62.33	8.33	15.43
T_5	85.0	82.0	8.0	8.53
T_6	52.0	50.67	18.33	32.8
T_7	54.66	52.66	21.0	34.26
T_8	41.0	30.33	18.0	27.03
T_9	64.33	62.66	25.66	51.93
T_{10}	43.66	32.66	26.66	52.76
T_{11}	63.0	62.33	5.66	12.63
T_{12}	63.66	60.33	17.0	37.86
T_{13}	6.0	13.666	6.0	6.0
T_{14}	42.66	41.33	8.33	33.16
T_{15}	66.0	59.0	20.33	36.8
T_{16}	13.66	14.0	8.66	23.06
F value	14.47 ^{NS}	8.17 ^{NS}	6.529**	16.19 ^{NS}
CD (0.01)			8.047	
CD (0.05)			10.812	

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

4.3.1.16. Spore count and Percentage root colonization of *Glomus fasciculatum*

The data regarding percent root colonization of *Glomus fasciculatum)* is presented in Table 31. A critical analysis of the data revealed that treatments T_1 (10g of *Glomus fasciculatum* application per sucker) and T_8 (10g of *Glomus fasciculatum*+ 20g of *Azospirillum* per sucker) were superior over other treatments (66.6 percent colonization) followed by treatments T_3, T_{11} and T_2 and which were statistically at par. The treatment mean of the best treatments were also on par with the means of all other treatments except control and treatmentT_6.

The data regarding the spore count is presented in the Table 31 which showed that the maximum spore count recorded was in treatment T_8 (10g of *Glomus fasciculatum*+ 20g of *Azospirillum* per sucker). followed by treatments T_1, T_2, T_{13}, T_{12}. Treatment means of T_1, T_2, T_3, T_9, T_{10}, T_{11}, T_{12} and T_{13} were on par with the mean of the best treatment and significantly superior over the means of the rest of the treatments. However, the initial spore

count of the applied inoculum in the potting media was 320 spore / g and therefore, only T_1, T_2 and T_8 treatments recorded an increase in number of spores.

The population count was not detected in any of the treatments after 6 months in the case of *Azospirillum*. However, the initial count of inoculum was 10^8 c.f.u g^{-1}

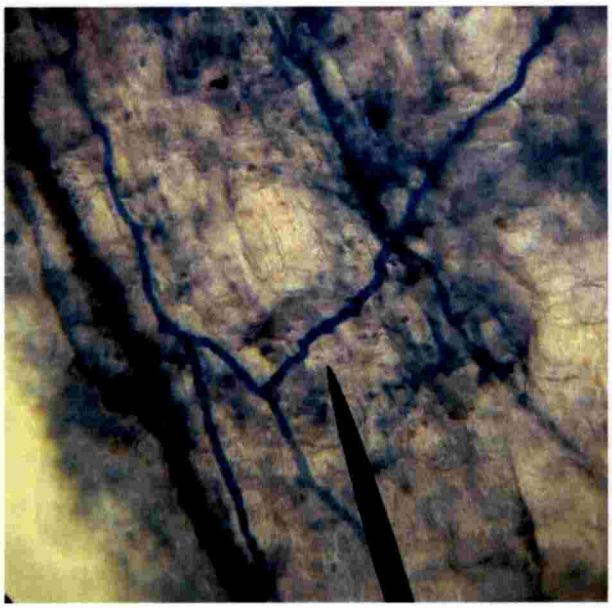


Plate 12. Hype of *Glomus fasciculatum* due to the effect of T_{10} (20g of *Glomus fasciculatum*+ 10g of *Azospirillum. spp* per sucker) at five-month in ratoon-1

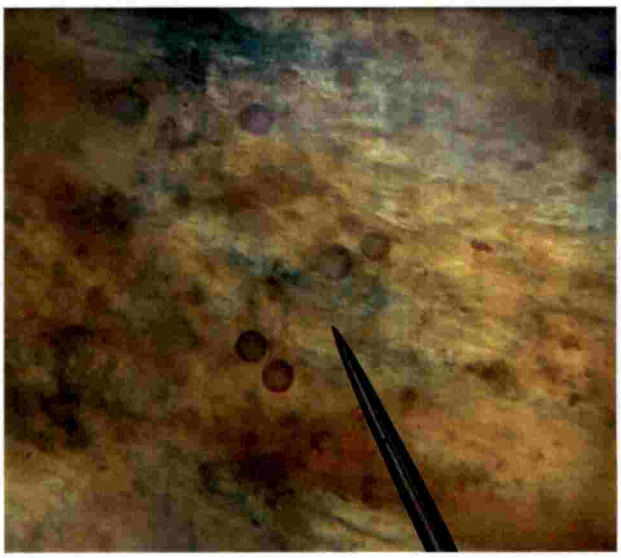


Plate 13. Spore of *Glomus fasciculatum* due to the effect of T_{10} (20g of *Glomus fasciculatum*+ 10g of *Azospirillum. spp* per sucker) at five-month stage Ratoon-1

Table 31. Spore count and percentage root colonization of *Glomus fasciculatum*.

Treatment	Per cent root colonization	Spore count (Number g^{-1})
T_1 (10 g AMF)	66.66	333.66
T_2 (20g AMF)	60.0	321.66
T_3 (30g AMF)	63.33	308.0
T_4(*10g Azospirillum.*)	56.66	80.66
T_5 (20g *Azospirillum*)	50.0	85.33
T_6 (30g *Azospirillum*)	40.0	73.0
T_7 (10g of AMF+ 10g of *Azospirillum*)	50.0	190.33
T_8 (10g of AM*F*+ 20g of *Azospirillum*)	66.66	375.0
T_9 (10g of AMF+30 g of *Azospirillum*)	46.66	267.33
T_{10} (20g of AMF+ 10g of *Azospirillum*)	60.0	248.0
T_{11} (20g of AMF+ 20g of *Azospirillum*)	60.0	306.0
T_{12} (20g of AMF+ 30g of *Azospirillum*)	56.66	311.0
T_{13} (30g of AMF+ 10g of *Azospirillum*)	56.66	314.33
T_{14} (30g of AMF + 20g of *Azospirillum*)	50.0	234.66
T_{15}(30g of AMF+30g of *Azospirillum*)	50.0	223.33
T_{16} (Without biofertilizer application)	13.33	16.33
F value	3.365 **	8.463**
CD (0.01)	27.181	146.820
CD (0.05)	20.220	109.235

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.1.17 Major available nutrient (N, P and K) content in soil before and after application of biofertilizers

Data regarding the major available nutrient content in soil at pre and post application of *Glomus fasciculatum* and *Azospirillum* are given in the Table 32. Analysis of the data revealed that in the case of nitrogen content, treatment T_{11} recorded the maximum of 312.75Kg/ ha followed by treatments T_9, $T_6$and T_7. Whereas, the lowest recorded was in treatment T_{17} (Control). The differences between the treatment means were also statistically significant.

The data on available phosphorous presented in the Table 32 revealed that T_9 (10g of AMF+ 30g of *Azospirillum* per sucker) showed the highest mean value which was on par with treatmentsT_{10} and T_{12} but significantly superior over other treatment means.

The potassium content in soil presented in the Table 32 revealed that treatmentT_9 (10g of *Glomus fasciculatum* + 30g of *Azospirillum. spp* per sucker) recorded the maximum content of potassium (96.264 Kg/ ha) followed by treatments T_{13}, T_{11}, and T_{12}. The treatment means were statistically at par with each other at one per cent level but significantly superior over other treatment means. Again, the lowest was recorded in the control (T_{17}).

Table 32: Major available nutrient (N, P and K) content in soil at pre and post application of biofertilizer treatments of *Glomus fasciculatum* and *Azospirillum*

Treatment	Nitrogen (Kg/ha)	Phosphorous (Kg/ha)	Potassium (Kg/ ha)
T_1	198.0	21.809	71.46
T_2	182.25	22.387	64.123
T_3	202.5	27.289	71.263
T_4	227.25	29.57	57.616
T_5	213.75	28.424	47.256
T_6	240.75	29.32	59.776
T_7	229.5	31.535	63.672
T_8	202.5	33.008	52.73
T_9	252.0	36.513	96.264
T_{10}	227.25	33.576	86.066
T_{11}	312.75	31.284	88.056
T_{12}	193.5	33.249	87.126
T_{13}	159.75	28.424	91.946
T_{14}	198.0	29.243	66.948
T_{15}	193.5	31.535	57.676
T_{16}	193.5	29.657	66.533
T_{17}	110.0	14.913	30.76
F value	334.67**	31.927**	280.7**
CD (0.01)	1.086	3.538	12.551
CD (0.05)	0.818	2.630	9.346

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

4.3.2 Ratoon-2

The results of the study after imposing the same treatment on the corm of R-1 suckers were planted and the results are as follows.

4.3.2.1 Number of new suckers produced in second ratoon

The analysis of the number of sprouts retained at monthly intervals presented in Table 33 revealed that in the first month sprouting was observed only in treatments T_2, T_3, T_8, T_{10}, T_{13} and T_{15}. Among these treatments, T_{15} recorded the maximum number followed by treatments T_{13}, T_3, T_{10}, and T_8 with which it is statistically at par. At the 60^{th} day there is a slight increase in the number of sprouts particularly in treatments T_2, T_3 and T_{10}. Treatment T_{15} (30g of AMF + 30g of *Azospirillum* per sucker) registered maximum mean number of retained suckers followed by treatmentsT_2, T_3, T_{10} and T_{13} that were statistically at par with each other. In third and fourth month new sprouts were found only in treatment T_1, T_2, T3, T_5, T_{10}, T_{12}, T_{13} and T_{15}. In all the four months the results were statistically significant even at one per cent level.

Plate 14. T_{15} (30g of *Glomus fasciculatum*+30g of *Azospirillum. spp* per sucker.) at 60 days (Ratoon-2)

4.3.2.2 Mean of total number of sprouts

The analysis of the data presented in the Table 33 revealed that treatment T_{15} (30g of AMF + 30g of *Azospirillum* per sucker) recorded maximum mean of total number of sprouts followed by treatments T_3, T_{10} (which recorded a mean of 3.5), T_2 and T_{13} (which recorded a mean of 2.0). The data clearly points to the superiority of treatment T_{15} over other treatments means.

Table 33. Number of new plantlets produced at R-2 at monthly intervals as influenced by biofertilizer treatments of *Glomus fasciculatum* and *Azospirillum.*

Treatments	No. of sprouts produced at monthly interval				
	30 days	60 days	90 days	120 days	Mean of total No. sprouts
T_1	0(0.7)	0(0.7)	0.33(0.87)	0.33(0.87)	0.66(1.09)
T_2	0.33(0.87)	1(1.18)	1(1.18)	1(1.18)	2(1.56)
T_3	1.33(1.26)	1.66(1.38)	1.33(1.265)	2(1.56)	3.5(1.99)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	0.66(0.99)	1.33(1.31)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66(0.99)	0.33(0.87)	0(0.7)	0(0.7)	1.3(1.3)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	1(1.18)	1.66(1.35)	2.33(1.64)	2(1.56)	3.6(1.99)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0.33(0.87)	0.33(0.87)	0.66(1.11)
T_{13}	1.33(1.34)	1(1.22)	0.66(1.05)	0.66(1.05)	2(1.56)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	2(1.56)	2(1.56)	2.33(1.65)	2.66(1.77)	4.3(2.19)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	3.817**	3.594**	30.78**	6.572**	48.84**
CD (0.01)	0.565	0.628	0.669	0.546	0.048
CD (0.05)	0.427	0.468	0.497	0.409	0.031

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.3.2.3. Height of retained sucker

The data regarding mean height of retained sucker are presented in the Table 34. The data revealed that the treatment means were statistically significant in all the four months of study. In the first month the maximum height was recorded in treatment T_{15} (30g of *Glomus fasciculatum*+30g of *Azospirillum. spp* per sucker) and which continued till the

4th month of the experiment. In the first thirty days treatments T_{13}, T_{10} and T_3 were on par with treatment T_{15} and this trend continued up to 90th day. At the 90th day treatment T_{15} is observed to be on par only with treatment T_{10}. At 150th day the initial trend was again observed.

Table 34. Height (cm) of the second ratoon suckers as influenced by biofertilizers treatments of *Glomus fasciculatum* and *Azospirillum*

Treatments	Height (cm) at monthly intervals			
	30 days	60 days	90 days	120 days
T_1	0(0.7)	0(0.7)	1.86(1.29)	4.9(1.78)
T_2	1.76(1.27)	5.33(2.17)	6.23(2.33)	7.56(2.53)
T_3	4.63(2.05)	5.43(2.18)	7.7(2.55)	16.4(4.09)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	1.6(1.24)	3.8(1.62)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	1.7(1.26)	2.13(1.35)	2.73(1.45)	3.3(1.54)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	3.8(1.89)	6.66(2.39)	12.13(3.45)	16.36(4.06)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	3.06(1.5)	3.86(1.64)
T_{13}	4.96(2.3)	6.3(2.58)	11.22(3.02)	11.9(3.08)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	6.6(2.65)	9.83(3.18)	22.23(4.76)	22.86(4.83)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	4.605**	5.063**	4.719**	5.262**
CD (0.01)	1.229	1.509	2.189	2.39
CD (0.05)	0.915	1.118	1.627	1.771

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.2.4 Collar girth of the retained suckers

The collar girth of the retained number of suckers are presented in Table 35. A critical analysis of the data revealed that maximum collar girth in first month of planting was observed in treatment T_{15} (30g of AMF+30g of *Azospirillum. spp* per sucker) followed

by treatments T_{10}, T_{13} with which it was statistically at par. From second month onwards, there is a drastic increase in the collar girth observed till the 4th month except in case of treatments T_6, T_{10} and T_{12}. At all intervals of observation, the treatment T_{15} excelled among other treatments followed by treatment T_{13}. The results also showed statistical significance.

Table 35. Influenced by biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum*) on collar girth of retained plantlets at R-2 stage.

Treatments	Collar girth (cm) at monthly intervals			
	30 days	60 days	90 days	120 days
T_1	0(0.7)	0(0.7)	0.53(0.95)	0.66(0.99)
T_2	0(0.7)	1.03(1.19)	1.43(1.32)	1.83(1.43)
T_3	0.56(0.97)	1.46(1.33)	1.46(1.33)	3.4(1.94)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0(0.7)	0.76(1.02)
T_6	0(0.7)	0(0.7)	0.3(0.86)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.43(0.92)	0.76(1.02)	1.2(1.14)	1.2(1.14)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	1.6(1.43)	1.43(1.3)	3.1(1.87)	1(1.09)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0.56(0.97)	0(0.7)
T_{13}	1.4(1.34)	2.03(1.59)	2.66(1.65)	2.9(1.69)
T_{14}	00(0.7)	0(0.7)	0(0.7)	1.6(1.24)
T_{15}	2.46(1.71)	3.16(1.89)	4.73(2.28)	5.13(2.36)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	7.824**	5.565**	4.608**	3.243**
CD (0.01)	0.44	0.633	0.879	1.096
CD (0.05)	0.33	0.467	0.656	0.818

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.3.2.5. Number of leaves retained by suckers

The data regarding the mean number of leaves retained in the second cycle or second ratoon plantlets are presented in the Table 36 revealed that, in the first month the T_{15} (30g of AMF +30g of *Azospirillum* per sucker) and T_{13} (30g of AMF+ 10g of *Azospirillum* per

sucker) retained the same mean number of two leaves each and that was significantly superior over all the other treatment means. From second month onwards up to fourth month, T_{15} excelled over other treatments. In the second month, treatment T_{13} recorded the second-best treatment and in the third and fourth month treatment T_{10} recorded the second-best treatment. In the first, second and third T_{13} and in all the 4 months treatment T_{10} were found to be on par with treatment T_{15}. The result is also statistically significant even at one per cent level.

Table 36. Influenced by biofertilizer treatments (*Glomus fasciculatum* and *Azospirillum*) on number of leaves of retained plantlets at R-2 stage.

Treatments	Number of leaves retained at monthly intervals			
	30 days	60 days	90 days	120 day
T_1	0(0.7)	0(0.7)	0.33(0.87)	1(1.09)
T_2	0.66(0.99)	1(1.18)	1.33(1.26)	1.3(1.26)
T_3	1(1.18)	1.33(1.29)	1.66(1.38)	1.33(1.34)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	1(1.09)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66(0.99)	0.66(0.99)	0.66(0.99)	1(1.09)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	1(1.17)	2(1.49)	3(1.86)	2.661(1.76)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	0(0.7)	0(0.7)	0.33(0.87)	0.33(0.87)
T_{13}	2(1.56)	2.33(1.64)	2.33(1.56)	1.33(1.29)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	2(1.56)	2.66(1.77)	4.33(2.20)	3.66(2.04)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	3.435**	5.079**	5.102**	3.682**
CD (0.01)	0.624	0.658	0.8	0.827
CD (0.05)	0.462	0.484	0.599	0.615

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4 Experiment IV: Standardization of macropropagation technique using micronutrients in Banana *Musa* (AAB) 'Nendran'.

The best physical activation technique and the best soil media formed the common practice which was uniformly given in all the treatments.

4.4.1 Ratoon-1

4.4.1 Days to first sprouting

A perusal of data presented in the Table 37 revealed that there is no significant difference between treatments in case of number of days taken to the first sprout emergence, it was 24 days in almost all treatments.

4.4.1.2 Number of sprouts retained

The result of the data on number of sprouts retained is presented in Table 37. In the 2nd and 3rd fortnight, treatment T_{13} (application of Zn (0.5%) +B (0.1%) to the sucker) recorded the maximum number of sprouts retained followed by treatment T_1 (application of Zn (0.1%) to the sucker) whereas in the 4th fortnight it was treatments T_{13} and T_1 which retained the maximum number of 2.66 suckers. In the 5th fortnight treatmentsT_{12} and T_1 showed maximum retention of suckers. In the 6th fortnight the maximum retention of suckers was observed in T_{13}. From 7th to 12th fortnight, the mean of treatment ranged from less than to slightly more than one. At all the fortnights the difference between the treatment means were not significant.

4.4.1.3 Mean of total number of sprouts

Analysis of the data presented in Table 37 reveal that at the end of the 12th fortnight or six month the mean maximum number of plantlet production was observed in treatment T_1 (application of Zn (0.1%) to the sucker) (4.0) followed by T_{13} (3.66) and T_{12} (3.0). The lowest mean production of suckers was observed in treatmentsT_2 and T_4 which produced an average of 1.0 plantlet only. Treatment T_1 certainly yielded a greater number of suckers, but the results were statistically not significant.

Table 37 Influence of application of Zinc and Boron on Number of days to first sprout, sprouts retained at fortnightly intervals and total number of sprouts in R-1 stage.

Treatment	Days to first sprouting	Days in fortnightly intervals											
		2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Mean of total No. of sprouts
T_1	24 (4.9)	2.66 (1.74)	2.66 (1.74)	2.66 (1.74)	2 (1.56)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	4 (2.11)
T_2	24 (4.9)	0.66 (1.05)	1 (1.18)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	1 (1.18)
T_3	24 (4.9)	1.33 (1.34)	1 (1.22)	1 (1.22)	1 (1.22)	0.66 (1.05)	0.66 (1.05)	1.33 (1.28)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	2. (1.56)
T_4	24 (4.9)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	1 (1.22)	0.66 (1.05)	0.66 (1.05)	1 (1.18)	0.33 (0.87)	0.66 (1.05)	0.66 (1.05)	0.66(1.05)	1 (1.18)
T_5	24.33 (4.936)	1 1.18)	1.33 (1.34)	1.66 (1.46)	1.33 (1.34)	1 (1.18)	1 (1.18)	1 (1.18)	1 (1.18)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	2.33 (1.64)
T_6	24.33 (4.93)	1 (1.18)	1.33 (1.34)	2 (1.56)	1.33 (1.34)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.66 (1.46)	1.33 (1.34)	1.33 (1.34)	1.66 (1.46)	2.33 (1.68)
T_7	24.66 (4.96)	0.66 (1.05)	1 (1.18)	1.66 (1.46)	1 (1.18)	1.66 (1.46)	1.66 (1.46)	2 (1.56)	1.66 (1.46)	1.33 (1.29)	1.33 (1.29)	1.33 (1.29)	2 (1.56)
T_8	24 (4.9)	1.33 (1.29)	1.33 (1.29)	1.66 (1.38)	1.33 (1.29)	1.33 (1.29)	1 (1.18)	1 (1.18)	1 (1.18)	1 (1.18)	0.66 (1.05)	0.66 (1.05)	1.66 (1.46)
T_9	24 (4.9)	2 (1.56)	2 (1.56)	1.66 (1.46)	1.33 (1.34)	1 (1.22)	1 (1.22)	1.33 (1.34)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	2.66 (1.76)
T_{10}	24 (4.9)	1 (1.18)	1 (1.18)	1 (1.18)	1.33 (1.34)	1 (1.18)	1 (1.18)	1 (1.18)	1 (1.18)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	2 (1.47)
T_{11}	24 (4.9)	1 (1.22)	1.33 (1.34)	1.66 (1.46)	1.66 (1.44)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	1 (1.22)	1 (1.22)	1 (1.22)	2.33 (1.67)
T_{12}	24 (4.9)	2 (1.53)	2 (1.53)	1.66 (1.44)	2 (1.58)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	3 (1.82)
T_{13}	24 (4.9)	3 (1.85)	3.33 (1.95)	2.66 (1.77)	0.66 (0.99)	2.33 (1.67)	1.66 (1.46)	1.66 (1.46)	1 (1.22)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	3.66 (2.02)
T_{14}	24 (4.9)	1.66 (1.35)	1.66 (1.35)	1 (1.09)	1.33 (1.34)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	0.66 (1.05)	2.33 (1.64)
T_{15}	24 (4.9)	1.66 (1.44)	1.66 (1.44)	1.66 (1.44)	0.66 (1.05)	1.33 (1.34)	1.33 (1.34)	1.66 (1.46)	1.33 (1.34)	1.33 (1.34)	1.33 (1.34)	1 (1.22)	2 (1.58)
T_{16}	24 (4.9)	0.33 (0.87)	0.33 (0.87)	0.66 (1.05)	1 (1.18)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	0.33 (0.87)	1.33 (1.29)
F value	0.883^{NS}	1.335^{NS}	1.369^{NS}	1.266^{NS}	0.898^{NS}	1.435^{NS}	1.147^{NS}	0.945^{NS}	1.22^{NS}	0.928^{NS}	1.027^{NS}	1.011^{NS}	1.359^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4.1.4. Number of new suckers produced at fortnightly intervals

It can be safely inferred from the data regarding the total number of new suckers (total of all replicates) produced presented in Table 38 revealed that treatment T_1 (application of Zn (0.1%) to the sucker) produced maximum number of sprouts followed by treatments T_9, T_{12}, T_{14} and T_{15} in the 2nd fortnight. In the 3rd fortnight new sprouts where produced only in 6 treatments and among them treatment T_{13} recorded maximum of 9.0 suckers. In the 4th fortnight treatments T_6 and T_7 produced an equal number of 2.0 plantlets and treatments T_5, T_8, T_{11} and T_{16} recorded one sucker each. From the 5th to the 11th fortnight practically no sucker production was observed except in certain and in isolated cases such as treatments T_3 that recorded 2.0 suckers in the 7th fortnight and in some rare case one plantlet each was produced in 7th, 10th and 11th fortnight. Again, a spurt in plantlet production was observed in the 12th fortnight in treatments T_{10} and T_{12}which recorded an equal number of 3.0 plantlets each followed by treatment T_{14}, T_{16}, T_8 and T_5 which produced 2.0 plantlet each.

4.4.1.5. Total number of suckers

In case of the total number of suckers presented in Table 38, there is no ambiguity that treatment T_1 (application of Zn (0.1%) to the sucker) with 12 plantlets, T_{13} with 11 number of plantlet and T_{12} with 9 number excelled over the others.

4.4.1.6. Number of suckers planted out

The number of suckers planted out are presented in Table 38. The data revealed that the active planting out started from the 4th fortnight onwards, except in treatment T_3 (application of Zn (0.5%) to the sucker) where planting out started at 3rd month. The maximum number of detachments observed were in treatment T_{14} (application of Zn (0.5%) +B (0.25%) to the sucker) followed by treatments T_{13}, T_{12}, T_9 and T_2. In the fifth fortnight there was an increase in detachment than that of previous fortnight and maximum recorded in treatment T_1 followed by treatments T_5 and T_9. In 6thfortnight a total of 4.0 suckers detached from three treatment in which treatment T_{13} recorded maximum. In the 7thfortnight no detachment was observed, while from the eighth fortnight to tenth fortnight again an increase in number of sucker detachment was observed which clearly point to a second

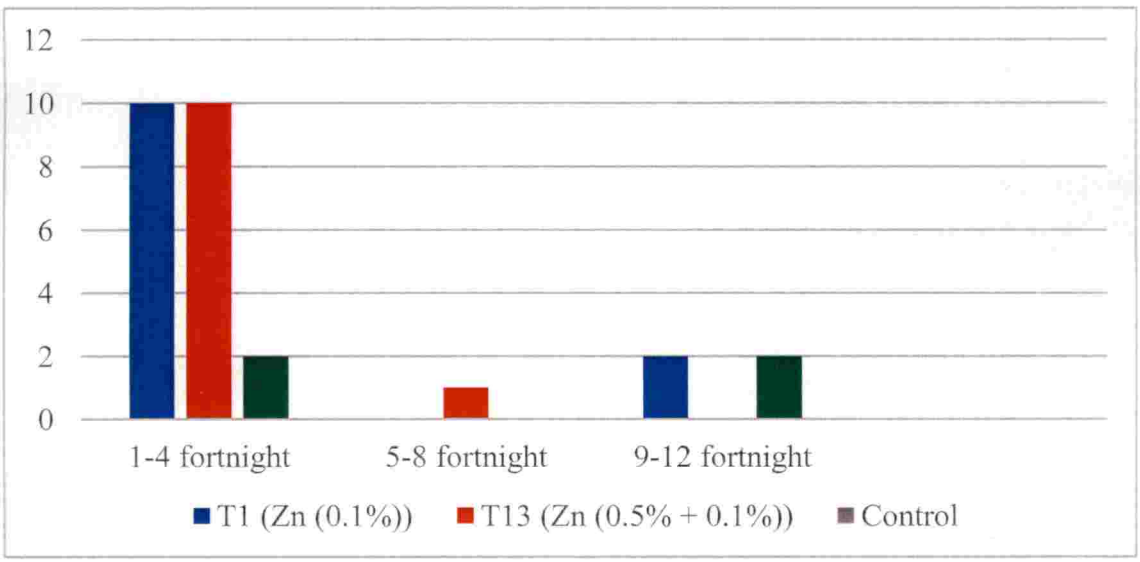
wave of sucker production. In eleventh and twelfth fortnight comparatively, lesser number of suckers were removed, and an equal number of 1.0 per treatment was recorded in treatments T_1, T_{11}, T_{12}, T_{15}, T_6, T_7 and T_{15} respectively.

Table 38. Influence of treatment of Zinc and Boron on number of new suckers produced, number of suckers detached (shown in brackets) at fortnightly interval and total number of suckers produced at R-1 stage.

	Total Number of suckers produced at fortnight intervals											
Treatment	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	Total No. of suckers
T_1	8	0	2	0(4)	0	0	0(1)	0	0	0(4)	2	12
T_2	2	1	0(2)	0	0	0	0	0	0	0	0	3
T_3	4	0(1)	0	0(2)	0	2	0(2)	0	0	0	0	6
T_4	2	0	0	0	0	0	0(2)	1	0	0	1	3
T_5	3	1	1	0(2)	0	0	0	0(1)	0(1)	0	2	7
T_6	3	1	2	0(2)	0	0	0	0(2)	0	1	0(2)	7
T_7	2	1	2	0	0	1	0(2)	0	0	0	0(3)	6
T_8	4	0	1	0(1)	0(1)	0	0	0	0(2)	0	2	5
T_9	6	0	0(2)	0(2)	0	1	0(2)	0	0	0	1	8
T_{10}	3	0	0	0	0	0	0	0(3)	0	0	3	6
T_{11}	3	1	1	0(1)	0	0	0(1)	0(1)	0(1)	0	2	7
T_{12}	6	0	0(3)	0(1)	0	0	0	0	0	0(2)	3	9
T_{13}	1	9	0(2)	0(2)	0(3)	1	0(3)	0	0	0	0	11
T_{14}	5	0	0(3)	0(3)	0	0	0	0	0	0	2	7
T_{15}	5	0	0	0(1)	0(1)	1	0(1)	0	0	0(1)	0(1)	6
T_{16}	1	0	1	0(2)	0	0	0	0	0	0	2	4

Values in the parenthesis show the number of detached suckers

Figure 5. Waves of suckering selected treatments at first ratoon as influenced by application of Zinc (Zn) and Boron (B).



4.4.1.7. Height of the suckers retained

The data regarding the height of the suckers presented in the Table 39 revealed that height of suckers retained was maximum in treatment T_{12} (Application of Zn (0.25%) + B (0.5%) to the sucker) followed by treatment T_1 on completion of first month. In the second month treatment T_9 followed by treatments T_{12} and T_{15}, T_{14} and T_4 produced plantlet of almost 30 cm tall and there was an explicit difference between the treatment means and the result were statistically significant. At 90 day it was again treatment T_9 that recorded the maximum height followed by treatmentsT_{15}, T_{10} and T_{14}. At120 days T_9 produced plants of 90 cm height which was the maximum. At 150 days it was again more a reflection of the character at 120 day with trend being more or less the same. At 180 days again, the trend was similar to that of 150 day except there was a marginal increase in treatment T_9 which was again the best, A phenomenal increase was observed in the treatment T_{12}, T_{14} and T_{15}. The results at all monthly intervals were statistically not significant.

Table 39. Influenced of treatment of Zinc and Boron on height of retained plantlets at R-1 stage

Treatments	Height (cm) of retained suckers at monthly interval					
	30 days	60 days	90 days	120 days	150 days	180 days
T_1	23.1(40.73)	35.66(5.96)	63.4(7.94)	56.4(7.52)	65.33(8.035)	61.66(7.69)
T_2	8.766(2.69)	25.16(4.35)	33.66(4.99)	33.96(5.014)	37.33(8.03)	37.33(5.25)
T_3	15.83(3.69)	37.86(5.82)	39.066(5.32)	33.86(5.01)	42.33(5.52)	35(4.82)
T_4	19.03(3.8)	50(6.02)	52(6.15)	52.23(6.16)	53.66(6.22)	57.33(6.42)
T_5	13.56(3.28)	34.666(5.42)	33.56(4.98)	40.46(5.45)	44.33(5.68)	47.33(5.85)
T_6	7.33(2.49)	27.23(5.1)	37.33(5.85)	40.43(6.1)	46.13(6.5)	35.66(5.65)
T_7	3.16(1.77)	12.53(3.44)	21.36(4.44)	22.86(4.81)	20.43(3.88)	21.533(4.06)
T_8	11.93(3.02)	25.83(4.41)	45.2(5.74)	44.16(5.67)	35.9(5.06)	49.3(5.99)
T_9	17.83(4.22)	60.83(7.805)	78.86(8.87)	89.76(9.45)	88.4(9.39)	93(9.63)
T_{10}	8.8(2.68)	22.43(4.05)	20.66(3.9)	23.26(4.03)	21.66(3.16)	20(3.061)
T_{11}	12.63(2.68)	26.6(4.97)	31.8(5.57)	42.3(6.38)	44.66(6.57)	54(7.1)
T_{12}	24.8(4.61)	59.76(7.74)	57.9(7.58)	71.5(8.48)	73(8.56)	84.33(9.19)
T_{13}	19(4.33)	37.4(5.85)	47.5(6.75)	58(7.48)	48.33(5.92)	54(6.24)
T_{14}	13.633(3.18)	51.1(6.08)	60.03(6.57)	67.3(6.95)	67.33(6.95)	74(7.27)
T_{15}	18.4(4.26)	54.46(7.403)	64.13(8.03)	66.46(8.17)	58.33(7.59)	72.33(8.51)
T_{16}	4.4(10.7)	10(2.312)	16.33(2.82)	26.33(3.44)	24.1(3.31)	24(3.306)
F value	0.777^{NS}	0.985^{NS}	0.828^{NS}	0.818^{NS}	0.745^{NS}	0.821^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4.1.8 Collar girth of the sucker retained

The collar girth of retained suckers presented in Table 40 revealed that the maximum collar girth at 30 day was observed in treatment T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) followed by treatments T_1 and T_4. At 60 days the mean collar girth was highest in treatment T_{12} (application of Zn (0.25%) + B (0.5%) to the sucker) followed by treatment T_9. At 90 days it was treatment T_9 followed by treatment T_{15} and T_1 which recorded the mean maximum collar girth. From the end of 4^{th} month to the sixth month there was a gradual increase in the collar girth in treatment T_9 which was also recorded the best and this was followed by treatment T_1 at 120-days, treatment T_{15} at 150days and 180 days. Collar girth which is an important parameter in the health of a plantlet is definitely influenced by the treatments, but statistical significance was not observed among the treatment means.

Table 40. Influenced of treatment of Zinc and Boron on collar girth of retained plantlets at R-1 stage.

Treatment	Collar girth (cm) of retained plantlets at monthly interval					
	30days	60days	90days	120days	150days	180days
T_1	7.46(2.81)	9.9(3.23)	11.6(3.46)	12.1(3.55)	11.73(3.48)	10.63(3.28)
T_2	3.4(1.81)	6.566(2.38)	7.53(2.52)	7.1(2.46)	7.33(2.49)	7.73(2.56)
T_3	5.46(2.2)	7.66(2.53)	8.43(2.6)	7.56(2.53)	10.73(2.95)	10.9(2.98)
T_4	6.16(2.32)	9.36(2.77)	8.8(2.69)	8.96(2.72)	9.1(2.74)	9.63(2.813)
T_5	4.26(1.98)	7.9(2.57)	8(2.59)	8.53(2.66)	9.26(2.76)	8.86(20.75)
T_6	4(1.92)	9.06(3.04)	7.36(2.72)	8.26(2.95)	9.6(3.13)	10.06(3.23)
T_7	0(0.7)	4.16(1.96)	5.06(2.35)	4.23(2.12)	4.53(2.04)	5.43(2.19)
T_8	4.2(1.97)	5.93(2.27)	9.53(2.79)	7.36(2.48)	8.3(2.61)	8.5(2.66)
T_9	9.16(3.11)	13.03(3.67)	13.03(3.68)	14.26(3.83)	15.93(4.05)	16.33(4.1)
T_{10}	3.8(1.88)	6.03(2.27)	6.5(2.36)	4.33(1.97)	3.33(1.55)	3.6(1.60)
T_{11}	2.16(1.35)	6.03(2.53)	7.66(2.84)	8.53(2.99)	8.7(3.)	8.36(2.98)
T_{12}	5.8(2.24)	13.1(3.68)	11.13(3.39)	12(3.53)	7.96(2.87)	11.3(3.48)
T_{13}	4.63(2.25)	9.76(3.18)	9.46(3.14)	8.1(2.81)	7.4(2.5)	8.46(2.65)
T_{14}	2.96(1.49)	9.73(2.82)	10.36(2.9)	10.16(2.87)	10.96(2.97)	11.06(2.99)
T_{15}	5.9(2.52)	10.46(3.3)	12.06(3.54)	10(3.23)	12.53(3.6)	11.73(3.50)
T_{16}	1.13(1.13)	0(0.7)	2.6(1.44)	3.83(1.62)	4.26(1.68)	3.96(1.64)
F value	1.183^{NS}	1.239^{NS}	0.643^{NS}	0.736^{NS}	0.74^{NS}	0.688^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.4.1.9 Number of leaves retained

The data on the number of leaves is presented in Table 41. The data did not show any explicit difference at 30 days of planting. At 60 days the mean number of leaves retained varied from 1.3 in treatment T_{16} (control) to 5.0 in T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) respectively. The trend at 90 days was almost similar that at 60 day with treatment T_9 again recording the maximum value which was immediately followed by T_1 and T_{13} that recorded an average number of 5.0 leaves each. Treatment T_9 continued to show maximum retention of leaves from 120 to 180 days. At 120 days treatment T_9 was followed by treatments T_{11} and T_{14} with an equal number of 4.0 leaves each and at 150th day the second-best treatment was observed in treatment T_{11}. The differences observed are explicit but statistical significance was not observed.

Table 41. Effect of treatment of Zinc and Boron on number of leaves of retained plantlets at fortnight intervals.

Treatment	Number of leaves retained at monthly interval					
	30days	60days	90days	120days	150days	180days
T_1	0.66(0.99)	4(2.11)	5(2.34)	3.83(2.09)	3.83(2.06)	3(1.82)
T_2	0(0.7)	3(1.72)	4.33(1.99)	3(1.72)	2.66(1.64)	1.33(1.29)
T_3	0.33(0.87)	3.66(2.02)	3.66(1.86)	2.33(1.54)	1.66(1.35)	2(1.47)
T_4	0.66(0.99)	3(2.02)	3.33(1.79)	2.66(1.65)	2.33(1.35)	2(1.47)
T_5	0.66(0.99)	3.33(1.89)	3.33(1.79)	2.83(1.67)	3.33(1.79)	3.333(1.79)
T_6	0.5(0.95)	3.16(1.91)	4.5(2.23)	3.33(1.95)	3.5(1.99)	3(1.86)
T_7	0(0.7)	2.66(1.77)	2.83(1.81)	3.16(1.87)	2.33(1.56)	2(1.47)
T_8	1(1.18)	2.83(1.77)	4(1.93)	2.16(1.52)	2(1.49)	2(1.47)
T_9	1(1.18)	5(2.34)	5.33(2.41)	5(2.34)	5.33(2.41)	5(2.34)
T_{10}	0(0.7)	2.5(1.61)	2.5(1.61)	1(1.18)	1(1.09)	1.33(1.175)
T_{11}	0.66(1.05)	2.83(1.81)	4.66(2.25)	4.33(2.18)	4(2.11)	4.66(2.25)
T_{12}	1(1.18)	3.16(1.9)	3.16(1.91)	3.66(2.038)	4(2.09)	3.66(2.02)
T_{13}	0.66(1.05)	3.5(1.99)	5(2.34)	2.66(1.77)	3.33(1.79)	3.66(1.86)
T_{14}	0.66(0.99)	3.33(1.79)	3.66(1.86)	2.33(1.56)	3(1.72)	3(1.72)
T_{15}	0(0.7)	4.333(2.20)	4.66(2.25)	3.16(1.9)	3.5(1.99)	2.66(1.76)
T_{16}	0.33(0.87)	1.33(1.17)	2(1.32)	2.33(1.49)	2(1.32)	1.33(1.17)
F value	0.631^{NS}	0.629^{NS}	0.516^{NS}	0.749^{NS}	0.783^{NS}	0.821^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4.1.10 Number of quality suckers produced

The data presented in Table 42 clearly revealed that treatment T_1 (application of Zn (0.1%) to the sucker) recorded the maximum number of quality suckers followed by treatments T_{13}, T_6, T_{12}, and T_{14}. The least number was recorded in treatments T_4 (application of B (0.1%) to the sucker) and T_{16} (control). The results did not reveal any statistical significance.

Plate 15. Effect of Application of Zn at 0.1% to the sucker at 60 days in ratoon-1.

4.4.1.11 Number of underdeveloped suckers

The data on number of underdeveloped suckers is presented in Table 42. It is evident that the number of under developed sucker in all treatments were very low or practically nil. The maximum mean number of 0.33 was observed in treatments T_5, T_9, T_{10}, T_{11}, T_{12}, and T_{16}whereas lowest recorded was in T_1 (application of Zn (0.1%) to the sucker). The differences in treatment means were also statistically not significant.

4.4.1.12 Number of dead suckers

The data regarding mean number of dead suckers are presented in the same Table 42. It can be inferred that the number of dead suckers were in the range of 0 to 0.66 suckers. Treatment T_5, T_{10}, T_{11} and T_{12} recorded maximum dead suckers and treatment T_1 (application of Zn (0.1%) to the sucker) recorded least. The results were also not statistically significant.

Table 42. Effect of treatment of Zinc and Boron on Number of quality suckers, underdeveloped suckers, dead suckers and total suckers produced in R-1 stage.

Treatment	No. of quality suckers	No. of underdeveloped suckers	No. of dead suckers	Mean of total
T_1	4.0(2.11)	0(0.7)	0(0.7)	4(2.11)
T_2	0.66(1.05)	0(0.7)	0.33(0.87)	1(1.18)
T_3	1.66(1.38)	0(0.7)	0.33(0.87)	2(1.56)
T_4	0.66(1.05)	0(0.7)	0.33(0.87)	1(1.18)
T_5	1.33(1.34)	0.33(0.87)	0.66(1.05)	2.33(1.64)
T_6	2(1.56)	0(0.7)	0.33(0.87)	2.33(1.68)
T_7	1.66(1.38)	0(0.7)	0.33(0.87)	2(1.56)
T_8	1.33(1.34)	0(0.7)	0.33(0.87)	1.66(1.46)
T_9	2(1.56)	0.33(0.87)	0.33(0.87)	2.66(1.76)
T_{10}	1(1.18)	0.33(0.87)	0.66(1.05)	2(1.47)
T_{11}	1.33(1.34)	0.33(0.87)	0.66(1.05)	2.33(1.67)
T_{12}	2(1.56)	0.33(0.87)	0.66(1.05)	3(1.82)
T_{13}	3(1.86)	0(0.7)	0.33(0.87)	3.66(2.02)
T_{14}	2(1.56)	0(0.7)	0.33(0.87)	2.33(1.64)
T_{15}	1.66(1.46)	0(0.7)	0.33(0.87)	2(1.581)
T_{16}	0.66(1.05)	0.33(0.87)	0.33(0.87)	1.33(1.29)
F value	1.42^{NS}	0.6^{NS}	0.221^{NS}	1.359^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4.13 Weight and volume of the corm

The data regarding the weight of the sucker are presented in the Table 43. The mean weight was highest (398.33g) in treatment T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) followed by treatments T_{14}, T_{12} and T_{15} and the lowest weights was recorded in the control. The volume of the sucker presented in the Table 41 also showed that treatment T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) recorded the maximum volume (358.66cc) followed by treatments T_{12}, T_{14}, T_4 and T_1 respectively. The lowest volume recorded was in control. In both the cases the difference between the treatment means was found to be not statistically significant.

4.4.14 Number of roots of sucker

A perusal of the data presented in Table 43 on the mean number of roots revealed that the highest number of roots (42.66) recorded was observed in treatment T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) followed by treatments T_{14}, T_1, T_4 and T_{12}. The lowest number (4) was recorded in treatment T_{10} (application of Zn (0.25%) + B (0.1%) to the sucker). The difference between the treatment means were statistically not significant.

Table 43. Corm weight, volume and number of roots of retained plantlets at R-1 stage influence by the treatment of Zn and B.

Treatment	**Weight (gm)**	**Volume (cm^3)**	**Number of roots**
T_1	181.33	167.66	34
T_2	75.333	57	13.33
T_3	92.33	106.66	24.33
T_4	155.66	195	33.33
T_5	141.33	118.66	27.66
T_6	91.33	87.66	15.5
T_7	131	106.33	18.66
T_8	141.33	120.33	17.33
T_9	398.33	358.66	42.66
T_{10}	48.66	47.33	4
T_{11}	95	94	12
T_{12}	235	263.33	31.33
T_{13}	102.33	103.66	18
T_{14}	293	245.33	40
T_{15}	169.66	146	17.333
T_{16}	36.33	25	8
F value	1.784^{NS}	1.132^{NS}	1.273^{NS}

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.4.2 Ratoon-2

The results of the study after imposing the same treatment on the corm of R-1 suckers were planted and the results obtained are as follows.

4.4.2.1 Number of suckers retained

A critical analysis of the data regarding the mean number of sprouts retained in the second ratoon presented in the Table 44 reveal that in the first month treatmentsT_{12} (application of Zn (0.25%) + B (0.5%) to the sucker) and T_3 (application of Zn (0.5%) to the sucker) produced the maximum number of suckers followed by treatmentsT_{13} and T_{10}. The lowest recorded was in treatments T_8. In the 60th day, treatment T_3 (application of Zn (0.5%) to the sucker) recorded the maximum number of sprouts retained followed by treatments T_{10}, T_{13} and T_{12}. In the third month treatment T_{10} showed maximum mean number of suckers retained followed by treatments T_3 and T_{12}. Up to 90thday the mean number of suckers retained in treatments T_3, T_{10}, T_{12} and T_{13} were at par with each other. At 120 days after planting, treatments T_{13}, T_3 and T_{10} recorded the maximum mean number of 2.0 sucker retained followed by treatments T_{12}, T_2 and T_{15} and they were statistically at par. At the end of fifth month, treatment T_3 recorded maximum number of suckers retained followed by T_{13}, T_{12}, T_2 and T_{15}. It is very clear from the data that the mean number suckers retained from first month to 5th month ranged from 0.66 to 2. Further at all 5 months the treatments means were statistically significant even at one per cent level.

Table 44. Influenced of treatment of Zinc and Boron on number of suckers retained in R-2 at monthly intervals.

Treatments	No. of suckers produced at monthly interval					
	30 days	60 days	90 days	120 days	150 days	Mean of total No. sprouts
T_1	0(0.7)	0(0.7)	0(0.7)	0.33(0.87)	0(0.7)	0.3(0.95)
T_2	0(0.7)	0.66(1.05)	1(1.18)	1(1.18)	1(1.18)	2(1.56)
T_3	1.33(1.26)	2(1.56)	1.66(1.4)	2(1.56)	1.66(1.46)	4.6(2.68)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	0.66(0.99)	0.33(0.87)	1.64(1.46)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66(0.99)	0.33(0.87)	0(0.7)	0(0.7)	0(0.7)	0.99(1.26)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	1(1.18)	1.66(1.35)	2.33(1.64)	2(1.56)	0.33(0.87)	4.3(2.62)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	1.33(1.34)	1(1.22)	1(1.22)	1.66(1.46)	1(1.18)	3(1.86)
T_{13}	1(1.22)	1.33(1.34)	1.66(1.46)	2(1.56)	1.66(1.44)	4.3(2.62)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0.33(0.87)	0.66(0.99)	1(1.09)	1(1.09)	3(1.86)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	3.495**	4.461**	4.821**	4.497**	3.012**	79.451**
CD(0.01)	0.501	0.531	0.588	0.641	0.616	0.398
CD (0.05)	0.378	0.403	0.436	0.482	0.45	0.297

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

Plate. 16. Effect of Application of Zn 0.5 per cent to the sucker at 60 days in ratoon-2.

4.4.2.2 Height of the suckers

The data regarding height of retained sucker are presented in the Table 45. At first month treatment T_{12} (application of Zn (0.25%) + B (0.5%) to the sucker) recorded maximum height of 6.63 cm followed by treatments T_{13}, T_{10} and T_3. From second month to fifth month treatment T_{13} recorded the maximum mean height. This was followed by treatments T_{12} and T_{10} up to 4th month and treatments T_3 and T_{12} at 150 days. This variation is due to the detachment of plantlets that reached the size of planting out. From second month to the fourth month treatments T_{10}, T_{12} T_{13} and T_3 were statistically at par with each other. At 150th day the second highest height was observed in treatment T_3. In all the five months the difference between the treatment means were found to be significant even at one percent level.

Table: 45. Influenced of treatment of Zinc and Boron on height of retained plantlets at R-2 stage

Treatments	Height (cm) at monthly intervals				
	30 days	60 days	90 days	120 days	150 days
T_1	0(0.7)	0(0.7)	0(0.7)	0.8(1.03)	0(0.7)
T_2	0(0.7)	3.3(1.79)	4.13(1.96)	5.63(2.23)	6.8(2.41)
T_3	2.066(1.4)	5.43(2.38)	8.03(2.91)	10.8(3.35)	9.26(3.12)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	1.2(1.14)	2.1(1.35)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	1.86(1.23)	1.63(1.24)	2.4(1.39)	3.13(1.5)	4.1(1.67)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	3.8(1.90)	5.63(2.23)	8.33(2.95)	13.16(3.70)	1.53(1.22)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	6.63(2.67)	8.53(3.1)	11.66(3.48)	14.83(3.91)	8.3(2.64)
T_{13}	6.6(2.65)	9.16(3.1)	12.4(3.58)	15.66(4.01)	15.9(4.05)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	2.23(1.37)	1.13(1.13)	2.26(1.37)	3.53(1.59)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	8.924**	7.051**	15.37**	13.126**	4.359**
CD (0.01)	0.913	1.286	1.089	1.382	1.944
CD (0.05)	0.679	0.954	0.806	1.026	1.443

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value

4.4.2.3 Collar girth of the suckers

The data of collar girth of the second ratoon presented in the Table 46 clearly revealed that at 30th day, treatment T_2 (application of Zn (0.25%) to the sucker) recorded maximum collar girth followed by treatments T_{13} (2.16) and T_3. TreatmentT_{13} followed by treatment T_{12} at 60th and 90th day recorded maximum of collar girth. At 120 and 150 days treatmentT_{13} followed by treatment T_{12} recorded the maximum values. T_{13} and T_{12} were statistically on par from second month to fifth month. At all stages the treatment means differed significantly and that too at one per cent level.

Table 46: Influenced of treatment of Zinc and Boron on collar of retained plantlets at R-2 stage

Treatments	Collar girth (cm) at monthly intervals				
	30 days	60 days	90 days	120 days	150 days
T_1	0(0.7)	0(0.7)	0(0.7)3	0.433(0.92)	0(0.7)
T_2	0(0.7)	0.86(1.11)	1.66(1.39)	1.83(1.436)	4.1(1.95)
T_3	0.73(1.23)	1.9(1.52)	2.76(1.81)	4(2.115)	6.9(2.72)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	1.13(1.13)	1.5(1.22)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.6(0.98)	0.5(0.95)	0(0.7)	0(0.7)	0(0.7)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	0.8(1.09)	1.76(1.41)	3.033(1.87)	4.56(2.24)	5.26(2.41)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	2.16(1.61)	2.26(1.65)	3.16(1.91)	5.33(2.4)	5.63(2.46)
T_{13}	1.86(1.52)	2.63(1.76)	3.76(2.07)	6.1(2.56)	6.93(2.73)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
$T1_5$	0(0.7)	0.86(1.05)	1(1.09)	1.16(1.13)	1.43(1.21)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	6.968**	5.765**	12.032**	5.765**	11.694**
CD(0.01)	0.449	0.623	0.588	0.623	0.934
CD (0.05)	0.33	0.469	0.43	0.469	0.691

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed values.

4.4.2.4 Number of leaves retained by second ratoon

The data regarding the mean number of leaves retained in the second ratoon or cycle-2 are presented in the Table 47. At all the 5 months of study very low number of leaves were recorded which ranged from 0.66 to 3.0. In the first month treatment, T_{10} (application of Zn (0.25%) + B (0.1%) to the sucker) produced the maximum leaves followed by treatments T_{12}, T_{13}, T_{10}, T_{13}, T_2, T_3 and T_8 which were statistically on par. In second month, treatments T_{12} recorded maximum number of leaves and was followed by treatment T_{13}. In the 3rd, 4th and 5th months treatment T_{13} recorded maximum number of leaves followed by treatment T_{10} in the third month, treatments, T_{10} and T_{12} in fourth month and treatment T_3 in 5th month. In fifth month, treatments T_{13}, T_{12}, T_2, and T_3 were statistically also at par. In all the five months the difference between the treatment means were statistically significant even at one per cent level.

Table 47. Influenced of treatment of Zinc and Boron on number of leaves of retained plantlets at R-2 stage.

Treatments	Number of leaves retained at monthly intervals				
	30 days	60 days	90 days	120 day	150 days
T_1	0(0.7)	0(0.7)	0(0.7)	.33(0.87)	0(0.7)
T_2	0.66(0.7)	.66(1.05)	1(1.18)	1(1.18)	1.33(1.29)
T_3	0(0.7)	2(1.56)	1.3(1.34)	2(1.56)	2(1.581)
T_4	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_5	0(0.7)	0(0.7)	0.66(0.99)	.66(0.99)	1(1.09)
T_6	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_7	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_8	0.66(0.7)	0.66(0.99)	0(0.7)	0(0.7)	0(0.7)
T_9	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{10}	1.33(1.05)	1.3(1.29)	2(1.56)	2.33(1.68)	1(1.09)
T_{11}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{12}	1(1.22)	2.33(1.68)	1.6(1.44)	2.33(1.68)	1.66(1.38)
T_{13}	1(1.22)	2(1.56)	2.33(1.68)	2.66(1.77)	3(1.88)
T_{14}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
T_{15}	0(0.7)	0.33(0.87)	.66(0.99)	1(1.09)	1(1.09)
T_{16}	0(0.7)	0(0.7)	0(0.7)	0(0.7)	0(0.7)
F value	3.998**	6.684**	5.899**	6.94**	3.44**
CD (0.01)	0.405	0.536	0.565	0.603	0.786
CD (0.05)	0.307	0.399	0.412	0.451	0.584

** Significant at 1 per cent, *Significant at 5 per cent, NS- Non-significant, Figures in parenthesis indicate square root transformed value.

4.4.3 N, P and K content in dry leaves of new quality suckers (R-1 and R-2) and dead suckers (R- 1).

Table 48 regarding content of N, P and K in the dry leaf sample revealed that there is much variation observed among the treatments. While comparing nitrogen content in ratoon- 1, ratoon- 2 and dead suckers, ratoon- 1 recorded maximum content of nitrogen followed by ratoon 2 and dead suckers. In ratoon -1 treatment T_{11} (application of Zn (0.25%) +B (0.25%) to the sucker) recorded the maximum content followed by treatmentsT_{12}, and T_1 which were statistically at par and significance observed even at one percent level. The lowest value was in the treatment T_{10} (application of Zn (0.25%) + B (0.1%) to the sucker). The lowest value was in the treatment T_{10} (application of Zn (0.25%) + B (0.1%) to the sucker). In the ratoon -2, the maximum content was recorded in treatment T_{11} (application of Zn (0.25%) +B (0.25%) to the sucker) followed by treatment T_6, T_1 and T_9 and the result were statistically not significant. In case of dead sucker, T_{12} (application of Zn (0.25%) + B (0.5%) to the sucker) recorded maximum nitrogen content followed by treatments T_8, T_{15} and T_{13} and the treatment were statistically at par. The difference between the treatment means of T_{12} and the rest of the treatments were statistically significant. The lowest recorded was in treatment T_4 (application of B (0.1%) to the sucker).

The phosphorus content in the dry leaf presented Table 48 revealed that in the first ratoon, maximum content was in treatment T_5 (application of B (0.25%) to the sucker) followed by treatments T_{11}, T_{15} and T_8. In the second ratoon there is a considerable decrease in the level and the maximum recorded was in treatment T_{11} (application of Zn (0.25%) +B (0.25%) to the sucker) followed by treatments T_{14}, T_7 and T_{15}. In dead suckers all the treatments recorded increased content than the live sample of ratoon- 2. Treatments T_1, T_2, T_4, T_6, T_9, T_{10} and T_{16} recorded more content than live samples of ratoon1. The maximum value recorded was in T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) followed by treatmentT_6, T_1, T_{11}, T_2 and T_{14} but in all the cases the results were statistically not significant.

The data regarding potassium content is also presented in the Table 48. A critical analysis of the data revealed that treatment T_{15} (application of Zn (0.5%) +B (0.5%) to the

sucker) recorded maximum potassium content followed by treatments T_{12} and T_5. The lowest content recorded was in the treatment T_{16} (control). In the second ratoon there is a decrease in the K content except in treatments T_9 and T_{11} that showed an increase. The maximum content was recorded again in treatment T_{15} followed by treatments T_{11}, T_9, T_{12} and T_1. In the dead suckers there is again an increase in the potassium content. Maximum content was recorded in treatment T_1 (application of Zn (0.1%) to the sucker) followed by treatments T_{11} and T_6. Further in case of dead suckers the content in all treatments were higher that ratoon - 2. A comparison between the treatments means of dead and ratoon revealed that the content was much higher in dead except in treatments T_4, T_5 T_7, T_{10}, T_{12} and T_{16} of in have increased content than ratoon - 2 and except in treatments T_5, T_7, T_{10}, T_{12}, and T_{16} of ratoon - 1. At all three stages there was no significant difference between the treatment means.

Table: 48. N, P and K content in dry leaves of new quality suckers (R-1 and R-2) and dead suckers following treatment of micronutrients Zn and B.

	Ratoon- 1			Ratoon- 2			Dead		
Treatments	N(mg/Kg)	P (mg/Kg)	K(mg/Kg)	N (mg/kg)	P (mg/Kg)	K (mg/Kg)	N (mg/Kg)	P (mg/Kg)	K (mg/Kg)
T_1	126.91	5.566	336.75	46.62	2.433	231.416	12.95	7.2	519.333
T_2	104.895	4.1	319.25	28.926	2.233	186.333	2.59	5.666	357.5
T_3	38.413	5.866	165.583	34.106	1.6	158.416	2.153	5	325.416
T_4	58.275	2.966	385.083	25.036	1.66	153.666	1.295	5.033	345.166
T_5	46.183	13.933	431.166	26.336	2.5	183.75	2.59	4.666	357.583
T_6	41.003	5.166	351.833	47.915	2.6	153.833	3.453	8.266	514.833
T_7	57.843	4.333	330	34.533	2.966	151.083	8.206	4.966	322.166
T_8	53.953	6.033	262.083	36.26	2.8	178.333	23.31	5.066	337.083
T_9	35.396	3.933	295.5	46.62	3.1	298.75	6.906	8.8	490
T_{10}	17.266	1.8	192.083	6.906	1.566	105.083	2.59	2.66	187.416
T_{11}	164.465	8.1	288	52.663	3.8	299.333	13.386	6.966	515.25
T_{12}	138.565	6.066	510	24.173	2.1	233.083	27.195	3.3766	478.25
T_{13}	73.383	6	285.833	20.72	1.233	82.416	16.835	4.8	336.416
T_{14}	36.26	5.966	183	28.49	3	148.666	8.633	5.833	349.25
T_{15}	106.626	6.4	575.833	34.965	2.966	311.5	18.993	3.5866	496.916
T_{16}	26.336	2.133	143.333	9.065	1.133	60.916	7.77	2.833	127.333
F value	3.373**	0.73^{NS}	0.89^{NS}	1.396^{NS}	0.491^{NS}	1.338^{NS}	2.873**	1.045^{NS}	0.762^{NS}
CD (0.01)	93.251						18.518	-	
CD(0.05)	69.388						13.778		

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

4.4.4 Mg, S, B, Zn, Fe (mg/kg) content in dry leaves of new suckers (R-1 and R-2) and dead suckers (R- 1)

The data presented in the Table 49 regarding the Magnesium content revealed that it was highest in treatment T_{11} in ratoon-1 (application of Zn (0.25%) +B (0.25%) to the sucker) followed by treatments T_9, T_{13} and T_3 respectively whereas in second ratoon the Mg content showed a decreasing trend. Treatment T_{15} (application of Zn (0.5%) +B (0.5%) to the sucker) recorded maximum content followed by treatment T_6, T_{11} and T_1. In dead suckers the Mg content further decreased. The maximum recorded was in treatment T_{11} (application of Zn (0.25%) +B (0.25%) to the sucker) followed by treatments T_1 and T_{15}.

In case of sulfur (S) a general decreasing trend is observed from ratoon -1 to 2 to the dead suckers. In ratoon 2 in four treatments (T_3, T_5, T_{13} and T_{14}) there was an increase observed. In ratoon- 1 and 2, treatment T_{11} recorded the highest value which was almost half times more than the second best and nearly double that of recorded in other treatment. In case of dead sucker treatment T_1 (application of Zn (0.1%) to the sucker) recorded maximum S, content followed by treatments T_6 and T_7.

In case of boron, treatment T_1 (application of Zn (0.1%) to the sucker) recorded maximum content followed by treatments T_9, T_{15}, T_{12} and T_{11}. In the second ratoon again, treatments T_1 (application of Zn (0.1%) to the sucker) record the highest value followed by treatments T_{11}, T_{14} and T3 whereas in dead sucker's maximum content was observed in treatment T_5 (application of B (0.25%) to the sucker) followed by treatments T_{11}, T_9 and T_{12}. In case of boron also the general trend is in the decreasing order from first ratoon to the dead suckers. There was no significant difference between the treatment means at all the stages.

In case of iron content maximum was recorded in treatment T_1 followed by treatments T_{15} and T_{11} in the first ratoon. In the second ratoon treatment T_9 (application of Zn (0.1%) + B (0.5%) to the sucker) recorded the maximum value followed by treatments T_{13} and T_{15}.In the dead suckers again treatment T_1 recorded maximum iron content followed by treatments T_9 and T_3. In case of Mg, S, B, and Fe the difference between the treatment means are not statistically significant.

In case of Zinc the maximum content recorded was in treatments T_1 in the first ratoon followed by treatments T_6, T_3 and T_4 and T_8 which recorded the same value. T1 was statistically at par with treatments T_6 T_3, T_8, T_4, T_2, T_7, T_9 and significantly superior over other treatments. In the second ratoon the content reduced, and maximum was recorded was in treatment T_5 (application of B (0.25%) to the sucker) followed by treatments T_1, T_{12} and T_{10}. In the dead sucker maximum Zn content was recorded in treatment T_1 followed by T_{15} T_5 and T_8. The treatments T_1, T_{15}, T_4, T_5, T_8, T_{12} and T_{13} are statistically at par with each other. The mean of T_1 was significantly superior over other treatment means.

Further a thorough scrutiny of the data of Table 49 revealed that the treatments recording highest content of Zn, B and Fe was observed as the treatment recording the highest number of sprouts in ratoon-1.

Table 49: Mg, S, B, Zn, Fe (mg kg $^{-1}$) content in dry leaves of new suckers (R-1 and R-2) and dead suckers as influenced by micronutrient treatment of Zn and B.

Treatments	Ratoon- 1					Ratoon- 2					Dead				
	Mg	S	B	Zn	Fe	Mg	S	B	Zn	Fe	Mg	S	B	Zn	Fe
T_1	598.33	708.45	0.637	22.966	903.033	116.778	575.202	0.506	6.833	351.6	52.398	231.001	0.093	0.866	197.7
T_2	306.48	620.244	0.426	12.233	440.7	85.601	424.576	0.193	2.7	246.2	26.778	72.576	0.126	0.233	129.2
T_3	613.15	401.685	0.427	13.666	557.133	82.796	840.87	0.436	3.8	373.9	28.028	81.994	0.088	0.233	160.33
T_4	335.29	801.082	0.446	12.733	602.166	80.73	511.647	0.233	0.8	360.466	23.666	181.089	0.053	0.533	115.566
T_5	365.65	144.913	0.446	8.5	611.5	102.648	458.892	0.146	9.233	171.266	34.601	47.032	0.376	0.7	87.233
T_6	447.5	596.946	0.598	14.4	633.4	139.546	588.555	0.257	2.466	351.966	27.375	140.059	0.053	0.1366	86.133
T_7	242.78	698.828	0.448	11.3	304.3	72.046	451.262	0.202	2.833	264.8	27.203	134.676	0.076	0.533	103.7
T_8	402.21	674.5	0.413	12.733	310.166	72.083	535.799	0.303	3.233	379	33.221	123.467	0.033	0.566	168.5
T_9	816.25	465.585	0.636	11.133	768.533	123.528	616.512	0.25	5.766	740.366	48.046	132.231	0.166	0.133	179.366
T_{10}	270	324.23	0.214	3.166	204.9	53.565	201.483	0.088	6.3	240.533	19.625	67.4	0.106	0.1	52.33
T_{11}	913.51	1424.69	0.613	7.1	789.9	138.546	1127.52	0.451	1.533	277.2	54.351	18.039	0.203	0.266	96.833
T_{12}	572.78	595.456	0.626	3.333	522.033	91.583	523.728	0.308	6.333	385.766	34.296	55.813	0.149	0.466	105.2
T_{13}	614.35	320.337	0.418	1.966	588.666	84.953	643.844	0.425	5.5	427.766	26.833	74.99	0.046	0.433	54.9
T_{14}	588.98	289.19	0.426	1.766	513	110.185	596.811	0.443	3.5	389.966	32.398	74.364	0.056	0.266	91.3
T_{15}	653.15	902.844	0.632	2.833	879.766	179.221	847.871	0.337	4.433	404.266	51.546	212.737	0.051	0.8	115.833
T_{16}	203.51	220.78	0.216	0.66	301.066	29.315	200.202	0.103	2.3	125.8	16.898	20.47	0.026	0.033	34.233
F value	9.24^{NS}	4.073^{NS}	0.643^{NS}	2.124**	0.977^{NS}	1.079^{NS}	0.975^{NS}	0.84^{NS}	0.934^{NS}	0.86^{NS}	0.895^{NS}	1.174^{NS}	1.06^{NS}	2.868**	1.59^{NS}
CD (0.01)														0.780	
CD (0.05)				12.211	-									0.585	

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

4.5. Economics of production and B: C ratio of sucker production through macropropagation.

Data from the economics and B: C ratio of sucker production presented in Table 50 revealed that in the first experiment the multiplication rate from one sucker in ratoon – 1 is 7.6 and that of ratoon- 2 is 4.6. Altogether from one sucker the total production is 35 suckers in one year. For production of one sucker it cost Rs. 45 and B: C ratio found to be 0.349.

In the second experiment the multiplication rate from one sucker in ratoon-1 is 5.6 and in ratoon- 2 is 4.3 from 6 months. Altogether from 1.0 sucker it produced 24 suckers in 6 months the cost of production of one sucker is only Rs. 7 as the best media was the locally available cheap Red soil and thus the B: C ratio increased to 2.29.

In the third experiment the multiplication rate from one sucker in ratoon -1 is 4.3 and in ratoon-2 is again 4.3 from five months. Altogether from 1.0 sucker it produced 18.4 suckers. Production cost of one sucker was thus Rs 9.3 and B: C ratio recorded worked to 1.6.

In the fourth experiment the multiplication rate from one sucker in ratoon-1 is 4 and in ratoon- 2 it is 4.6 in 6 months. Overall from 1.0 sucker it produced 18.4 sucker. Production cost of one sucker was thus Rs 7.1 and the B: C ratio was 2.14. In all the case selling price of sucker is Rs 15.

Table 50. Economics of production and B: C ratio of sucker production in different macropropagation method.

Inputs	Exp 1			Exp 2			Exp 3			Exp4		
	Mother corm	R1 (1Year)	R2 (5months)	Mother corm	R1 (6months)	R2 (4month)	Mother corm	R1 (5months)	R2 (4month)	Mother corm	R1 (6months)	R2 (5months)
Planting material banana sucker (Nendran)	15 (1)	(7.6)	(4.6)	15 (1)	(5.6)	(4.3)	15 (1)	(4.3)	(4.3)	15 (1)	(4)	(4.6)
Initial planting material cost	Rs 450 (30)	(228)	(1049)	675 (45)	(252)	1084	Rs 825 (55)	(236.5)	(1017)	Rs825 (55)	(23.6)	(1017)
Coir pith (1000 suckers)	Rs 30(12 Kg)		Rs 31470 (12,588 Kg)									
Saw dust (1000suckers)	Rs 8(4Kg)		Rs 8392 (4196 kg)									
Soil (1000 suckers)	Rs 0.4(4Kg)		Rs 420 (4196kg)			Rs 2168 (21,680)			Rs 2034 (20,340)			Rs 2034 (20,340)
Poly bag / Sacks (1000 suckers)			2000			Rs 2000			Rs 2000			Rs 2000
Sulfuric Acid (1%) (1000 suckers)			Rs 0.04			Rs 0.04			Rs 0.04			Rs 0.04
Labor (Bag filling) (1000suckers)			Rs 2250 (3)			Rs 2250 (3)			Rs 2250 (3)			Rs 2250 (3)
Azospirillum									Rs 762.75 (10.17Kg)			
AMF									Rs 1526.25 (20.345 Kg)			
Zinc suphate (0.1 %)												Rs 0.8
Total			Rs 44982.04			Rs 7093.04			Rs 9398.04			Rs 7110
Cost of 1 sucker			Rs 45			Rs 7			Rs 9.3			Rs 7.1
Return			Rs 15735.00			Rs 16260.00			Rs 15255.00			Rs 15255
B: C ratio			0.349			2.294			1.6			2.145

Value in the parenthesis shows the quantity of suckers, media, *Azospirillum*, AMF and number of laborers.

Discussion

5. DISCUSSION

The major results under each experiment of the project are discussed concept wise here under.

5.1 Physical activation of buds

The underlying philosophy of this experiment is that there are many under developed or miniature buds lie within the corm that have the potential to develop as sprouts. These buds are potential suckers if activated and allowed to further develop.

The result of study reveals that acid treatment by pouring 5 ml of 1 per cent H_2SO_4 acid on the apical meristem portion of sucker activated more number of quality suckers from the mother corm. Banana is basically a perennial crop but cultivated as an annual (Stover and Simmonds, 1987). In conventional planting normally, sword suckers are used. Apical meristem at the apices of the corm when planted lies at or above the soil surface. The growing apices shows high apical dominance which result in inhibition of lateral buds. The study convincingly proves that when the apical dominance was arrested it led to the development of the miniature buds immediately as sprouts and then as quality suckers. This is evident in our studies as it is seen that irrespective of treatments all the physical activation technique leads to development of sucker. The explicit influence of acid treatment can be argued on the lines that this particular treatment leads to complete arrest where in other treatments the arrest is incomplete or partial. In this particular treatment there was boring out of the growing apices plus acid treatments which promoted the activation of miniature but to its best.

Another probable reason has to why the acid scarification lead to more sprouting could be the more activation of the lateral buds in and around the vicinity of the decapitated apical meristem (plate 17).

Plate 17. Sucker initiation around the acid treated portion.

A critical analysis revealed the three waves of suckering were observed the first wave being observed from the first to sixth fortnight, the second from the thirteenth to eighteenth fortnight and the third from the nineteenth to twenty fourth fortnight. This can again be argued that the first formed sucker normally pulled out the major share of nutrients and photosynthate till it reaches a level of independence. These suckers that initially developed also could have suppressed the still smaller buds. On their removal as quality suckers, the next set of smaller buds then developed which on removal also gave way for the development of next set. The study also pointed to the fact that once it has reached a developmental stage or nearing a stage of physiological independence it has to be planted out or would further inhibit the sprouting. Thus, it substantiated the need for removal or detachment of developed plantlets which was actually enforced in our present study on attainment of a particular collar girth and planted out. This stage of sucker based on physiological dependence or independence on the mother rhizome has been proved based on ^{14}C studies (photosynthate) by

Bhende and Kurien, (in press) and in case of nutrients (based on ^{32}P) by Kurien, *et al* (1999)

A study of original genesis of the bud revealed that the origin of sucker lies in the cortex of the corm, which is mostly in the subapical part or in the upper cortex and the dependency of the developing sprouts until its detachment inhibited further sprouting and thus the production of new sprouts in waves. The first step was the production of new sprouts then a period to attainment of its physiological size to independence. The second period of activation of sprouts occurred after the first the detachment of the first formed sprouts.

The morphological characters in the study *viz,* height, collar girth, number of leaves, number of roots was more a reflection of early stage of sprout initiation and the detachment of quality suckers for planting. In banana the pseudostem is made up of leaf sheaths which is most pronounced at collar and this reflect both the number of leaves as well as the plant vigor (Blomme *et al.,* 2003). Another aspect of importance is the number of roots. Roots and collar girth are also highly correlated. Therefore, the plant psudostem circumference or collar girth reflect shoot growth and is an important determination of vigor (Blomme *et al.,* 2003). In our study the values recorded in the treatments were actually based up on the observation of morphological character of the plants that remain attached and this is the reason why as days progress there is a decrease in the values observed of plantlets that reached a quality planting stage were detached.

The observations on mean weight, volume and number of roots were taken only at the last stage of each experiment as the plantlets produced at early stage had to be carried forward to the ratoon studies. Thus, it is very clear that these characters were more a factor associated with number of plantlets at the last stage. In our study T_9 (three cuts of incision up to $3/4^{th}$depth of sucker.) showed only 4 number of plantlets and thus the competition was comparatively low which lead to better or

higher values as observed. Studies of Kurien *et al.,* (2002) on nutrient cycling from mother to daughter suckers and that of Bende and Kurien, (in press) for photosynthates overwhelmingly proved that there is a competition for nutrient between the sucker produced on a corm and this answer the finding of our study.

A critical analysis of the data of number of underdeveloped suckers and dead suckers revealed that T_{15} (control) recorded the highest values which could possibly due to the inefficient arrest of apical dominance which lead to production of lanky sprouts.

The ratoon study showed the explicit superiority of T_{13} (acid treatment by pouring 5 ml of 1% H_2SO_4 acid on the apical meristem portion of sucker). In second ratoon if the plantlets produced in the second ratoon are not planted out, they perish as the corm of the first ratoon has only limited reserve and cannot supplement the required need of the newly developing suckers in R-2. The decreasing weight and volume of the followers in addition to the carbohydrate content per unit gram makes it difficult for the new suckers to thrive on the maternal mother corm. This is evident from the very low level of carbohydrate observed in the dead suckers and this has already been proven ^{14} C and ^{32}P studies by Bende and Kurien, (2016) and Kurien *et al.,* (2006). The mother sucker from which the R-1 regeneration of sprouts occurred had high reserve of carbohydrate (Table 12, Fig 2) and this was the very reason why more sprouting could be observed at ratoon - 1 or cycle – 1 added to the fact that at this stage the mean weight of the sucker was 1.5 kg but when it came to ratoon -2 the inherent size of the corm was reduced to 1/15th in most cases and 1/7.5 in the best treatment (T_9). However, in T_9 the inherent carbohydrate content was again low. The decrease in T_9 was from 24.7 mg/100g in mother sucker 17.10 mg/100g in ratoon- 1 and 5.40 mg/ 100g in ratoon- 2. In the best treatment T_{13} it ranges from 20.3 to 10.9 to 4.46 to 4.41 mg/100g. Thus, the picture emerging is very clear that there is a depletion in the reserve to a level of less than 5 times which proves beyond doubt that the regenerative potential is governed by the inherent reserve of carbohydrate. The

studies of (Ntamwira *et al.,* 2017) also revealed that the soil was the best media and improvement in potting media does not proffer any special advantage. Though he did not make a study on carbohydrate level, he proposed that it is probably the inherent carbohydrate reserve alone on which regenerate sprouting relies. Our study convincingly proves this point the earliest formed plantlets at ratoon- 1 stage where better and they alone produce quality plantlets in ratoon – 2.

The effects manifested at morphological aspect, height collar girth, number of leaves etc. were more a reflection of the vigor of plantlets produced as a consequence of carbohydrate.

5.2 Standardizing the grow bag media constitution for macropropagation.

The result on the potting media standardization revealed a very interesting and important inference. The study on potting media involved seven combinations of potting media, two types of apical dominance arrest in soil media with each of the above 9 treatments at two holding weights of potting media i.e. 15kg and 20kg formed the 18 potting media treatments. This along with the two control treatments of soil alone in the above two weight formed the 20 treatments.

Irrespective of the weight of the potting media, acid treatment in soil media gave the best sprouting. This revealed that though, coirpith, sawdust and soil combination rendered better physical conditions and more nutrients the soil potting media turned out be the most rewarding. This opens out 2 or 3 very important debatable points, the first and foremost aspect is that, sprouting is not a factor of nutrients or better quality. It is more absolutely depended up on the inherent starch reserve of the mother corm. In the early stages of sucker primordia initiation and its external development into peepers. The newly developing sprouts is totally dependent on the corm. This reliance on the mother corm is total until root development on corm of the new sprouts which from our study has revealed will take about three to four fortnights or 45- 60 days.

Hence in the sprout development reliance is totally or absolutely on nutrient recycling from the mother corm which supplies or meets cent per cent of the requirement of for the new sprouts. Studies of nutrient recycling from mother to daughter suckers in banana has been reported by Twyford, (1967), Rajeevan, (1985) and equitable and just allocation between developing suckers in a sequential way in the order of emergence has been reported by Kurein *et al.,* (2002) and Bhende and Kurien, (2016) under actual field situation. The difference in the study is only that this project focused on activation of new buds into new suckers by arresting apical dominance. In the above-mentioned studies and in our present study the reliance of the sprouts is exclusively on the mother corm and hence this could be the reason as to why there was no additional response in the different combination of media. The soil media which was the control treatment was just the soil taken from where the original mother sucker was grown and hence could have adapted to the condition in much better way. In a recently concluded project supported by Department of Science and Technology, Government of India. It has been reported that the first flush of root production starts after 45 days of planting this is a stage where in the planted sucker starts its own nourishment from soil. In our study detachment of new plantlets started mostly from 3rd fortnight or 45 days or it can be safely inferred that the plantlets were exclusively depended on mother corm and hence *per se* the different media combinations could not exert any influence by way of nutrient supply.

What need to be highlighted is on the particular treatment of boring plus acid treatment (which was most effective of physical activation techniques in the first experiment) plus potting media soil alone yielded maximum number of sprouts. A critical review of the effect of this treatment reveal another glaring phenomenon. The boring and acid treatment almost have a total arrest of apical dominance. But this total arrest spurred the activation of the buds in and around or in immediately vicinity of the decapitated apices. This is in confirmation with earlier reports (Aliero, 2004; Mojeremane *et al.,* 2017; Baličević *et al.*, 2016)

The result generated in the study is of immense practical relevance due to manifold reasons. The first aspect being total decapitation can be achieved by a minimal investment of easily available acid (H_2SO_4). Secondly the potting media used in study was from the same field and soil is locally available, comparatively cheap and filling needs no added skill. Another significant contribution that emerge from the study is that any farmer can readily take up this method of macropropagation by resorting to selection of healthy mother corms from elite mother corm. The production process is simple easy and cheap that it can be taken up by small and marginal resource impoverished farmers and that too at *in situ* level.

The morphological character mainly height, collar girth, Number of leaves, weight and volume are all an expression of the vigor of the plantlet that arose from this particular treatment again suggesting that this particular treatment of production process not only produce more number of plantlets but they were of better quality.

In the ratoon studies, new sprouts in ratoon-1 or cycle-1 were observed only in treatments with complete boring of apical meristem plus acid treatment and in soil media. As already mentioned sprouting is a factor that is depended on the carbohydrate reserve in the mother corm. In this particular study quality plantlets of at R-1 stage or C- 1 was observed only in the above combination irrespective of weight of media and hence when carried over to R-2 they showed the capacity for sprouting (Plate 17). In comparison, the plantlet quality at R-1 stage was not only superior but explicit and glaring and this should be sole reason for the regeneration capacity at R-2 stage.

5.3 Effect of *Glomus fasciculatum* and *Azospirillum. spp* on macropropagation by using banana sucker (Nendran AAB).

Arbuscular Mycorrhizal Fungi form mutualistic or symbiotic relationship with plants and more than ninety per cent of AMF are important for accessing requirement in one way other (Jefwa *et al.,* 2010). In our study all the 15 treatment that using

Glomus fasciculatum, Azospirillum and in combination showed higher spore count and per cent root colonization. This is the basis of all the improvement generated in the study

The most effective treatment was a combination of 20g *Glomus fasciculatum* and 10g *Azospirillum*. A critical analysis of the result shows that the better colonization lead to higher available N, P and K in soil. In case of media there was a general increase of available N, P, and K content. In the most effective treatment (T_{10}), N recorded the 3rd highest value but it differed from the best only at the fractional level. In case of P it recorded the second highest and it was as good as best. In case of available K, the relative level was high though not the best. Across the treatments in terms of N, P and K together there is obviously a balanced increase in case of available N, P and K in the media.

What has to be understood from the study based on application of *Glomus fasciculatum* and *Azospirillum* is that there is a very effective increment in the root number and also in quality of root as observed in the root length. Secondly, the high degree of per cent root colonization in the root pave the way for better uptake of more available nutrients. Though it is generally believed that daughter sucker relies on mother corm exclusively on nutrient reserve this study particularly with respect to per cent root colonization proves that it could lead to earlier and better uptake due to more intense quality root production.

A thorough examination of the spore count reveal that the most effective treatment in the experiment in terms of quality sucker production, number of root and root length are in line with the spore count Thus number of spores have a profound effect on the growth and development of suckers and roots (Ortas *et al*., 2017).

The morphological character, height, collar girth, number of leaves volume and weight of the corm was more a reflection of the detachment of plantlets reading or planting on one side and other as the number of plantlets retained increased there

was a general reduction height and collar girth which was the reason for varying trend observed

The general increase in the availability of major nutrients N, P and K and their uptake have been reported in different studies. (Chisho *et al.*, 2017; Selvamani *et al.,* 2011; Phukan and Baruah, 2017; Singh and Prasad, 2006; Naher *et al.*, 2013) Another possible reason could be that the *Glomus fasciculatum* can increase plant access to water (Gavito and Varela, 1995)

Another reason for improved sprouting and quality plantlet production could be at the level of production of hormones which has not been undertaken in this study. But there are many reports that promisingly prove the enhanced production of hormones like auxin, gibberellins and cytokinins (Allen *et al.*, 1982; Allen *et al.*, 1980; Barker and Tagu, 2000; Ortu, *et al.,* 2012; Shaul-Keinan, *et al* 2002) as a consequence of AMF associationship which generally promote rooting, eventually lead to the good morphological development of the plantlets.

In the ratoon (R-2 or cycle- 2) there is a difference observed with the number of sprouts being highest in combination (30g of *Glomus fasciculatum* plus 30g of *Azospirillum*). At R-1 stage this treatment had produced only an average of 2.0 plantlets against a mean maximum of 4.3 in case T_{10}. On contrary in R-2 stage. T_{15} produced average of 4.3 plantlets against 3.5 in T_{10}. Which is a reflection of weight and volume of corm of R-1 taken for studies of R-2. The better vigor of these sprouts due to the better corm size (weight or volume) resulted in plants with better height, collar girth and more number of leaves.

In the analysis of *Azospirillum* interaction the result showed no trace of *Azospirillum* at the end of five-month stage, the probable reason could be the pH of the soil used. *Azospirillum* actively flourish under the neutral pH (Bethlenfalvay, 1992), but the soil pH recorded in the study was 5.5.

5.4 Standardization of macropropagation technique using micronutrients in Banana Musa (AAB) 'Nendran'.

Micronutrient are required by plants in minute quantity and are effective in regulating plant growth and other physiological process as they form a part of enzyme system that regulate plant growth and development. In banana micronutrient like Zn, Cu, B, Mn have been reported to be important for the healthy growth of banana (Srivastava, 1964). Deficiencies of any of these micronutrients not only effect plants growth but even suckering habits.

In our study the best physical activation technique was combined with the best media to which the micronutrient treatment was applied. The most effective treatments were application of Zn at 0.1 per cent (1000ppm). Though the Zn and B have tried individually and in combination it was Zn 0.1 per cent which produced maximum number of sprouts.

It is well known that Zn is required for production of tryptophan which is a precursor for production of indole acetic acid (IAA) an auxin, that is known to promote growth and development. All hormones regulate plant growth process at a defined concentration and that could be reason as to why Zn at 0.1 per cent was most beneficial in production of new sprouts. It could have led to the most optimal production of auxin. The beneficial effects of Zn in growth (Longnecker and Robson, 1993; Tenorio *et al.*, 2006; Balaji *et al.,* 2016; Pathak *et al.,* 2011; Ghanta and Dwivedi, 1993) and yield of plants have been reported in many cases, but effect of sucker is not been well attempted. However, when a comparison is made between the application of micronutrient it has only led to decline in number of quality sucker production.

The result on height, collar girth, number of leaves, weight, volume and number of roots are also not significant, and the erratic nature observed in height and

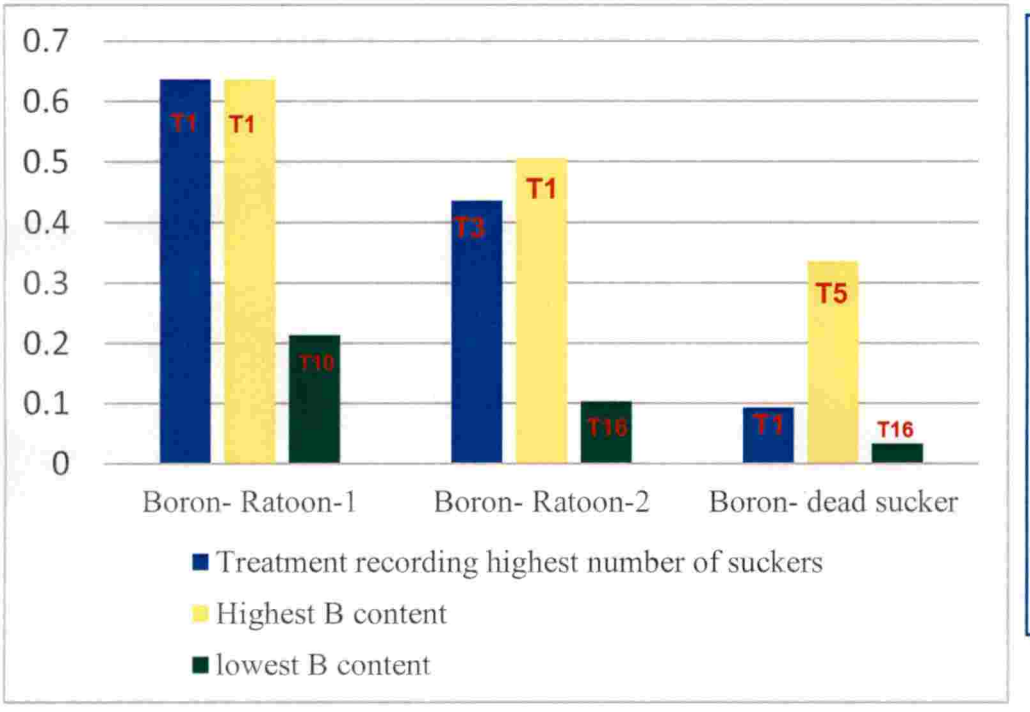
collar girth at different intervals are due to the detachment of quality suckers that have satisfied the prescribed quality parameters prior to the stage of reading.

The difference observed in N, P and K content were significant only in the case of N. This is mainly due to the fact that Zn application would have led to more auxin which produced better growth of plantlets as observed in early stage prior to detachment of quality plantlets. This should be the reason for better N content due to the inherent vigor. Identical studies and references are not available on the subject, but this could be the only probable reason.

Ratoon studies revealed that Zn alone at 0.5 per cent was the best treatment at R- 2 followed by a combination of 0.5 per cent Zn and 0.1 per cent B respectively. This shows that at R-2 level the requirement of Zn is much more than at R-1. Depletion of Zn at R- 1 should have occurred and that should be possible reason as to why the same treatment could not regenerate the sprouts. However, this need to be examined at length. The critical requirement value at R-1 and R-2 need to be further probed which is recommended as a future line of investigation.

Analysis of the various micronutrient yielded no significant difference except in case of Zn, Where the results were significant at ratoon – 1. At ratoon- 2 there is a gross reduction in Zn level which shows the reason for the most effective treatment (T_1) 0.1 per cent Zn becoming ineffective at R- 2 stage. The general trend is that of decline for all the secondary and micronutrient taken up in the study from stages of R-1 to R-2 to dead sucker. One striking feature noticed is that the treatment recording highest content of Zn, B, and Fe recorded highest number of sprouts in the first ratoon (Fig 6, Fig 7, Fig 8) and hence it's very clear that the application of Zn and B had definite role in the sucker production. Gupta, (1993) has also stressed on this aspect based on his studies.

Figure 6. Boron content in dry leaf tissue (mg kg $^{-1}$) at six-month stage of R-1, R-2 and dead suckers.



T_1 - Zn (0.1%)

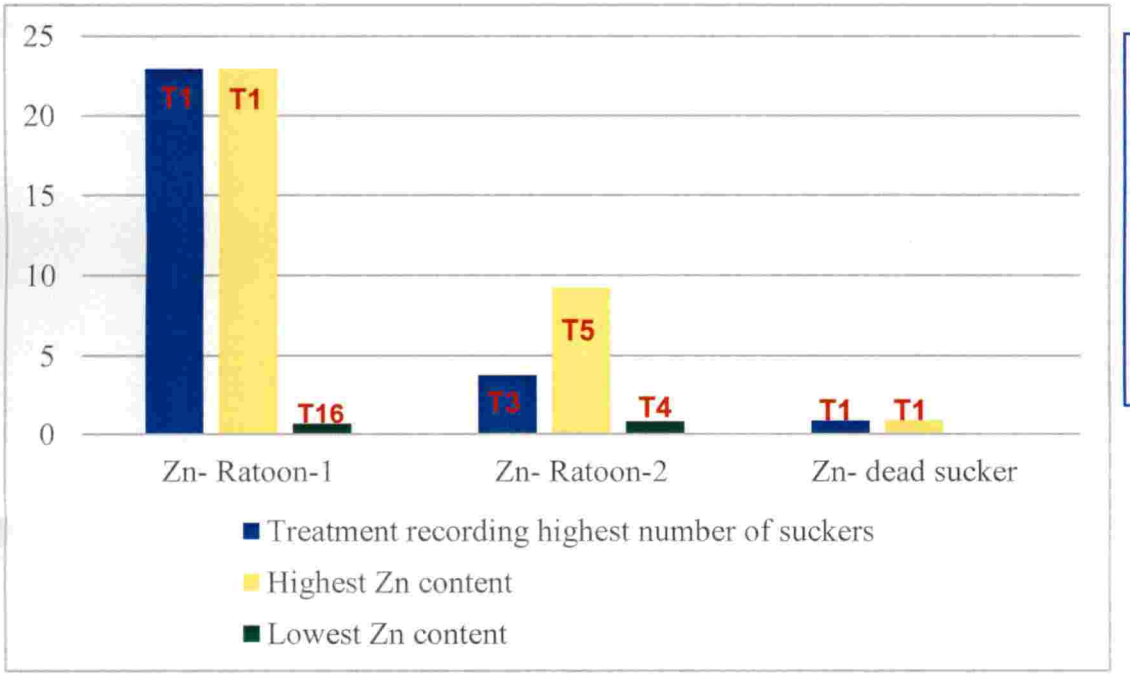
T_3 - Zn (0.5%)

T_5 - B (0.25%)

T_{10}- Zn (0.25%) +B (0.1%)

T_{16} - Control

Figure 7. Zinc content in dry leaf tissue (mg kg $^{-1}$) at six month stage of R-1, R-2 and dead suckers.



T_1 - Zn (0.1%)

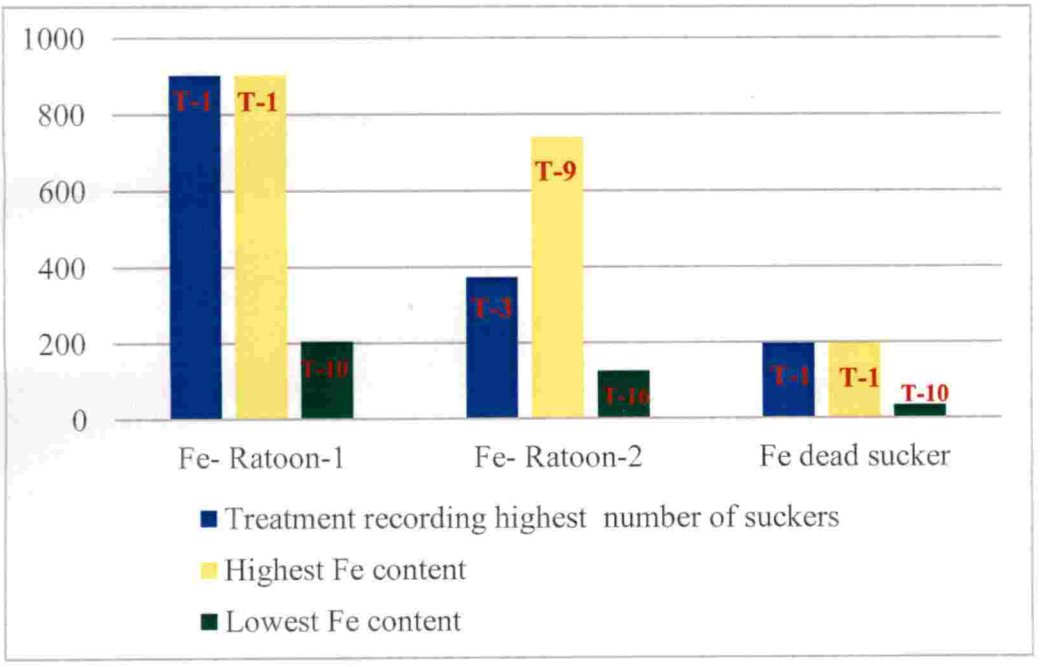
T_3 - Zn (0.5%)

T_4 - B (0.1%)

T_5 - B (0.25%)

T_{16} - Control

Figure 8. Iron content in dry leaf tissue (mg kg $^{-1}$) at six month stage of R-1, R-2 and dead suckers.



T_1 - Zn (0.1%)

T_3 - Zn (0.5%)

T_5 - B (0.25%)

T_9 -Zn (0.1%) + B (0.5%)

T_{10}- Zn (0.25%) +B (0.1%)

T_{16} - Control

5.5 Economics and B: C ratio of sucker production through macropropagation.

Analysis of economics and B: C ratio of the sucker production through macropropagation, in the first experiment for a span of twelve months B:C ratio found to be 0.345 this is due to high cost of coir pith and sawdust. In the second experiment for a span of six months ratio found to be 2.29 while in the third experiment for a span of five months it is 1.6. In the fourth experiment for a span of six months it is 2.14. As a matter of fact, there are 3 labors has been added, but this could reduce while considering the small and marginal farmers demand, as he himself could perform the work and produced the suckers. Hence the B:C ratio could have been much higher.

Summary

6. Summary

With the precise objective of standardizing a protocol of macropropagation technique and thereby enhancing the production of quality planting material in Nendran this study was taken up at Banana Research Station and College of Horticulture, Vellanikkara during 2016-18. The study involved standardizing the bud activation/ invigoration technique leading to efficient quality sucker production, with to identify the best potting/ grow bag media preferably using locally available materials. The study further extended to improve the efficacy of quality sucker production using biofertilizers particularly *Glomus fasciculatum* and *Azospirillum* in macropropagation as this has already been proven to be have positive effect on the growth and yield of banana and also to study the effect of micronutrient Boron and Zinc in macropropagation.

The salient findings are summarized below:

- Pouring 5 ml of 1 per cent H_2SO_4 acid on the apical meristem portion of the sucker found to be best bud activation/ invigoration technique for production of quality sucker production in first and second ratoon.
- All the bud activation/ invigorating technique for quality sucker production found to be fruitful. Since sprouting had observed in almost all treatments
- The acid treatment had activated the bud that are found close to the apical meristem following the arrest of apical dominance.
- Sucker production is greatly influenced by the inherent carbohydrate content in the mother corm, which propel the sucker production from first ratoon to second ratoon.
- A trend of decreasing carbohydrate content was observed from mother corm (20.3 mg /100ml) to first ratoon (10.933 mg /100ml) to second ratoon (4.46 mg /100ml) to dead sucker (4.366 mg /100ml).

- A critical analysis of the data of number of underdeveloped suckers and dead suckers revealed that T_{15} (control) recorded the highest values which could possibly due to the inefficient arrest of apical dominance which lead to production of lanky sprouts.

- Though many combinations of coir pith, saw dust and soil were tried. Soil media as potting media was found to be ideal for rapid multiplication of sucker through macropropagation. Though sprouting was observed in all treatments, highest was observed in soil media in the first ratoon whereas in the second ratoon sprouting was observed only in the soil potting media.
- In all the experiments the readings of height, collar girth and number of leaves showed an erratic trend as the sucker production was in waves or phases and suckers that had reached optimum stage were detached and planted out. Thus, the observation on intact suckers revealed such waving trend. Thus, the observation revealed of have less significance.
- The height, collar girth and number of leaves of second ratoon were highest in that treatment record the highest number of suckers.
- The weight, volume and number of roots of the corm were not the treatments that yielded highest number of quality suckers. This is due to the treatments with highest weight, volume and number of leaves produced less number of sucker hence the competition for the carbohydrate is less as compared to the treatments recording highest suckers.
- The study using biofertilizers revealed that 20g of *Glomus fasciculatum* + 10g of *Azospirillum* per mother corm produced the highest number of quality suckers in the first ratoon. In the second ratoon the combination of 30g of *Glomus fasciculatum* + 30g of *Azospirillum* gave more number of quality suckers.
- Irrespective of the treatments in the biofertilizer experiment, available N, P and K content of the soil was observed to increase when compared to the

control. In case of available N and K the treatment that recorded the highest number of suckers had also recorded high available N and K in the soil. In case of P the treatment recording the highest number of suckers recorded the second-best highest available P content.

- *Glomus fasciculatum* an AMF species was found to be highly acclimatized to the banana roots even in the acidic soil, the per cent root colonization was as high as 66.66 per cent and spore count was 333.66 spore /g of soil.
- Though the nitrogen content in the soil was found to have increased than the control, population count of *Azospirillum* gave negative results probably due to the acidic pH (5.5).
- Application of Zn (0.1%) to the sucker recorded maximum number of sucker production in the first ratoon. In the second ratoon, it was application of Zn (0.5%) that recorded the maximum sucker production.
- Application of Zn in the second ratoon increased the sucker production (4.0 to 4.6).
- From the analysis and data on micronutrient and macronutrient first and foremost inference is that there is trend of decrease in the content of all micronutrients due to the dilution effect. Further for the treatment the recorded the highest number of suckers is the treatment that recorded the highest Zn, B, and Fe content. Thus, it proves beyond doubt that the effect of Zn and B in the sucker production.
- Sucker production reduced from 7.6 in ratoon-1 or cycle-1 to 4.6 in second ratoon or cycle -2 in first experiment. while in second experiment it ranges from 5.6 to 4.3. In third experiment it was stable from 4.3 in ratoon-1 to 4.3 in ratoon -2. In fourth experiment sucker production got increased from ratoon-1 to ratoon-2. (4.0 to 4.6).
- The economic analysis based on B: C ratio revealed that in the first experiment the ratio found to be 0.345. This is due to high cost of coir pith

and sawdust. This could be significantly improved in the second experiment where in the ratio found to be 2.29. In the third experiment it is 1.6 and in fourth it is 2.14. this is inclusive of the prohibitive cost of laborer. In small and medium holding farmers this part is done by the farmer himself and hence in real terms the B:C ratio would be much higher.

- The study has convincingly established a protocol for macropropagation which is simple, less skilled, low in cost and can be taken up by easily by the resource impoverished small and marginal farmers by selecting disease free mother corm at in situ level and hence is of immense practical relevance.

References

7. REFERENCE

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Abstract

STANDARDIZATION OF MACROPROPAGATION TECHNIQUE IN BANANA

(*Musa* (AAB) 'NENDRAN')

By

AMAL PREMACHANDRAN

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120

Abstract

The quality of the planting material is of paramount importance in successful crop production and banana is no different. Dearth of planting materials and heavy demand ends up with banana farmers forsaking the sucker quality aspects. Different techniques have been attempted for activation of new sucker. However, a standardized protocol of rapid mass multiplication macropropagation technique to produce quality planting material in Nendran is lacking and is the need of the hour.

Hence, this study was undertaken with the prime objective of standardizing the bud activation/ invigoration technique leading to efficient sucker production. The second objective was to identify the ideal potting/ grow bag media preferably using locally available and cost effective materials. The third objective was to study the efficacy of the application of biofertilizers particularly *Glomus fasciculatum* and *Azospirillum* in macropropagation as this has already been proven to be have positive effect on the growth and yield of banana and finally to study the effect of micronutrient boron and zinc in improving macropropagation efficiency.

The study was taken up at Banana Research Station (BRS), Kannara, during 2016- 18 using disease free healthy suckers of Nendran (*Musa* AAB) and the new sprouts were evaluated for all major morphological characters in all the four experiments. Additionally, carbohydrate content of banana corm was analyzed in the first experiment, percent root colonization and spore count of *Glomus fasciculatum,* population count of *Azospirillum* and major soil nutrients (N, P and K) in the biofertilizer experiment, and the nutrient content of selected nutrients in leaf samples in ratoon-1, ratoon-2 and dead sucker in the micronutrient study were also analyzed and evaluated.

In the first experiment on standardizing the bud activation/ invigoration technique leading to efficient sucker production, acid treatment by pouring 5.0 ml of one per cent H_2SO_4 acid on the apical meristem portion produced the highest mean number of quality suckers of 7.6 in ratoon – 1 and 4.6 in ratoon-2 respectively. Based on the carbohydrate content it could be inferred that the reduction in the inherent carbohydrate reserve had affected the sucker production from mother sucker stage to ratoon-2.

In the second experiment to identify the ideal potting/ grow bag, it was found that the soil media gave the highest mean number of quality suckers in ratoon- 1 (5.6) and 4.3 in ratoon-2. In the second ratoon sucker sprouting was only observed in the soil media irrespective of quantity of media used.

In the third experiment to study the efficacy of the application of biofertilizers, particularly *Glomus fasciculatum* and *Azospirillum* in macropropagation. The treatment, 20g of *Glomus fasciculatum* plus 10g of *Azospirillum* per sucker (T_{10}) recorded the highest mean number of quality suckers (4.3) whereas in the second ratoon it was the treatment 30g of *Glomus fasciculatum* plus 30g of *Azospirillum* per sucker that recorded the highest sucker production. Based on the spore count, percent colonization and nutrient content of media, it can be confirmed that T_{10} is the most effective treatment. The soil nutrient analysis revealed that all treatments recorded higher values than that in the control.

The fourth experiment to study the effect of micronutrients boron and zinc in macropropagation confirmed that application of Zn (0.1%) to the sucker recorded highest mean number of quality suckers (4.0) in the first ratoon but it was application of Zn at 0.5% that recorded the maximum number of suckers of 4.6 in ratoon-2. This clearly showed that Zn has a promotive role in the sucker production probably by the proven route of enhanced production of auxin. The micronutrient analysis revealed a decreasing trend from ratoon- 1 to ratoon-2 and dead suckers due to dilution effect.

The economic analysis based on B: C ratio revealed that in the first experiment the ratio was found to be 0.345. This is due to high cost of coir pith and sawdust. This could be significantly improved in the second experiment where in the ratio was 2.29. In the third experiment it is 1.6 and in fourth it is 2.14. This is inclusive of the prohibitive labour cost added in actual terms. In small and medium holding farms. This part is done by the farmers themselves and hence in real terms the B: C ratio would be much higher.

Thus, it can be concluded that with 5.0 ml of one per cent H_2SO_4 acid application on the apical meristem portion of sucker in 20 kg soil media along with a combined application 20g of *Glomus fasciculatum* plus 10g of *Azospirillum,* and Zn (0.1%) to the sucker in the first ratoon and Zn at 0.5% in ratoon-2 will form a standard protocol of rapid multiplication using macropropagation technique for quality planting material production in banana (*Musa* (AAB) 'Nendran'