CARBON PARTITIONING IN BANANA INTERCROPPED IN COCONUT GARDENS

By

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(2009 - 12 - 110)

DEPARTMENT OF POMOLOGY & FLORICULTURE

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KERALA, INDIA

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Carbon partitioning in banana intercropped in coconut gardens ."** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other university or society.

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We the undersigned member of the advisory committee of **Mr. Adnan (2009 - 12 - 110)** a candidate for the degree of **Master of Science in Horticulture** agree that this thesis entitled **"Carbon partitioning in banana intercropped in coconut gardens."** May be submitted by **Mr. Adnan Ashraf (2009 -12 - 110)**, in partial fulfilment of the requirement for the degree.

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Date: *Adnan Ashraf*

Place: Vellanikkara

Dedicated to the Almighty, my father, mother, brothers & sisters

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INTRODUCTION

1. INTRODUCTION

The production of banana surpasses all other fruit crops at the global scale, at the national level (FAOSTAT 2010) and is also the most important fruit crop in Kerala with an annual production of 4.06 lakh tonnes (DES, 2010). The state of Kerala is known for having one of the largest biodiversity of *Musa* species and the home gardens are a natural gene pool for the shade tolerant types, particularly Palayankodan and Njalipoovan. Despite being the due of centres of maximum diversity, the production and productivity are very low and the demand is so high both at domestic and export to level that it is met from flow across the border.

Unlike other crops, where crop husbandry is restricted to soil, crop growth and yield components, *Musa* husbandry deserves an extra dimension of practices like male bud pruning, bunch covering and dehanding that have been reported to increase the yield. Translocation of nutrients applied in tracer have been monitored in all parts of the bunch inflorescence indicating sink mobilisation and competition among hands, fingers, peduncle and the male bud. Hence it is imperative to study the effects of retention of male bud, optimise the number of fingers and hands such that inter hand and finger competition is minimum, yield is maximum and quality optimum.

Many theories on shooting and yield have been advanced and validated in bananas. One theory which has gained maximum importance is the number of leaves retained at shooting and harvest, as it is these leaves that nourish and carry the bunch to logical maturity and consequent harvest. Hence, reduction or damage to leaves at and from the stage of shooting will adversely affect the finger characters and yield.

The study is expected to bring out primarily the source-sink relationship in banana. Secondly, it will deal in depth the varying allocatory patterns. Thirdly, it will bring out the individual effect of each leaf to the development of each hand of a bunch and in doing so the effects of age dependent allocatory efficiency of leaves.

The main objectives of the experiment is to study the assimilate partitioning in two banana clones commonly cultivated in coconut gardens at the pre-harvest stage, to understand how specific leaves contribute to yield at mid harvest and to know whether there is any variation among the commonly grown clones of Njalipoovan and Palayankodan. Another main aim was to standardise a pruning regime of bunches so that yield improved to the maximum extent.

A study of the source-sink relationship of fruits assumes more significance in as much as the source-sink relationship is a key determinant of productivity of fruit crops than in any other group of crops. The study will conclusively lay out the foundation principles governing allocatory patterns for further studies on increasing age of leaves (source level) through management practices on improving the efficiency of flow to the bunch (regulation at transport level) and fixing the bunch (hand) trimming regimes (regulation at sink level). Indirectly any improvement at any of these levels will increase the finger characters and thereby, the consumer preference and yield. Besides this study is all the more important from the trade and export point of view.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Many factors regulate source-sink relationship. Broadly they may be classified as environmental, nutritional and metabolic factors. The effect of horticultural management techniques like pruning helps to balance and to regulate cropping by bringing in a desired ratio between the vegetative and reproductive structures that help in improving the yield, fruit size and quality. The application of hormones can also alter the source-sink relationship. Other horticultural practices like girdling, notching, ringing, pruning, adequate irrigation and timely application of bio-regulators and fertilizers have also been reported to increase the yields.

The review of literature on carbon partitioning in banana is very limited but for a single work. However, genuine efforts have been put in to bring in the literature on various fruits crops on all the related aspects of the study. The available research works are reviewed under the following sub heads.

2.1. Carbon assimilation

Photosynthesis is the most important biochemical reaction that is necessary for sustaining life in the world for all living being. It is also equally important for the well being of the living beings. Photosynthesis can be defined as the production of carbohydrates in plant parts by the fusion of carbon dioxide and water in the presence of chlorophyll as a catalyst will absorb the light energy from the sunlight and convert it into carbohydrates which are the basic food of all the living organisms in the world (Salisbury and Ross, 2007). There are many factors affecting the process of photosynthesis like the environmental factors, the inherent factors.

2.1.1. Effect of leaf age

Schultze and Hall (1982) studied the influence of both leaf age and position in the canopy with regard to their CO_2 balance. There was a positive daily carbon balance of both immature and mature leaves irrespective of position in the canopy. This study provided important data regarding the contribution of young leaves and shaded leaves to the carbon balance of the entire grapevine.

Ekanayake *et al.* (1994) studied the influence of leaf age, soil moisture, VPD and time of day on leaf conductance of various *Musa* genotypes in a Humid Forest-Moist Savannah transition site. The results revealed that conductance’s were higher on the abaxial leaf surfaces than on the adaxial surface and higher in the afternoon than in the morning, with some genotypic differences.

2.1.2. Effect of Specific leaf area

Dejong (1999) studying the ecophysiology of bananas and functioning of the leaf canopy reported that the productivity in bananas is governed by 'source' and 'sink' components of the plant system. Source components include intercepted radiation, and radiation use efficiency. Sink components include estimates of sink size, such as harvest index and the number of bunches present, and sink activity is expressed as a temperature coefficient. It was found that banana leaf canopies are sensitive to shading. Banana leaves are much hydrated tissues that resist drying by rapidly closing their stomata. However, leaf tearing reduces productivity independently of the effects of wind speed and the stomata on shredded leaves partially close so that the temperature of torn and untorn leaves remains quite similar.

Evan and Poorter (2001) concluded that the specific leaf area is an important attribute contributing to carbon assimilation, while studying the photosynthetic acclimation of plants to growth irradiance: the relative importance of specific leaf area (SLA) and nitrogen partitioning in maximizing carbon gain and found that across a range of species, acclimation to a low-light environment is characterized by increased allocation of leaf organic nitrogen to pigment-proteins, as well as by increased SLA. Increasing SLA was found to be far more important in maximizing carbon gain per unit leaf mass than re-allocating nitrogen between leaf pools, especially under low light. Specific leaf area was found to increase proportionately with increasing shade.

2.1.3. Effect of natural shade

Banana clones show distinct reactions to light regimes. Some require bright open condition and some are shade loving or are tolerant types.

Balasimha (1989) reported the light penetration patterns through arecanut canopy and leaf physiological characteristics of intercrops confirming the feasibility of intercropping in arecanut plantations. Work done at Banana Research Station Kannara to evaluate shade tolerance of banana varieties has also revealed that Palayankodan was best suited as intercrop in arecanut gardens (Aravindakshan and Pushkaran, 1996). Throwing light on future research strategies in banana the same authors have opined the need for screening critically all available banana varieties for their performance in home gardens and under varying shade intensities.

Canopy of mature steady bearing coconut trees intercepts only forty four percentage of incident solar radiation due to its poor light use efficiency (Lyanage, 1994). Reports have shown that growing medicinal plants and banana as intercrop in coconut gardens gave a high benefit cost ratio. Banana is the most common, profitable and compatible mixed crop in coconut gardens in Southern Indian states (Kurien *et al.,* 2003).

A study on the effect of shade on flowering showed that when the density of a commercial banana plantation is high and light transmitted is reduced to 10% of the above-canopy intensity; growth and production of the plants are severely affected. It was also reported that in a tropical climate, rate of flowering declines significantly some 6 months after a period of low light (Stover and Simmonds, 1987).

Robinson and Nel (1988; 1989) observed a prolonged cycle time and a decrease in bunch mass under increased plantation density in *cv.*. ‘Williams’ growing in a subtropical climate. They proposed that the reduction in incident light to the secondary canopy contributes to these effects.

Effect of shade on banana morphology, growth and production was studied by Isreali *et al.* (2000). The effect of three shade levels on morphology, growth and productivity of 'Grand Nain' (AAA) bananas during their first and second production cycles was studied in the Jordan Valley, Israel. The resultant photosynthetic photon flux density (PPFD) was reduced to 80%, 60% or 30% of the unshaded control. Also the bunch weight was reduced by 7% and 32% under medium and heavy shade, respectively. It was found that the yield was reduced by all levels of shade, owing to the combined effect of reduced bunch weight and a lower stand. Shading reduced the rate of leaf emergence, leaf and foliage area, plant height and pseudostem circumference.

Growth and photosynthetic performance of banana (*Musa* sp.) grown in three levels of natural shade (33, 55 and 77% reduction in incoming radiation) were compared to an unshaded control treatment by Senevirathna *et al.* (2007). They found out that the net CO_2 assimilation rates generally decreased with increasing shade. Chlorophyll fluorescence revealed short-term dynamic photoinhibition under high light conditions but no evidence of sustained photoinhibitory damage to photosystem II. Specific leaf area and leaf area ratio increased proportionately with increasing shade, whilst the chlorophyll *a*/*b* ratio decreased, reflecting a greater efficiency of light utilization under shady conditions

Hauser *et al.* (2010) studied the growth and yield response of plantain hybrid FHIA to shading. It was reported that the proportion of plants that produced an edible bunch and the fresh bunch yield was higher in the low canopy cover area than in high canopy cover areas. Bunch mass per producing plant, although highly variable, was not significantly affected by shade level.

2.1.4. Effect of photo oxidation

Photorespiration protects C_3 plants from photo oxidation. Plants absorb light for photosynthesis but as light can itself be dangerous to plants, they need to protect themselves against its damaging effects. Here, using transgenic plants, it is shown that photorespiration can act as such a defence mechanism. Transgenic tobacco plants enriched or reduced in rice plastidic glutamine synthetase [glutamate-ammonia ligase (GS2)], a key enzyme in photorespiration, were constructed and it was observed that photorespiration protects C_3 plants from photooxidation by Kozaki *et al. (*1996).

In avocado, net rate of CO_2 assimilation of fruit exposed to light was studied and it was reported that the relative amount of carbon assimilated by the fruit was small compared with the total amount of carbon assimilated by the leaves. It was found that avocado fruit contribute to their own carbon requirement by means of CO_2 assimilated in the light (Whiley and Schaffer, 1994).

2.2 Carbon partitioning

Carbon partitioning and assimilation pathways are complicated and vary among fruit plants. Basically regulation of carbon partitioning occurs at three levels in a plant namely,

1. At the source level
2. At the translocation level and
3. At the sink level

At the source level, the leaf area and leaf activity are important factors helping in carbon partitioning. Translocation in plants has three steps namely, phloem loading, phloem transportation and phloem unloading. Phloem loading is explained well by apoplastic and symplastic movement. Partitioning at sink level is dependent on the position of sink, the connection between the sources and sink strength. Sink strength is dependent on sink activity and sink size. Sink strength is the most important factor that forces the source to produce more amounts of photosynthates and to transport it to the developing fruit due to the sink demand.

Work up to 1975 on source-sink relationship is covered in the review of Wareing and Patrick (1975).

2.2.1. Partitioning at source level

Source can be defined as any exporting organ capable of producing photosynthates for their own use as well as in excess for export to different parts of the plant which are in need of them (Moorby, 1968). The source will photosynthetic in nature. Eg: Leaves, bract, green fruits, flower, calyx, green shoots, fruit wall *etc.* A source can become a sink and a sink can become a source. A good source will retain only very small quantities of photosynthates produced by it and will export most of it to different parts of the plant.

Carbon partitioning in crops is a prime area of study Haigler *et al.* (2001) based on their work on partitioning occurring at source level, translocation level and at sink level and the factors altering them were also reported.

The factors affecting carbon partitioning at source level have been studied. The various factors affecting source are environmental factors like light, water, temperature and carbon dioxide and nutritional factors like effect of potassium and phosphorous. The metabolic factors like Fructose 2, 6 biphosphatase and Sucrose phosphate synthase formation were studied by Taiz and Zeiger (2003). The amount of carbohydrate supplied to tree fruits depends on the amount produced by leaf photosynthesis, which is related to leaf area and photosynthetic capacity and activity. Again the photosynthetic capacity has been reported to be influenced by climatic conditions (LeRoux *et al.,* 2001) and this can be affected by changes in source-sink relationships, as has been reported in species, like in mango (Urban *et al*., 2003).

2.2.2. Partitioning at translocation level

Minchin *et al.* (1997) in their studies on the carbon partitioning between apple fruits reported the short and long-term response to availability of photosynthate and the source-sink interactions play an important role in determining both crop yield and the distribution of individual fruit sizes. In the study short-term changes in partitioning of recently fixed photosynthate between alternative apple fruitlets were followed using an *in vivo* measurement of photosynthate movement.

In peaches *(Prunus persica* L. Batsch) the degree of sink and source limitations based on fruit growth during several growth periods was established. The source limitations on fruit growth may be due to either a shortfall in assimilate supply within the tree (supply limitation) or due to a deficiency in the capacity of the translocation system to deliver assimilates in sufficient quantity to support the maximum fruit growth rate (transport/competition limitation). On the contrary the apple fruits import photosynthates at a rate matching their utilisation capacity. Quantifying sink and source limitation on dry matter partitioning to fruit growth in peach trees have also been reported by Allen *et al.* (2004).

The metabolism and transport of carbohydrates within the grape leaf are probably similar to those described for other C3 plant species (Hawker and Jenner, 1993).However, it was found out that the leaf age and time during the growing season influence the concentrations of reducing and non reducing sugars and starch in grape leaves.

Dejong and Goudriaan (1989) in their studies reported on the patterns of various organs influencing the dry matter partitioning within a tree in peaches. The maximum organ potential of individual fruits was determined on stress which was manipulated to create sink limited conditions for fruit growth Grossman and Dejong (1995).

Percival *et al*. (2001) reported on the cultivar differences in carbon assimilation and partitioning of primo cane fruiting in raspberry. 'Montomorency' sour cherry (*Prunus cerasus*) trees was established in a one year potted were manipulated by partial defoliation or continuous lighting to investigate the phenomenon of end product inhibition of photosynthesis. The translocation studies of photosynthates to different parts of the plant like the vegetative part and the translocation part revealed carbohydrate differences in strawberry crowns and fruit (Rodriguez *et al*., 2002).

2.2.3. Partitioning at sink level

The amount of carbohydrate supplied to tree fruits also depends on sink demand, which is generally defined as the sum of assimilates required for maintenance and potential growth of the sink organ, the latter being determined under optimal environmental conditions*, i.e.* non-limiting supplies of carbon (C) and other resources (Warren-Wilson,1972; Ho, 1992).

Developing fruits on the same branch or plant can act as competitive sinks. There are many models in this line on biomass production and yield of crops that have been reviewed by Marcelis (1996).

CaiXi *et al. (*2005) reported the C- photosynthate accumulation in Japanese pear fruit and inferred that the period of rapid fruit growth is limited by the sink strength of the fruit rather than by the transport capacity of the pedicel. From the studies it was found out that larger fruit size resulting from GA application during the period of rapid fruit growth caused an increase in cell size of the mesocarp and increased carbon partitioning to the fruit.

Partitioning at sink level is dependent on the position of sink, the connection between the sources and sink strength. Sink strength is dependent on sink activity and sink size Sink strength is the most important factor that forces the source to produce more amounts of photosynthates due to the sink demand (Salisbury and Ross, 2007).

2.5.2. The position and distance of the sink.

If the sink is situated closer to the source cells the sink can accumulate and it gets the adequate quantity of assimilated whenever needed and also in time. Vascular connections between the source and sink are an important parameter that determines the amount of photosynthate accumulated at the sinks.

Sink strength is defined as the capacity of the sink to assimilate and utilize the amount of photosynthates available. The sink strength of a sink is determined by a number of factors like sink activity and sink size by studying in cucumber (Marcelis, 1992). They reported that Sink strength = Sink activity x Sink size where Sink activity is the potential rate of uptake of assimilates per unit sink per unit time and the Sink strength is the volume or weight of sink or the accumulation of starch in plastids.

In many crops, the source nor the transport path are dominating factors in regulating. Dry matter (DM) partitioning at the whole plant level, DM partitioning among plant organs is primarily regulated by the sink strengths of the organs. Accordingly, models have been developed where the fraction of DM partitioned into each organ (*f*i) is determined by its sink strength (*S)* relative to the total sink strength of all organs together (Marcelis, 1996).

2.5.3. Effect of Sink Load

The removal of sinks (either the fruit or actively growing shoot apices) from potted grapevines results in a significant decrease in the net CO2 assimilation rate of individual leaves (Kriedemann and Lenz, 1972).

Once fruit set has occurred the fruit tend to be the largest sink on the vine (Mullins *et al.,* 1992). The proportion of biomass partitioned to the fruit from bud break until fruit maturity ranged from 44% to 69% of the total biomass accumulated during that period for Thompson Seedless grapevines.

The accumulation of hexose sugars in the pericarp of the grape berry reported by Coombe (1992) include three broad sub groups (a) active transport of sugars through the tonoplast of pericarp cells, (b) sucrose unloading from the phloem into the apoplast, and (c) sugar flow caused by leakiness of the plasma membrane in the pericarp cells.

Sink load as defined by Marcelis (1996) is the sum total of all the sinks present on the plant. Thus sink can be all the organs like fruits, leaves, trunk, bark, the stem, the roots, the buds etc. During the initial growth of the plant there are more parts acting as source but at the later stages more sinks are observed than parts acting as source.

In studies on cucumber fruits, the simulation of the partitioning among individual fruits was improved when the sink strength of each fruit was not only related to its potential demand for assimilates but also to its affinity or priority for assimilates (Marcelis, 1992).

2.5.4. Sink competition

Competition between developing sinks were studied and the order of priority between sinks were listed as given below seeds>fruits>shoot tips>cambium>roots in case of seeded plants (Kurien *et al.,* 2008) and Male bud>fruits>pseudostem>roots>leaf were reported in case of parthenocarpic fruits (Cannell *et al.,* 1985).

2.6. Bunch management

Research work on bunch management of banana mostly centres around the aspects such as bagging, male bud pruning, de handing and the use of plant growth regulators.

2.6.1. Bagging /Sleeving /Bunch covering

Bagging or sleeving of banana bunches improves the yield significantly (Trupin, 1959; Perumal and Adam, 1968; Walker, 1975). Enclosing young banana flowers of Dwarf Cavendish in a plastic bag increased the number of flowers with persistent perianth and hence the yield (Isreali *et al.,* 1980). In banana *cv.* 'Williams' (Daniells *et al.,* 1987) reported a four per cent increase in bunch weight, when polythene covers were used, one week after abscission of the last female bracts.

Both sealed and unsealed clean covers under a standard blue/ silver cover with an ethylene absorbent inside increased the weight of the bunches by 37 per cent

(Johns and Scott, 1989). Daniells *et al.* (1992) reported that by use of sealed covers the bunch weight increased up to nine per cent and this increased the finger length along the entire bunch, whereas there were no promising results, when open covers were used. Studies in *cv.* Williams using double bunch covers recorded increment in finger weights of top six hands by four percent, but did not affect the yield extra large fruits and appeared not to be worthwhile for all price scenarios used (Johns, 1989).

2.6.2 Male bud Removal

Various studies have shown that removal of male bud resulted in an increase in the weight of bunches in banana. The favourable effect of trimming male bud after bunch emergence, on bunch weight has been interpreted as the utilisation of energy, other wise lost for the opening of flowers for finger development (Simmonds, 1959; Sampaio and Simao, 1970; Walker, 1973; Meyer, 1975; Jaramillo, 1984; Amma *et al.*, 1986).

According to Rodriguez (1974) a 13 per cent gain in bunch weight was recorded in *cv.* Valery when the male inflorescence was removed at different periods, i.e. 10, 30 or 60 days after bunch development. Inflorescence removal at the earliest yielded the best results.

Dry weight analysis indicated that the male bud represented a significantly competing photosynthetic sink (Daniells *et al.*, 1994). Using tracer technique, Kurien *et al.* (2000) confirmed that among the various parts, the male bud is the major physiology sink siphoning the quantity of applied nutrients.

2.6.3. Dehanding

Removal of false hands plus one or two of the smallest apical hands improves the yield of the first class fruit (Trupin, 1959; Perumal and Adam, 1968; Walker, 1973). A trial in Congo Bananas (Hosselbach and Idoe, 1973; Stevenson, 1976) and in *cv.* Palayankodan (Amma *et al.*, 1986) revealed that dehanding treatment did not increase the average bunch weight but it gave better sized fingers. Instead of increasing the yield, removal of one hand/ bunch reduced the yield /bunch by seven per cent and the removal of 2 hands /bunch reduced the yield by 15 per cent, with out any improvement in fruit grades in *cv.* Williams in the studies of (Daniells *et al*., 1987).

According to Irizarry and Rivera (1991) Super Plantano (AAB) bunches trimmed to 4 and 5 hands yielded 14680 and 18200 marketable fruits /ha, respectively. This represented a yield increase of about 26000 and 59400 fruits /ha, respectively compared with unpruned controls. Out of the various bunch trimming treatments, retention of 6 hands and removal of the bell produced 35 percent more extra large fruits.

2.6.4. Bunch management using nutrient sprays

The direct effects of potassium salts of gibberellic acid on increasing the yield, length, weight and volume of banana fruits and that of potassium dihydrogen phosphate by Venkatarayappa *et al.* (1976).

Yield increase consequent to urea sprays was reported as early as 1963 by Pan and later by a number of scientists. Macronutrients sprays are important in plant metabolism, particularly affecting the process of photosynthesis (Humbert and Hanson, 1952). Sharma (1984) reported increased bunch weight and number of fruits /bunch in plants receiving 187.5g N applied to soil + 187.5gN/plant applied in 12 sprays at biweekly interval. Patel (1980) confirmed that with pre as well as post shooting sprays of N, P and K (1.0, 0.5 and 1.0%), an increment in bunch weight was noticed. Like wise, Gandhi (1984) observed increase in yield per plant in banana *cv.* 'Basrai' with one and two percent post shooting urea sprays. Firth (1986) on other hand reported negative results.

Experiments by Devi (1991) resulted in a 35 %increment in bunch weight (11.5kg) in Nendran over control by normal dose of N, P and K at three and five MAP (110:35::330g NPK/plant/year) in combination with four foliar sprays at 3, 5, 7 and 9 months at two per cent concentration.

Kumar *et al.* (2006) reported that potassium is having a profound influence on fruit quality through its influence on size, appearance, colour, soluble solids, acidity and vitamin contents. Studies showed that potassium regulates many vital functions like carbon assimilation, translocation of proteins and sugars, water balance in plants, maintaining turgor pressure in the cell, root development, improving quality of the fruits by maintaining desirable sugar to acid ratio, ripening of fruit and many other processes.

Ganpathy *et al.* (2011) reported that Banana requires heavy manuring for its optimum growth and better fruiting. Studies showed that higher values for total soluble solids (TSS) and total sugars with least acidity besides better physiological parameters with high available soil and leaf nutrient contents were recorded when mixtures of Calcium ammonium Nitrate (CAN), Urea (U) and Ammonium Sulphate (AS) applied as N sources to the plants. Hence, the application of required nitrogenous fertilizer as a mixture of different N sources registered better values in terms of growth, yield, physiological parameters, leaf nutrient contents and quality characters rather than applied as a single source of N.

2.6.5. Hormonal regulation

The potassium salts of gibberellic acid applied to banana plants three months after planting and to fruits two weeks after flowering markedly increased the plant height, circumference and yield, length, weight and volume of fruits (Lockard, 1975).

Deshmukh and Chakrawar (1980) reported that pre harvest application of ancymidol, GA, or ethrel increased the average weight and size of bunches and weight of fingers. The effect of 2, 4- D (10ppm) on size banana *cv.* Nendran has been studied by Aravindakshan (1981). Mishra *et al.* (1981) observed that GA_3 at 10^{-4} concentration increased the weight and volume of fingers in young and old bunches of banana.

Maluk *et al.* (1986) analysing the cause for increments in size and weight inferred that foliar applied GA can influence the source- sink relations in early reproductive development by manipulation of photosynthate production and partitioning.

Chattopadhyay and Jana (1988) reported the effect of growth substances (NAA or GA3 each at 10, 25 or 50 mgl^{-1} or 2, 4- D or 2, 4, 5- T each at 5, 10 or 20 mgl^{-1}) applied to bunches of banana *cv.* Giant Governor banana thirty days after emergence, with or without male bud in improving the fruit length, girth, pulp: peel ratio and bunch weight.

Pradhan *et al.* (1988) reported that 100mgl^{-1} of GA_3 was very effective increasing the bunch and fruit weight and pulp-peel ratio of banana var. Giant Governor.

2.6.6. Bunch Stalk Feeding

Post shooting application of urea in *cv.* Giant Cavendish has been reported to promote yield (Venkatarayappa *et al.,* 1976). I t was inferred that yield increments were due to more availability of urea in aqueous form at later stages and for a prolonged period. Similar positive results were later reported by Buragohain and Shanmugavelu (1986) in banana *cv.* Vayal vazhai. According to them, a 23 % increase in a polythene bag to the cut stalk end immediately below the bunch 2 days after the male bud was removed.

Translocation of nutrients in the inflorescence of banana *cvs.* Poovan, Monthan and Nendran have been reported by various scientists (Buragohain and Shanmugavelu, 1985; Sobhana and Aravindakshan, 1989; Kurien *et al.,* 2000). It was concluded from the experiment that late application of fertilizer to banana may be beneficial.

Ancy *et al*. (1998) reported that bunch stalk feeding and male bud pruning had a significant increase on the yield of bunches, increase in the finger characters like length, girth and also the quality of the fruit.

Sindhu (1999) working under guidance of Kurien reported studied the influence of post bunching sprays of cytokinin, potassium and calcium on yield and shelf life of *cv.* Nendran. It was reported that when 3% K_2SO_4, 50mgl^{-1} kinetin and 75mgl^{-1} of BA when applied at the third and fourth week after bunch emergence significantly increased the yield of the bunch and also improved the finger characters like length ,girth and curvature index.

Based on more than a decade long work of Kurien at the Department of Pomology & RARS, Kumarakom the KAU package of practices recommendation has incorporated the sprays of 3% K_2SO_4 at two defined stage in its new POP (KAU in press).

The morphology, phenology and production potential of banana cultivars ‘Dwarf Cavendish’ and ‘Williams’ were compared under similar conditions of climate, soil and management at Burgershall Research Station, Eastern Transvaal. Pseudostem height increased progressively for both cultivars over 3 crop cycles, with ‘Williams’ plants being 41% taller than ‘Dwarf Cavendish’ in the second ratoon. ‘Williams’ produced significantly larger leaves and a leaf area index 36% higher than ‘Dwarf Cavendish’ at 1666 plants ha^{-1}, which caused increased shading and a longer ratoon cycle time in the former (Robinson and Nel, 2003).

Source-sink interactions have involved perturbing the system (e.g. pruning) and observing the effect some time later. This approach has led to the concept of sinks being in some form of competition with each other for available photosynthate, summarized by the priority order, seeds > fleshy fruit parts = shoot apices and leaves >cambium > roots > storage (Wright, 1989; Wardlaw, 1990).

MATERIALS & METHODS

3. MATERIALS AND METHODS

The investigation on "Carbon partitioning in banana clones namely (*Musa* AAB) Palayankodan and (*Musa* AB) Njalipoovan genomic group intercropped in coconut gardens were carried out at the Regional Research station (RARS) Kumarakom, Kottayam.

The research farm is located $9^0$3'N latitude and $76^0$3'E longitude, following a bund and channel system type of cultivation peculiar of 'Kuttanad' part of the problem zone. Cultivation is generally taken up 0.6m below mean sea level and cultivation of horticulture crops especially banana is taken up on raised bunds of reclaimed lands at approximately 0.5m above mean sea level the area enjoys typical warm humid tropical climate. The soil of the area belongs to the order inseptisols/ entisols with pH of 5.0 to 5.5.

The study was taken up as four experiment

1. The carbon partitioning studies in Palayankodan and Njalipoovan
2. The effect of hand trimming regimes on yield and finger characters in Palayankodan and Njalipoovan

Experimental Materials

For the first and second experiment on carbon partitioning in Njalipoovan and Palayankodan intercropped in coconut gardens. Twenty plants each from both the clones were selected. The selection of plants were done at the bunch emergence.

For the third and fourth experiment to standardise the bunch trimming regimes Palayankodan and Njalipoovan. The plants were selected for uniform characters and a secondary selection for bunches having eleven hands except in case of male bud pruning where ten hand bunches were selected. There were seven treatments and four replications for both the clones. So total of twenty eight Palayankodan plant were selected just after the formation of the bunch. The same number and same stage of plants were selected in the case of Njalipoovan also. Both Njalipoovan and Palayankodan selected were intercropped in coconut gardens in RARS Kumarakom farm spaced and maintained as per POP recommendation of KAU (KAU, 2007). The experiment was taken up from July, 2010 to January, 2011.

3.1. Experiment I and II

The first and second experiments were of Carbon partitioning studies in banana Palayankodan and Njalipoovan intercropped in coconut. Both the clones which are the major clones of banana grown in the home gardens of Kerala. Though the crop has been extensively worked upon there are no reports of the actual ^{14}C translocation. This is mainly because of the large leaf of lamina. Our aim was to test the standardized apparatus used in the case of Nendran banana to feed the ^{14}C. Feeding a banana leaf is not only a Herculean task but also standardization of the carbon for different clones of banana.

3.1.1. Development of leaf chamber

A prototype apparatus enclosing the full leaf lamina retaining its correct orientation and inclination and at the same time remaining air tight was one of the fundamental requirements. The present apparatus was evolved after a series of ‘trial and error’ studies and appropriate modifications which was then prestandardised for the purpose Kurien (2007). There was no major change made in respect of the leaf chamber.

Two wooden frames, one forming the lower frame and other forming the upper frame were made of the same dimension. The length of the frame was 2.75m and breadth 1m, as a fully developed banana leaf measures 2.5m length and 0.7m breadth. The outer frame was made of coconut wood of 2 inch width and 1 inch thickness. A nylon fish net was fixed on the frame to support the leaf such that the leaf margin ends were well held on the frame and did not any way intercept the light. To the inner side of this was thermocole of equal width and ½ inch thickness neatly fixed using an adhesive.

Over the thermocole, teak frame of same width and of ½ inch thickness was placed and held firmly by drilled in small nails. Over this, a first lining of sponge of same ¼ inch thickness was neatly pasted. Over this lining, a sponge padding of same width and ½ inch thickness was given with rubber adhesive. This was covered with a sheet of polythene (400 gauge) to cover the entire lower frame. This formed the lower part of the apparatus.

A similar frame made in the same dimensions with three strips of sponge of 2 inch width and ½ inch thickness each stuck neatly using rubber adhesive formed the upper cover. On the lower part of the frame on the mid part of the breadth a carving was given for placing the petiole of the leaf.

Aluminium pipe of 9mm diameter was placed in the inner part of the upper frame (as light falls on top part and temperature build up starts on top part) to form two concentric circles. At the bends (corners) they were provided with rubber tube joints. The pipes were held firmly with small clamps provided in the interior on the wooden frame. The inlet on the top side was connected to a rocker pump and the outlet was given rubber tubing outside the frame to collect the circulated water into the same bucket from where the pumping was done. Ice cubes were kept inside the bucket to maintain the temperature so that there was a steady circulation of ice cold water.

The centre part of the lower frame was joined by a 2 inch wide and 1 inch thick mid frame that held suspended crucible (top 5cm diameter) and covered with a wire gauge except on top part. The crucible was suspended from the mid frame using a small thin wire. Opening of the polythene sheet just below the crucible was made possible by a neat lining which could be well stuck using transparent adhesive tape thus permitting the replacement of a known aliquot of activity prior to releasing the labelled ^{14}C.

One end of an I-V saline infusion set with control unit was connected to a graduated wash bottle filled with dilute HCl (N/10) and it was suspended sufficiently higher outside the frame. The fine end of the infusion set was placed in such a way that the droplets fill only into the crucible. The tube was

Plate 1. Apparatus used for CO_2 feeding banana leaf

Plate 2. Leaf chamber placed in correct orientation of leaf for feeding of CO_2

passed through the frame such that the entry was made air tight and reinforced with roofing compound (H&J IFOMARK-‘SUPER’ Roofing compound). The regulator of the infusion set was free outside the frame and this permitted to discharge a known volume of the acid into the crucible which held a known strength of activity.

The upper part of the frame was also covered with polythene sheet (400 gauge)and held firmly by using ‘Thumb Tacks’ (Drawing Pins) on all the sides of the frame. Prior to this both the outer and lower frame were provided with roofing compound to avoid any possible leakage at joints or drilled in holes. Four GI flat protrusions at each end on linear plane on both frames were provided. On all four sides at ½ feet distance, 6” GI hooks were provided on top frame which fitted tightly into its corresponding fasteners on the lower frame.

The frame was mounted based on the inclination and orientation of leaf by digging in GI poles and then fitting the lower frame on the four ends of the GI poles such that the orientation of the leaf remained unchanged.

3.1.2. Stages of improvisation in standardization of leaf chamber apparatus

The initial apparatus was purely based on a thermocole frame covered with polythene sheet. The initial difficulty was in maintaining the erect position as wind could change inclination and orientation of leaf. Further, it was not sturdy enough to be used for full sized leaves in the study.

Even a short time lapse inside the chamber caused heating up resulting in scorching of leaf. Hence modification of regulated ice cold water flow was made which overcame the defect.

The third crucial challenge was in confirming the air tight nature of the apparatus. Ten lighted incense sticks (Agarbathi) were placed inside the frame. The entire frame was held vertically fitted rightly ensuring all locks were in position and was checked from all sides to see whether there was any leakage of smoke. To be cent per cent fool proof air was blown through the four sides of the apparatus to confirm any trace of smoke.

3.1.3. Placement of leaf

Four GI pipes were bored in the direction of the 2nd fully opened leaf of the experiment plant. The lower frame was first placed as per the orientation of the leaf and the four ends well fastened. Care was taken to see than the petiole was correctly placed in groove provided in the lower frame. The upper frame was then correctly mounted on top of the lower frame and all hooks tightly fastened.

The groove provided for the petiole was plugged with cotton from outside and inside the petiole. Further it sealed with adhesive tape drawn to the side of the frame.

3.1.4. Placement and discharge of activity

The nature of the activity was as Na_2CO_3 solution in water and hence standardization using unlabelled Na_2CO_3 was done using different strengths of HCl and narrowed down to N/10. The evolution of CO_2 was instantaneous but 25 minutes were given for the leaf to absorb the released CO_2. This was based on previous studies from other crops. 15ml of HCl was required for complete discharge of CO_2. However after 15 minutes of giving the 15 ml HCl another 10 ml discharged to the crucible again to confirm that no radioactive CO_2 is left. The total process was completed in 25 minutes after which the sealed opening of the crucible area of the polythene sheet (hitherto referred as window) on the lower frame was detached and opened. The spent liquid was drained out into a radioactive waste collection unit maintained for the purpose. The crucible was repeatedly washed, cleaned, dried with tissue paper and made ready for the next treatment application.

Plate3. The mid harvest stage of bunch development selected for feeding the leaf with the radioactivity

Plate 4. ^{14}C in the form of $Na_2\,^{14}CO_3$ in 1ml ampules procured from BRIT,BARC, Mumbai

Activity ^{14}C in the aqueous form of Na_2CO_3 (Code No. LCC 37) was obtained from Board of Radiation and Isotope Technology (BRIT) of Bhabha Atomic Research Centre (BARC), Mumbai and was made available in 1.0ml vials containing 0.5mCi (18.5 MBq). 1.0ml vial was made upto 10ml by adding 9ml of 0.1N Na_2CO_3 just prior to application. From this 10ml, 5ml (0.25mCi) was taken and placed in the crucible. Single plant formed the experimental material for each treatment in a replication. Prior to this the 2nd fully opened leaf was placed in position and the apparatus sealed and made airtight.

The different treatments in the experiment are

1. (L1) – First fully opened leaf fed with the activity
2. (L2) – Second fully opened leaf fed with the activity
3. (L3) – Third fully opened leaf fed with the activity
4. (L4) – Fourth fully opened leaf fed with the activity
5. (L5) – Fifth fully opened leaf fed with the activity

The window outlet was also sealed, ensuring no leakage; the rocker pump was put into action to regulate inner apparatus temperature. Now the control unit of I-V Saline infusion set was gently opened out to discharge 15 ml of HCl and stopped time was monitored on release of HCl. Instant release of CO_2 could be observed as bubbles. After 10 minutes and then after 15 minutes of the first release of HCl another 10ml was dispersed into crucible. At the end of ten minutes when HCl was added a few more bubbles could be seen. Though there was no bubbles observed following discharge of HCl after 15 minutes, at the end of 20 minutes another discharge of 5ml of HCl was just given to confirm that no more CO_2 is released. Finally it was confirmed that all CO_2 was released by twenty minutes. Then the window was opened the spent radioactive waste was taken and drained out into separate collection jars for radioactive spent waste.

Plate 5. Crucible in which the activity was placed.

Plate 6. Liquid scintillation counter Hidex Triathler Multilabel tester used for recording the radioactivity in tissues

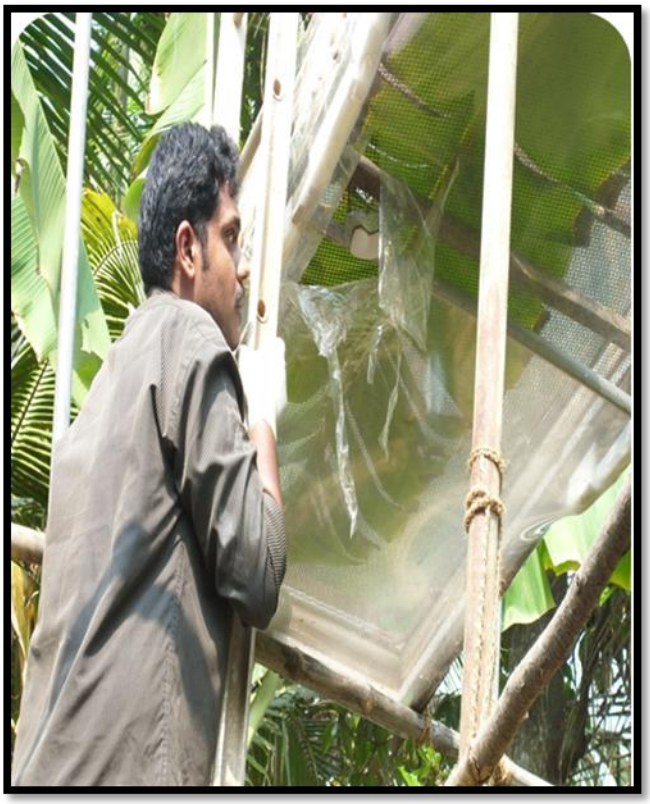


Plate 7. Suspending the crucible inside the leaf chamber below the mid part of the adaxial side of the leaf using a wire mesh

The samples after 15 days after application of radioactivity was collected from the plant in the form of fresh samples which was prestandardised for the purpose (Kurien, 2007).

The fresh and the dry weight of the following tissues were recorded at sampling namely,

(a)Roots

(b)Corm

(c)Pseudostem

(d)Petiole

(e)Leaves

(f)Male Bud

(g)Bunch

(h)Peduncle

The fresh tissue samples were cut into small pieces, dried in a hot air oven maintained 60-65^{0}C for a week then it was powdered. One gram of the sample of each tissue, different leaves, different petiole and different hands were weighed out and then transferred into separate scintillation vials. Radiochemical analysis of ^{14}C was done using cocktail scintillator (cocktail –W) by adding 15ml of the scintillator and then reading the sample using Liquid Scintillation Counter (Hidex Triathler Multi Label Tester, Turku, Finland). Reading were corrected for background radiation and finally expressed as *cpm/g* of dry tissue. The counts recorded per gram dry weight of sample were multiplied with dry of various tissues to express the counts on a whole plant basis.

Studies on Carbon partitioning were taken up on both the major clones of banana namely Palayankodan Syn. Mysore (*Musa* AAB group) and Njalipoovan (*Musa* AB group).

Plate 8. Wilting of leaf when the leaf chamber was kept intact inside the chamber beyond twenty minutes.

Plate 9. Collection of tissue samples from the uprooted plants fed with the radioactivity.

The counts per minute per gram of the dry weight of the tissue sample were recorded. Four reading were taken per sample both in Palayankodan and

3.2. Experiment III and IV

Effect of bunch trimming regimes on yield and finger characters.

The study was conducted on both the clones, namely

1. Njalipoovan (*Musa* AB genomic group)
2. Palayankodan (*Musa* AAB genomic group)

A eleven hand bunch system was selected except in the treatment involving male bud pruning where a ten hand system was selected. Hands were pruned from each bunch as per treatment specification and thus the following treatments were taken up for the study.

1. T1 – Retention of six hands
2. T2 – Retention of seven hands
3. T3 – Retention of eight hands
4. T4 –Retention of nine hands
5. T5 – Retention of ten hands
6. T6 - Pruning of male bud only
7. T7 – No pruning

Thus there were seven treatments as shown above and each treatment was replicated four times. The experiments were in a Completely Randomised Design (CRD). The other materials used for the experiment were knife, tags for marking and weighing balance.

The observations recorded in the study were

Bunch weight: The weight of the harvested bunches were taken using an analytical balance and expressed in grams.

D' hand weight: The D' hand i.e. second formed hand was separated and weighed separately and expressed in grams (Gottreich, 1964).

D' finger weight: The weight of D' fingers i.e. the second finger of the inner whorl of the second hand formed (Gottreich, 1964). Weight of D' finger was measured and recorded in grams.

D' finger length: D' finger length was measured and recorded every week. The growth pattern of the finger could be studied but the finger length measured at harvest (as cm) was only used in the study.

D' finger grade: D finger grade was also measured at the central part of the finger using a twine and recorded (in cm) till harvest but only the girth at harvest was used in the study.

3.2.1. Statistical analysis

Each of the four experiments was replicated four times in a Completely Randomised Design (CRD). The recoveries of activity in each tissue were recorded as counts per minute per gram (*cpm*) of the dry sample tissue. The data recovery of activity of individual source leaves mean of sink leaves, individual hands and individual petiole were analysed separately to know the retention in source leaves and accumulation or translocation to the other respective parts. For analysis of retention in source leaves and partitioning to various other parts, the mean values all source leaf, mean values of the sink leaves, mean values of hand, corm, pseudostem, peduncle and roots were worked out. The data were appropriately transformed using square root transformation and analysis of variance in both clone were done using SPSS software by Duncan Mean RT method (SPSS16, 2007).

The data on percentage recovery on a unit gram basis was obtained by adding the recovery of all parts of the plant (except in case of leaves, petiole and hands) where the means were taken and then expressing the cpm of unit part as a percent of the total in a replication.

The data on per cent recovery on a whole plant basis was obtained by multiplying the *cpm/g* of the dry weight of that part and then expressing the same as a percent of the total *cpm* obtained for a plan.

The data on yield and finger characters in both clones were analysed by applying the analysis of variance technique using SPSS software package.

The overall comparative photosynthetic efficiency of individual leaves of both the clones which is the total of both that is retained in source leaves and that translocated to other parts were also done in similar way by using square root transformation values and then applying the analysis of variance technique using the above software. Comparison of respective leaves of Palayankodan and Njalipoovan from first leaf to fifth leaf were done again after square root transformation, using **t- test** and by applying the SPSS software package (SPSS 16, 2007).

RESULTS

4. RESULTS

The results of the study on "C*arbon partitioning in banana intercropped in coconut gardens"* undertaken from 01/09/2010 to 31/03/2011 at RARS research farm, Kumarakom are summarised below under the following broad sub heads.

4.1 Carbon partitioning studies on (*Musa* AAB Palayankodan)

The recovery of radioactivity in various tissues of banana is presented in the table 1 to table 20. The study was taken up by feeding individual leaves beginning from the first leaf to the fifth leaf (L1-L5) based on the pre-standardised work as described below.

4.1.1. Partitioning at the Source Leaves

The efficiency of different source leaves in retention of photosynthates is presented in table 1 revealed that the third fully opened leaf is the most efficient and significantly superior over all other leaves. The second most efficient is the first leaf followed by the second leaf. Overall the first three leaves are observed to be most efficient in retention of photosynthates. A gradual gradation in the efficiency of retention is observed with the fifth leaf.

4.1.2. Partitioning from source leaf to different sink leaves

The partitioning of photosynthates from the source leaves to the various sink leaves presented in table 2 revealed that when the first leaf was given the activity, maximum amount of translocation occurred in the second leaf followed by the fifth leaf which was also statistically significant. The lowest level of partitioning was observed at the fourth and the third leaf which was statistically at par with each other.

When the second leaf was given the radioactivity, maximum partitioning occurred to the third leaf followed by the sixth and first leaf and the differences in the mean recovery of activity observed in the above leaves were

Table1. Recovery of radioactivity showing photosynthates (cpm/g of dry leaf sample) accumulated in different source leaves fed with labelled carbon dioxide in banana (*Musa* AAB Palayankodan)

	Source leaves					
	(L1)	(L2)	(L3)	(L4)	(L5)	CD (0.05)
Source leaf	391.75^{b} (19.80)	236.75^{c} (15.40)	495.75^{a} (22.27)	197.75^{d} (14.07)	127.25^{e} (11.29)	0.48

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 2. Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in other leaves when the different source leaves was fed with labelled carbon dioxide in banana (*Musa* AAB Palayankodan)

	Source leaves				
Sink leaves	(L1)	(L2)	(L3)	(L4)	(L5)
L1	L1	116.50^{c} (10.8)	124.50^{bc} (11.17)	64.25^{d} (8.03)	119.75^{c} (10.95)
L2	144.25^{a} (12.02)	L2	132.75^{ab} (11.54)	157.50^{a} (12.56)	98.50^{d} (9.94)
L3	57.50^{d} (7.61)	160.25^{a} (12.66)	L3	105.75^{c} (10.30)	132^{b} (11.50)
L4	63^{d} (7.96)	99^{e} (9.97)	126.25^{bc} (11.25)	L4	85.25^{e} (9.25)
L5	108.50^{b} (10.43)	115^{cd} (10.74)	116.75^{c} (10.82)	124.75^{b} (11.18)	L5
L6	94^{c} (9.71)	136.75^{b} (11.71)	137.50^{a} (11.74)	95.25^{e} (9.77)	177.50^{a} (13.34)
CD (0.05)	0.47	0.61	0.45	0.58	0.55

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

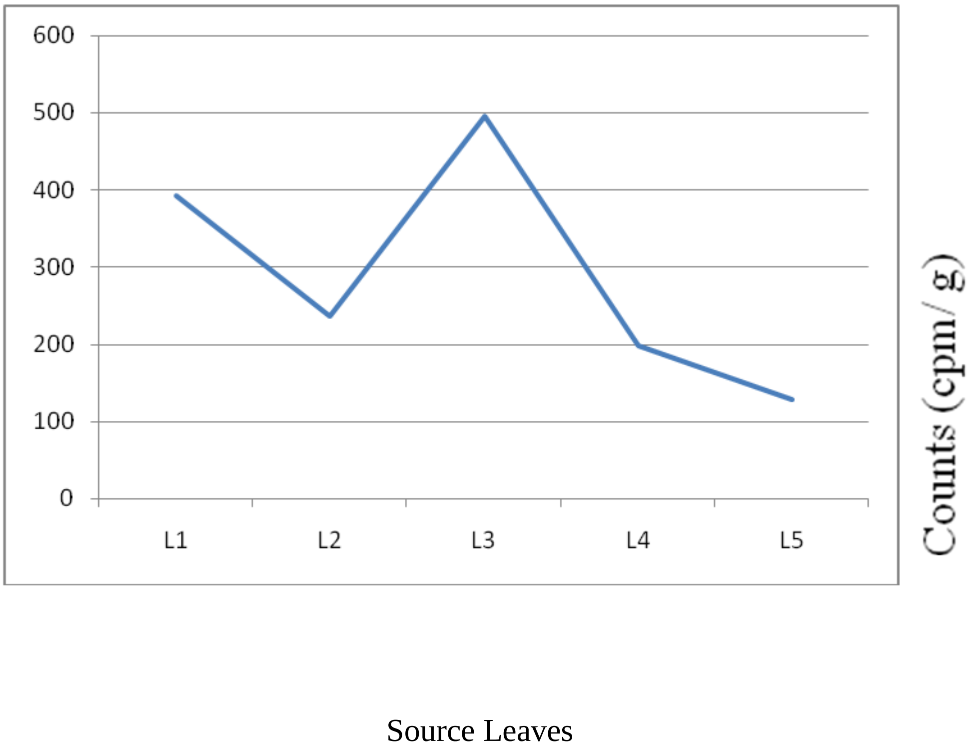


Figure1. Retention of photosynthates in different source leaves in Palayankodan

also statistically significant. The fifth leaf was at par with the first leaf and the lowest partitioning occurred in the fourth leaf.

When the third leaf was given the activity, maximum partition occurred to the sixth leaf and the recovery observed in the leaf was significantly superior to the means observed in all other leaves. The second highest partitioning occurred to the second leaf followed by the fourth and the first, the former being superior to the latter two which were at par with each other. The lowest was observed in the fifth leaf.

When the fourth leaf was fed with the radioactivity, maximum partitioning occurred to the second leaf followed by the fifth leaf, third leaf, first leaf and the sixth leaf. The differences between the means of recovery of activity were also significant.

When the fifth leaf was fed with activity, maximum partitioning occurred to the oldest sixth leaf followed by the third leaf, first leaf, second leaf and fourth. The differences in the recovery of means were also statistically significant.

4.1.3. Partitioning from source leaf to different hands

The partitioning of photosynthates from the source leaves to the various hands presented in the table 3 reveal that in case when the first leaf (L_1) was given the activity feeding, the maximum recovery of activity was observed in the last formed hands namely the seventh and eighth hand. The recovery in the former was significantly superior to all other hands. This was followed by the second which was at par with the eighth, then the third, sixth, first, fifth and fourth with the means of each being significantly superior over the other in the order.

When the second leaf was given the activity, the maximum recovery of activity is observed in the mid hands namely the fourth and fifth hand the former being significantly superior to the latter. This was followed by the last formed hand followed by the third, second, sixth, first and the seventh hands. The

Table 3. Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in various hands when the different source leaves were fed with labelled carbon dioxide in banana (*Musa* AAB Palayankodan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	308 ^{e} (17.56)	157.5 ^{e} (12.55)	174 ^{f} (13.20)	98.25 ^{f} (9.93)	355.60 ^{b} (18.86)
H2	888.2 ^{b} (29.80)	228 ^{d} (15.11)	219.75 ^{e} (14.84)	481.25 ^{b} (21.94)	327.75 ^{c} (18.11)
H3	541.2 ^{c} (23.26)	240 ^{d} (15.50)	377.75 ^{a} (19.44)	380.50 ^{d} (19.51)	393 ^{a} (19.83)
H4	130 ^{g} (11.42)	598.7 ^{a} (24.78)	324 ^{c} (18.01)	610.50 ^{a} (24.71)	84 ^{g} (9.18)
H5	227.50 ^{f} (15.09)	557 ^{b} (23.61)	345.25 ^{b} (18.59)	439.75 ^{c} (20.98)	193.50 ^{e} (13.92)
H6	446 ^{d} (21.12)	159 ^{e} (12.62)	205.75 ^{e} (14.36)	368.25 ^{d} (19.19)	117.25 ^{f} (1086)
H7	1278.8 ^{a} (35.76)	127.5 ^{f} (11.31)	182.75 ^{f} (13.53)	294.50 ^{e} (17.17)	193.25 ^{e} (13.91)
H8	891.5 ^{b} (29.84)	462.7 ^{c} (21.52)	237.75 ^{d} (15.43)	301 ^{e} (17.36)	247.75 ^{d} (15.74)
CD (0.05)	0.47	0.57	0.36	0.44	0.488

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

means of the recovery in the second and third and fifth and first did not vary significantly with each other.

When the third hand (L_3) was fed with the activity, the mid hands revealed not only the maximum recovery of activity but also a sizeable chunk was observed in the source leaf itself. Among the hands, the mid hands the third, fifth and fourth hand recorded the maximum recovery followed by the eighth, sixth, second, seventh and the first formed hand. Except the means of the recovery in the seventh and first hands, the differences between the means were statistically significant.

When the fourth leaf was fed with the activity, the fourth hand, second, followed by the fifth recorded highest recovery of activity and the differences between the means were also significantly superior to each other. This was followed by the sixth and the third hand the means of it were statistically at par with each other followed by the seventh and the eight and finally the first formed first hand.

In case of the fifth leaf, the maximum recovery of activity was occurred in the first formed hands, the order being third, first and second followed by the eighth hand. The differences in the means of recovery were also significant. The lowest recovery was observed in the fourth hand and the differences in the mean being significantly inferior.

The bigger size the first and second hand (D hand) can be explained on the basis of the recovery. Though the oldest active leaf was more nourishing the first formed hands it can be seen that all the leaves well contributed well to the first formed hands.

Another point worth examining is the regulation of carbon partitioning. It is evident that in both the cases of the first and second leaves, sink regulation can be seen whereas in case of the third leaf maximum recovery is seen in the third leaf revealing a clear case at the source level of regulation. In case of the fourth and fifth leaf activity is seen slightly higher in old hands but almost

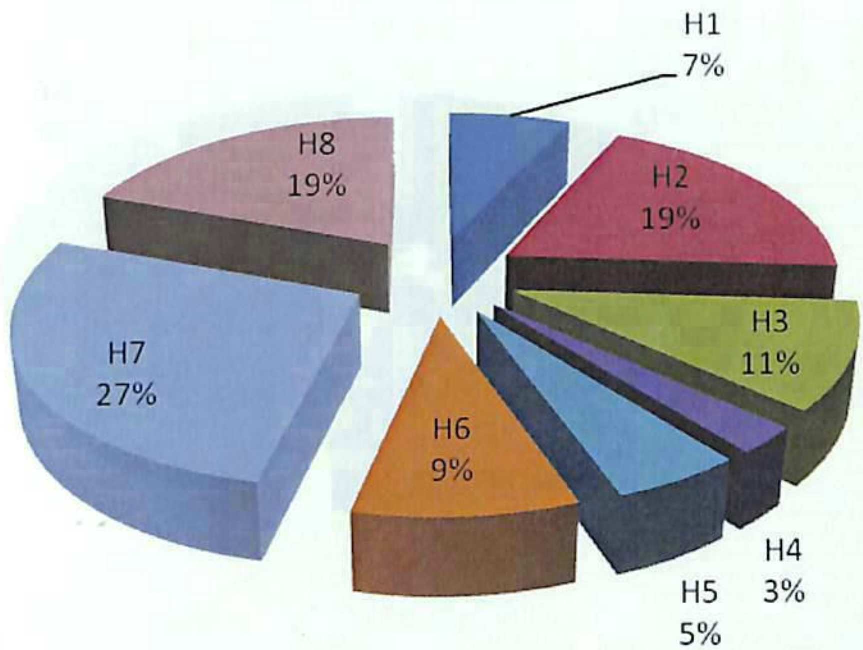


Figure 2. Partitioning of photosynthates in hands when the first leaf (L1) is fed with activity in (*Musa* AAB Palayankodan)

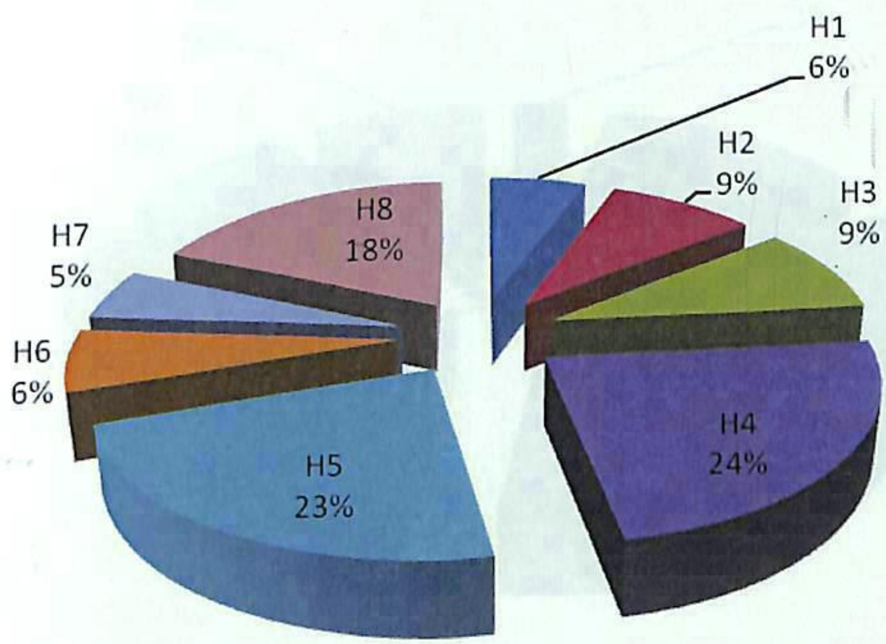


Figure 3. Partitioning of photosynthates in hands when the second leaf (L2) is fed with activity in (*Musa* AAB Palayankodan)

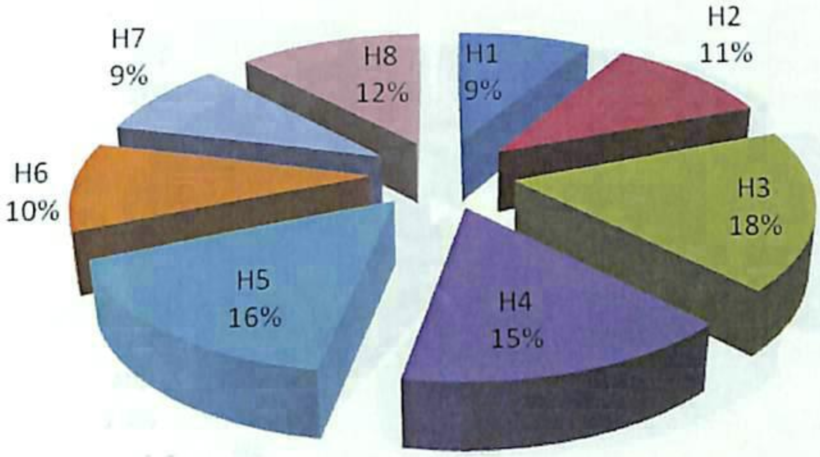


Figure 4 Partitioning of photosynthates in hands when the third leaf (L3) is fed with activity in (*Musa* AAB Palayankodan)

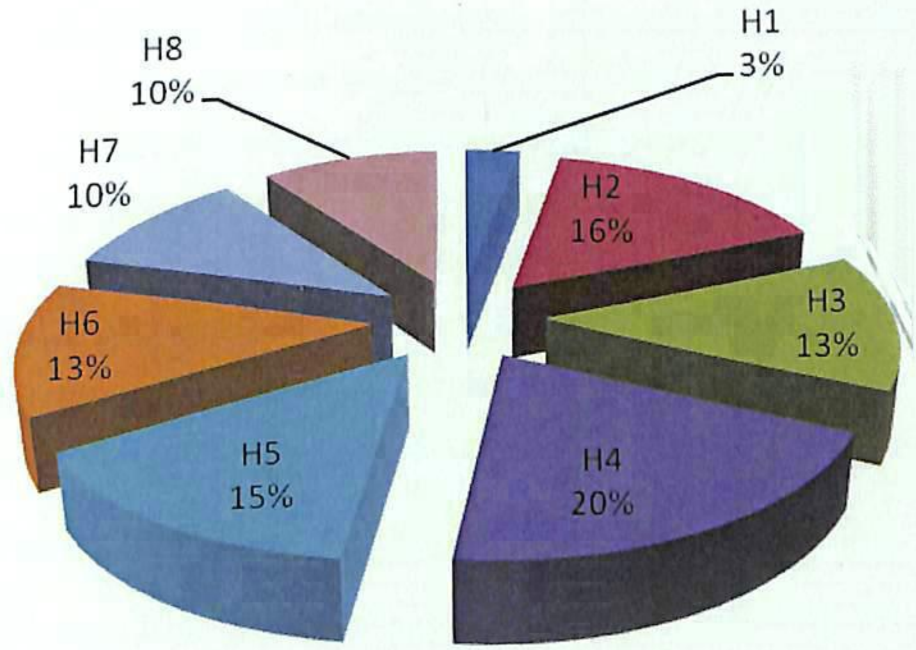


Figure 5.Partitioning of photosynthates in different hands when the fourth leaf (L4) is fed with activity in (*Musa* AAB Palayankodan)

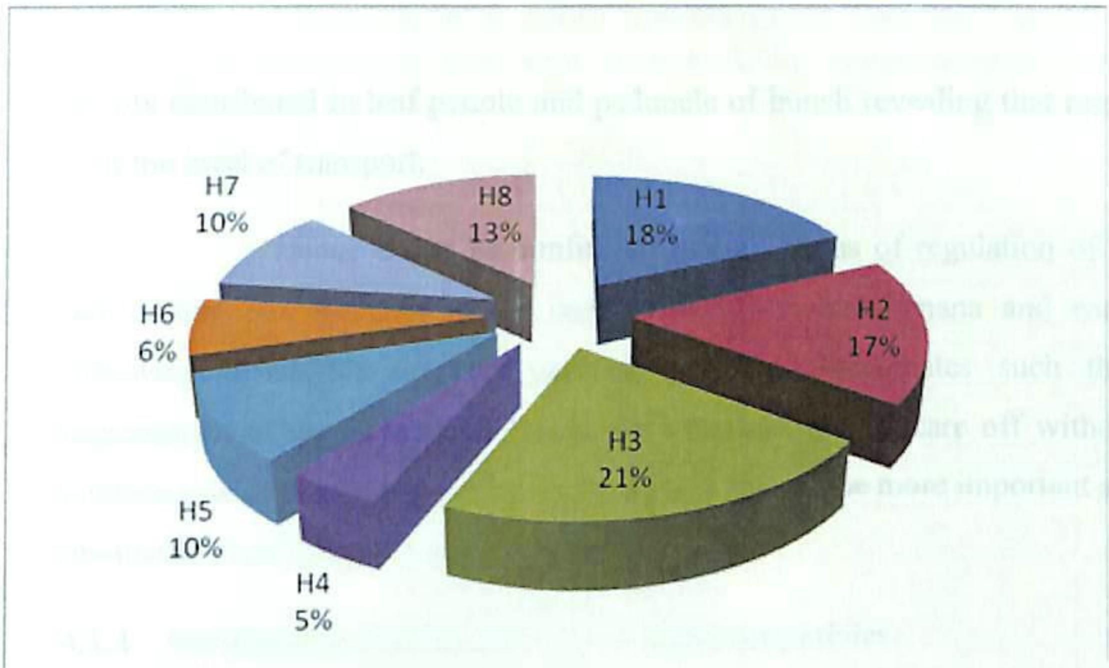


Figure 6. Partitioning of photosynthates in different hands when the fifth leaf (L5) is fed with activity in (*Musa* AAB Palayankodan)

evenly distributed in leaf petiole and peduncle of bunch revealing that regulation is at the level of transport.

Hence it can be confirmed that all forms of regulation of carbon partitioning can be seen in the case of Palayankodan banana and each leaf following a distinct type of partitioning of photosynthates such that the requirement of the developing hands are adequately taken care off without any compromise on the both the structural make up and on the more important side the photosynthesising tissues of the green leaf.

4.1.4. Partitioning from source leaf to different petioles

A critical analysis in the recovery of photosynthates in the petiole presented in table 4 revealed a different picture altogether. When the first and the fifth leaf were given the activity, the highest recovery of activity was also observed in the corresponding petiole. In the case of the second leaf fed with the activity, maximum mean recovery was observed in petioles of the fifth and third leaf which differed significantly between each other as well as the means of recovery in other petioles. In the case of the third leaf fed with the activity almost an even recovery of activity was observed in all the petioles except in the case of the fourth. Statistical analysis revealed an identical trend. When the fourth leaf was given the activity, maximum activity was observed in the fifth petiole, which was significantly superior to means of the other followed by the sixth, second, third and first petioles which were at par with each other. The activity observed in other petioles were almost the same

4.1.5. Partitioning from source leaf to different tissues

A comparison of the recovery of activity of all the leaves presented in table 5 revealed that the maximum recovery was observed when the third leaf was given the activity followed by the second and the first leaf. A gradual reduction was observed in the fourth and fifth leaf. An identical trend was observed at the level of statistical analysis with the third leaf being most superior

Table 4. Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) partitioning to petioles when the different source leaves was fed with labelled carbon dioxide in banana (*Musa* AAB Palayankodan)

	Source leaves				
Petioles	(L1)	(L2)	(L3)	(L4)	(L5)
Petiole1	232.25^{a} (15.25)	130.5^{c} (11.43)	129.75^{ab} (11.41)	124.75^{b} (11.18)	112.50^{d} (10.62)
Petiole 2	126^{c} (11.24)	125^{cd} (11.2)	122.5^{ab} (11.08)	125.50^{c} (11.22)	162.50^{a} (12.76)
Petiole 3	156.75^{b} (12.53)	166.5^{b} (12.91)	122^{ab} (11.06)	125.50^{b} (11.22)	162.50^{b} (12.76)
Petiole 4	88^{d} (9.40)	116.25^{d} (10.80)	99.25^{b} (9.97)	110.50^{e} (10.53)	110.25^{d} (10.51)
Petiole 5	151.25^{b} (12.31)	225.50^{a} (15.02)	126.5^{ab} (11.26)	173.25^{a} (13.18)	181.75^{a} (13.49)
Petiole 6	125.75^{c} (11.23)	79^{e} (8.90)	131.50^{ab} (11.48)	122.50^{b} (11.08)	136.50^{c} (11.69)
CD (0.05)	0.48	0.52	0.512	0.417	0.54

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 5 Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) partitioning to various tissues when the different source leaves was fed with labelled carbon dioxide in banana (*Musa* AAB Palayankodan)

	Source leaves					
Tissues	(L1)	(L2)	(L3)	(L4)	(L5)	CD (0.05)
Leaves	143.17^{b} (11.98)	144.04^{b} (12.02)	188.92^{a} (13.76)	124.21^{c} (11.16)	123.38^{c} (11.12)	0.23
Hands	588.94^{a} (24.27)	316.31^{c} (17.79)	258.38^{d} (16.08)	371.75^{b} (19.29)	239.06^{e} (15.47)	0.32
Petiole	144.83^{a} (12.05)	139.66^{b} (11.83)	116.66^{c} (10.82)	128.5^{b} (11.35)	151.16^{a} (12.3)	0.23
Peduncle	207^{c} (14.40)	126.50^{e} (11.26)	280^{b} (16.74)	139.75^{d} (11.83)	315.75^{a} (17.78)	0.54
Pseudo stem	195.50^{b} (13.99)	127.75^{c} (11.31)	93.25^{d} (9.68)	271.25^{a} (16.48)	136.25^{c} (11.67)	0.68
Corm	132.5^{c} (11.53)	141.75^{bc} (11.92)	153.25^{b} (12.39)	248^{a} (15.75)	147.75^{bc} (12.16)	0.65
Root	171.25^{b} (13.10)	135.50^{d} (11.65)	280^{a} (16.74)	112^{e} (10.60)	170.50^{c} (13.07)	0.51

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

and means differences significant. The means of second leaf and fifth were at par with each other.

A comparison of recovery of the mean activity in the hands revealed that the maximum recovery was observed when the first leaf was fed with the activity and this was significantly superior to the means realised in other leaves. This was followed by the fourth, second, third and the fifth leaf in the order. Statistical superiority of the means of recovery was also in the above order.

In the case of petiole maximum recovery of activity was observed when the oldest fifth and the youngest first and second leaf were fed with the activity. This was followed by the second and the fourth leaf. Statistical analysis also revealed that the fifth and the first and the second and fourth were at par with each other. The lowest recovery observed in the petiole when the third fed leaf was given the activity.

Maximum mean recovery of activity in the peduncle was observed when the oldest leaf was fed with the activity. This was followed by the third leaf, the first leaf, fourth leaf and lastly the second leaf. This significance superiority of the means was also observed in the same order.

In the case of pseudostem, maximum recovery of activity was observed when the fourth leaf was fed with activity. This was followed by the first leaf and differences in means were also significant. Recovery mean in the case of the fifth leaf and the second leaf was observed in the pseudostem when activity was fed in the third leaf.

In the case of corm maximum mean recovery was observed in the case of the fourth leaf followed by the third leaf. The differences were also statistically significant. This was followed by the fifth and second leaf. The least recovery was observed in the first leaf. In the case of roots the maximum mean recovery was observed in the third leaf followed by the first leaf, fifth leaf, second leaf and the fourth leaf. Significant difference in the treatment means were also in the same order except in the case of the first and the fifth leaves which were at par with each other.

4.1.6. Percentage accumulation of C^{14} activity from photosynthates in various hands when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AAB Palayankodan)

When the first leaf was fed with the activity, maximum recovery was observed in the seventh hand followed by the eight hand, second hand, the third hand, sixth hand, first hand, fifth hand and the fourth hand which is the least means of recovery with regard to statistical count also followed the same order as shown in table 6. The difference between the maximum partitioning hand and the least were in the order of more than two fold times.

In the case of the second leaf, maximum partitioning occurred in the fourth hand followed by the fifth hand, the eight hand, third hand, second hand, sixth hand, first hand and the seventh. Except in the case of the two sets the third and second hand and sixth and first hand which were at par with each other, all the other partitioning mean per cent showed statistical significant of superiority as in the order above.

In the case of the third leaf again the superiority of the mid hand namely the third, the fifth, fourth was very explicit. The gradation in the order of superiority was H3> H5>H4>H8>H2>H6>H7>H1. A similar order of superiority in statistical significance was observed in the statistical analysis with one over the other.

In the case of the fourth leaf, the significant superiority of the fourth hand, followed by the second and the fifth hand, the third and the sixth hand which were at par, the eighth hand and the seventh hand which were at the par and the least in first hands were observed

In the case of the fifth leaf, the maximum recovery was observed in the third leaf followed by the first leaf, the second leaf, the eighth leaf, the seventh leaf and fifth leaf which were equal and the least were observed in the sixth and

Table 6.Percentage recovery of activity showing photosynthates accumulated in various hands when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AAB Palayankodan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	4.31[e] (2.07)	3.28[e] (1.94)	3.81[h] (2.07)	1.80[f] (1.51)	8.37[b] (2.97)
H2	12.43[b] (3.52)	4.76[d] (2.29)	4.81[e] (2.30)	8.85[b] (3.05)	7.72[c] (2.86)
H3	7.57[c] (2.75)	5.01[d] (2.34)	8.27[a] (2.96)	7.00[d] (2.73)	9.25[a] (3.12)
H4	1.82[g] (1.34)	12.51[a] (3.60)	7.09[c] (2.75)	11.23[a] (3.42)	1.97[g] (1.57)
H5	3.18[f] (1.78)	11.68[b] (3.48)	7.56[b] (2.83)	8.09[c] (2.93)	4.55[e] (2.24)
H6	6.24[d] (2.49)	3.32[e] (1.95)	4.50[f] (2.23)	6.77[d] (2.69)	2.77[f] (1.80)
H7	17.90[a] (4.23)	2.66[f] (1.77)	4.00[g] (2.12)	5.42[e] (2.43)	4.55[e] (2.24)
H8	12.47[b] (3.53)	9.67[c] (3.18)	5.20[d] (2.38)	5.53[e] (2.45)	5.83[d] (2.51)
CD (0.05)	0.046	0.065	0.046	0.046	0.046

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

fourth hands. Statistical significance in the superiority was observed in the above order except in case of the seventh and the fifth hand.

4.1.7. Percentage accumulation of C^{14} radioactivity from photosynthates in various tissues when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AAB Palayankodan)

Analysis of table 7(a) & 7(b) revealed that in the case of source leaf maximum means recovery was observed in the third leaf followed by the first leaf, fourth leaf, fifth leaf and least in the second leaf. Statistical significance in superiority was also explicit at each level and in the case of the mean recovery in the sink leaf. The mean recovery in the sink leaf was highest when the second leaf was given the activity which was followed by the fifth leaf, the third, fourth and the first which recorded the least. Significance in the superiority was also observed at the each level.

Maximum per cent partitioning of activity was observed in the hands. This ranged from sixty five percent to forty five percent. The highest was observed when the first leaf was given the activity followed by the fourth leaf, second leaf, the third leaf and the finally the fifth leaf which recorded the least. Statistical significance was observed at each level, except in the case of third and the fifth which were at par.

In the case of pseudostem, maximum per cent recovery of activity was observed when the fourth leaf was given the activity. This was followed by the fifth leaf, first leaf, second leaf and the third leaf respectively. Statistical significance of superiority was observed at each level.

In case of petiole maximum per cent recovery was observed when the fifth leaf was given the activity followed by second, third, fourth and the first. Statistical significance of superiority was observed at each level.

Table 7(a). Percentage recovery of activity showing photosynthates accumulated in various tissues when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AAB Palayankodan)

	Source leaves					
Tissues	(L1)	(L2)	(L3)	(L4)	(L5)	CD
Source leaf	5.67^{b} (2.44)	2.37^{e} (1.71)	10.85^{a} (3.37)	3.65^{c} (2.03)	3.00^{d} (1.86)	0.067
Sink leaf	6.55^{e} (2.59)	15.77^{a} (4.03)	13.97^{c} (3.80)	10.07^{d} (3.25)	14.42^{b} (3.86)	0.095
Hand	65.90^{a} (8.14)	52.67^{c} (7.30)	45.27^{d} (6.76)	54.72^{b} (7.43)	45.20^{d} (6.74)	0.047
Pseudo stem	2.99^{c} (1.82)	2.63^{d} (1.77)	2.05^{e} (1.59)	5.07^{a} (2.34)	3.30^{b} (1.92)	0.082
Petiole	12.42^{e} (3.58)	17.57^{b} (4.25)	16.05^{c} (4.06)	13.75^{d} (3.75)	21.05^{a} (4.63)	0.095
Peduncle	2.22^{d} (1.83)	2.67^{e} (1.64)	4.05^{b} (2.13)	3.52^{c} (1.98)	5.70^{a} (2.49)	0.067
Corm	1.96^{d} (1.54)	2.95^{c} (1.85)	3.35^{b} (1.96)	4.65^{a} (2.24)	3.47^{b} (1.99)	0.082
Root	2.29^{c} (1.63)	3.47^{b} (2.01)	4.40^{a} (2.21)	4.57^{a} (2.23)	3.70^{b} (2.02)	0.047

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 7(b). Percentage recovery of activity showing photosynthates accumulated in various tissues when different source leaves are labelled with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AAB Palayankodan)

	Source leaves				
Tissues	(L1)	(L2)	(L3)	(L4)	(L5)
Source Leaf	5.48[d] (2.44)	4.94[d] (2.33)	10.86[d] (3.37)	3.64[c] (2.01)	2.99[e] (1.86)
Sink leaves	6.24[c] (2.59)	13.11[c] (3.68)	13.97[c] (3.80)	10.07[b] (3.25)	14.4[c] (3.86)
Hands	65.79[a] (8.14)	52.89[a] (17.58)	45.28[a] (6.76)	54.73[a] (7.43)	45.04[a] (6.74)
Petiole	12.35[b] (3.58)	17.58[b] (4.25)	16.02[b] (4.06)	11.14[b] (3.29)	21.01[a] (4.63)
Pseudo stem	2.83[e] (1.82)	2.66[fg] (1.77)	2.04[g] (1.59)	4.98[c] (2.34)	3.19[e] (1.92)
Peduncle	2.87[e] (1.83)	2.22[g] (1.64)	4.06[e] (2.13)	3.43[c] (1.98)	5.71[d] (2.49)
Corm	1.90[f] (1.54)	2.95[f] (1.85)	3.35[f] (1.96)	4.55[c] (2.24)	3.47[e] (1.99)
Root	2.18[f] (1.63)	3.55[e] (2.01)	4.38[e] (2.21)	4.49[c] (2.23)	3.58[e] (2.02)
CD(0.05)	0.06	0.07	0.04	0.53	0.09

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

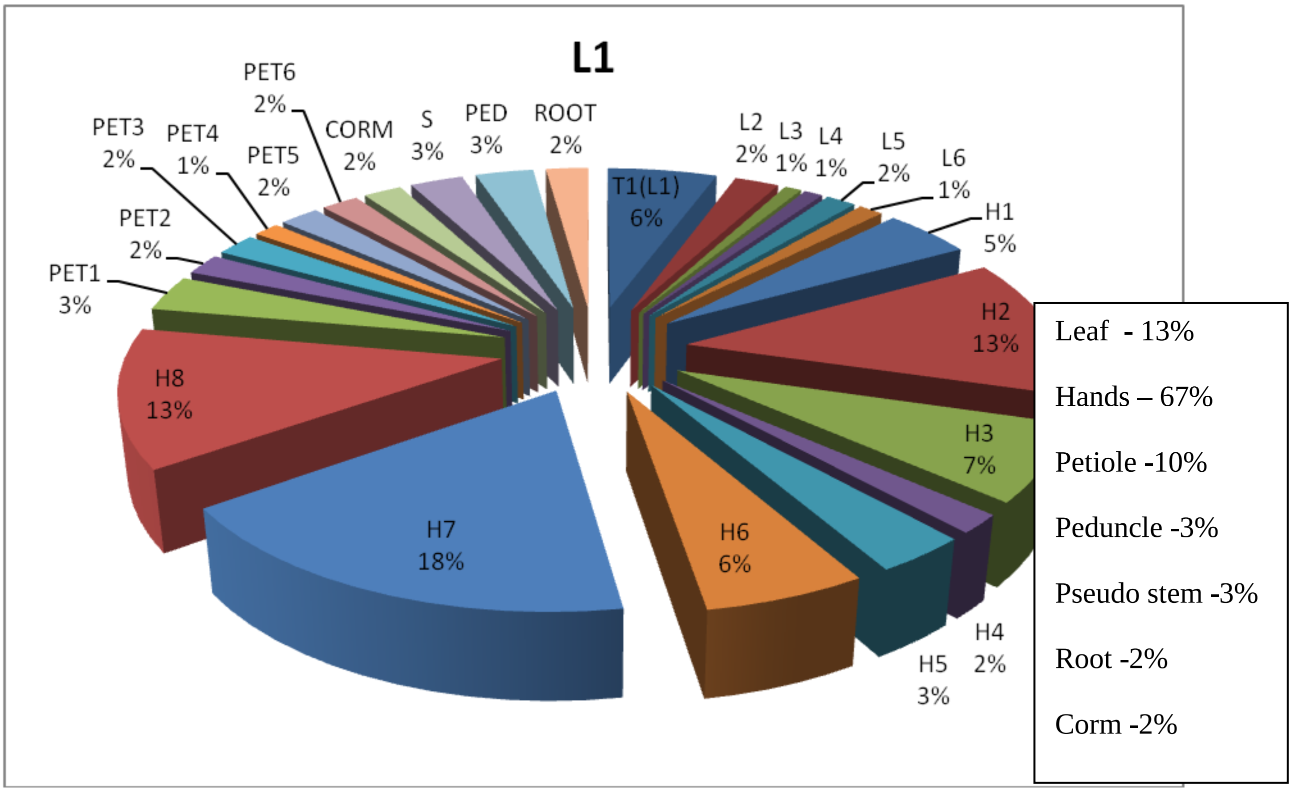


Figure 7 Partitioning of photosynthates among tissues when the first leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AAB Palayankodan)

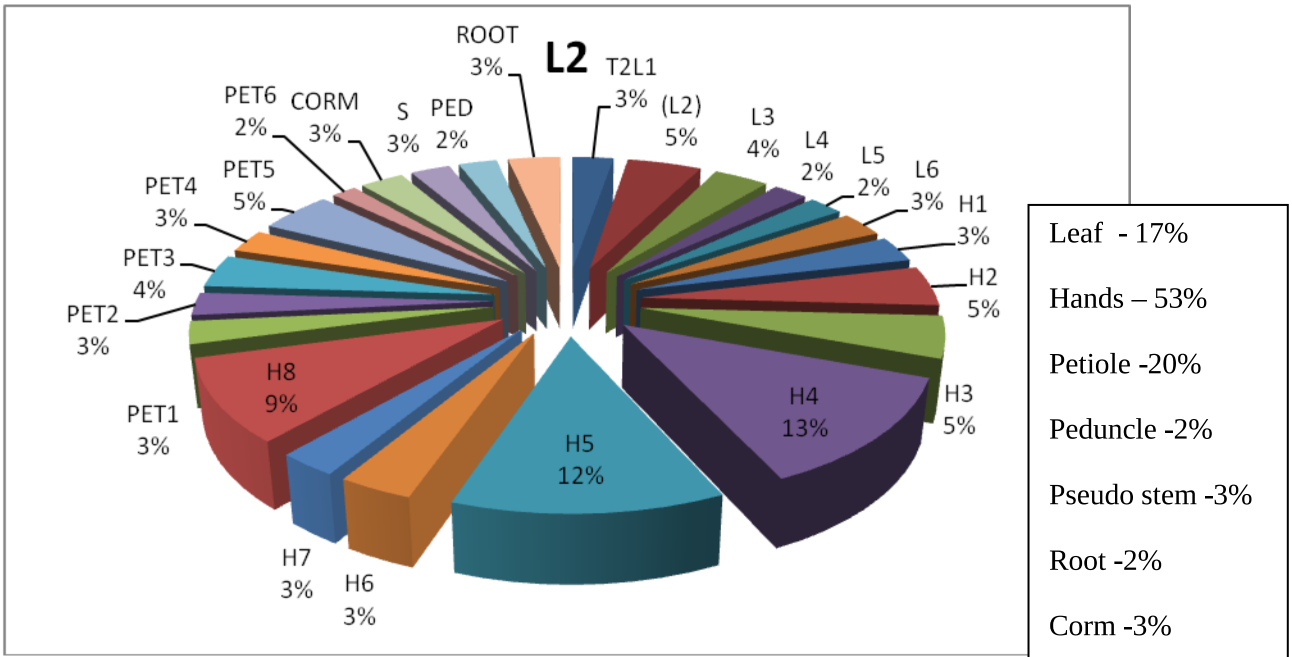
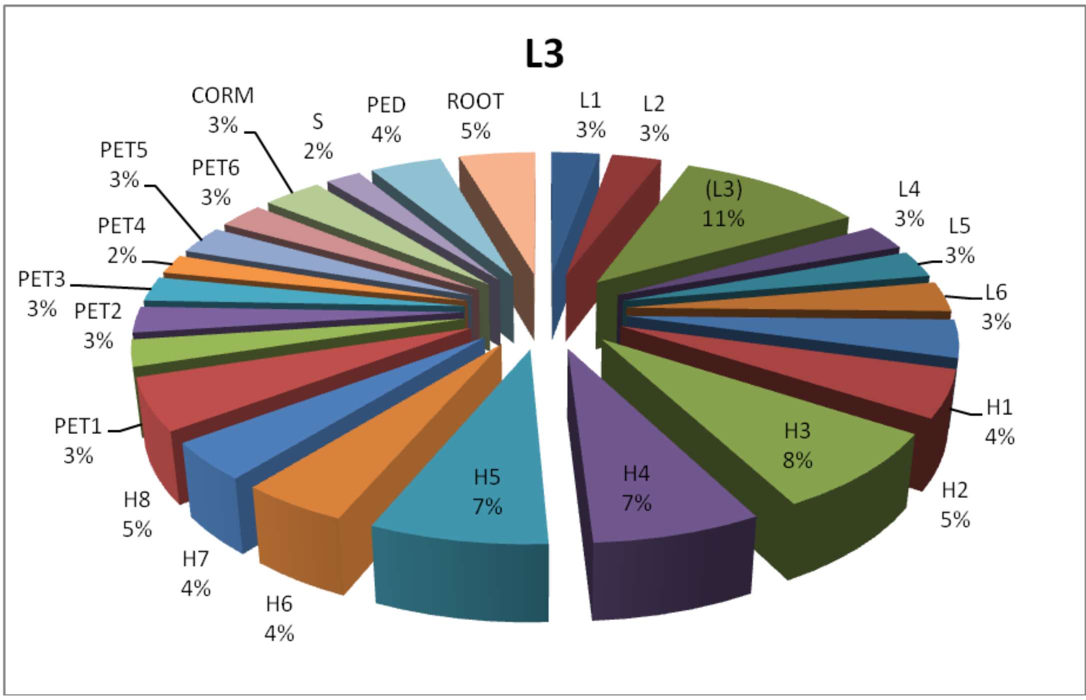


Figure 8 Partitioning of photosynthates among tissues when the second leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AAB Palayankodan)



Leaf – 26%

Hands- 44%

Petiole – 17%

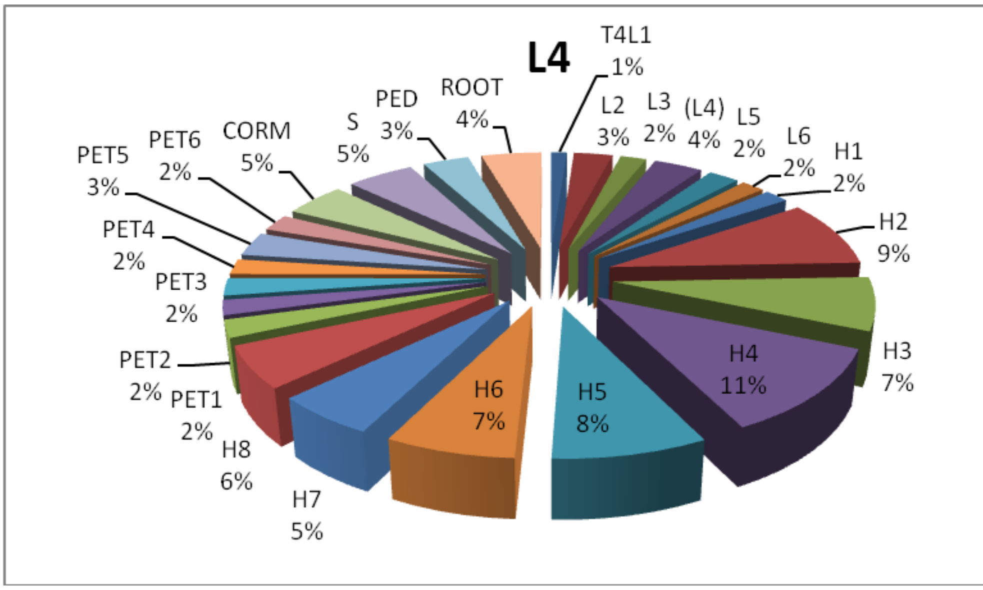
Corm -3%

Pseudostem -2%

Peduncle- 4%

Root-4%

Figure 9 Partitioning of photosynthates among tissues when the third leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AAB Palayankodan)



Leaf – 14%

Hands- 55%

Petiole – 11%

Corm -5%

Pseudostem -5%

Peduncle- 4%

Root-5%

Figure 10 Partitioning of photosynthates among tissues when the fourth leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AAB Palayankodan)

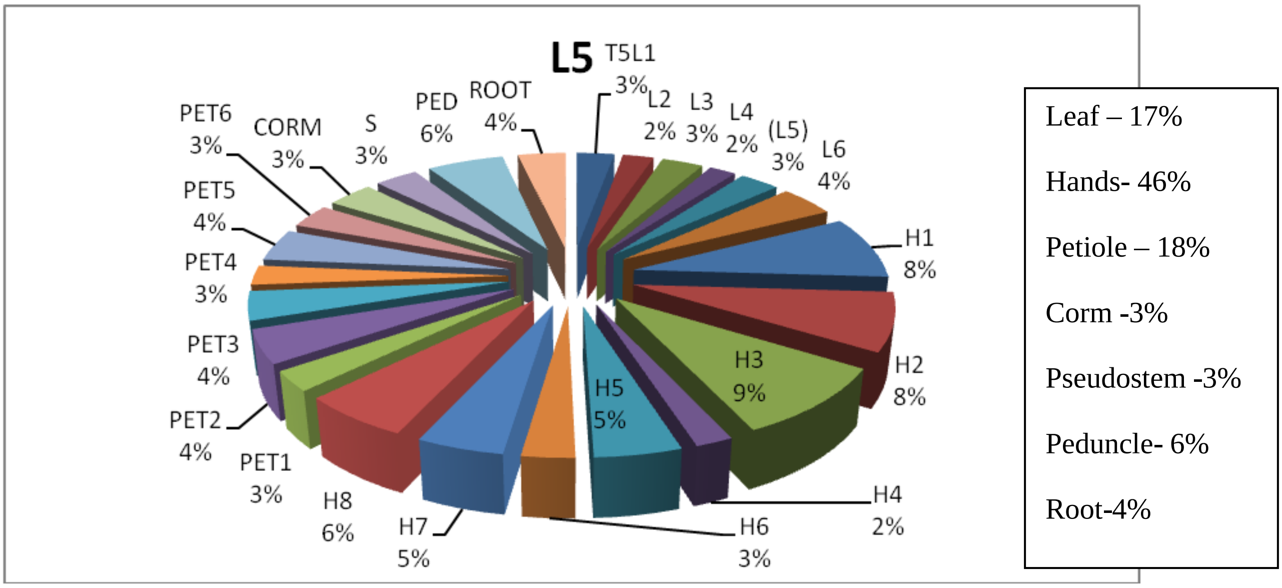


Figure 11 Partitioning of photosynthates among tissues when the fifth leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AAB Palayankodan)

In the case of peduncle the maximum per cent of recovery of activity was observed when the fifth leaf was fed with activity followed the third, fourth, second and the first leaf.

In the case of corm, maximum per cent recovery of activity was observed when the fourth leaf was fed with activity. This was followed by the fifth, third, second and the first. Statistical significance of superiority in the corm was observed at each level except in the case when the activity was given to the fifth and the third leaf which were at par.

In the case of roots, maximum per cent partitioning was observed when the fourth and the third leaf was given the activity which was at par and significantly superior to the per cent sink partitioning observed in the other cases. This was followed by the fifth and second leaf which was also at par and significantly superior over the percentage partitioning observed in the first leaf.

4.1.8. Percentage partitioning of photosynthates to various hands when different source leaves are fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AAB Palayankodan)

When the first leaf was given the activity the per cent sink partitioning into the different hands on a whole plant basis followed almost a similar trend as in the case of unit gram dry basis (Table 8). Highest per cent was observed in the seventh hand, the second, the eighth, the third, the sixth, the first and the least in the fifth hand.

When the second leaf was given the activity, the per cent sink partitioning into the different hands on a whole plant basis followed almost a similar trend as in the case of unit gram dry basis. Highest per cent activity was observed in fourth hand, the fifth, the eight and the second the sixth, the seventh and the first hand. The gradation was explicit in the above order except in the case of the second and the third hand which was statistically at par. Significant superiority was observed in all the other cases.

Table8. Percentage recovery of activity showing photosynthates accumulated in various tissues when different source leaves are fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AAB Palayankodan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	3.32^{f} (1.95)	2.41^{e} (1.70)	3.24^{e} 1.93	1.16^{g} (1.28)	5.96^{a} (2.53)
H2	9.14^{b} (3.10)	3.40^{d} (1.97)	3.89^{c} (2.09)	5.41^{b} (2.43)	5.29^{b} (2.40)
H3	5.41^{d} (2.43)	3.42^{d} (1.97)	6.54^{a} (2.65)	4.19^{d} (2.16)	6.08^{a} (2.56)
H4	1.23^{h} (1.31)	8.11^{a} (2.93)	5.42^{b} (2.43)	6.62^{a} (2.66)	1.26^{e} (1.32)
H5	2.10^{g} (1.61)	7.29^{b} (2.79)	5.55^{b} (2.45)	4.64^{c} (2.26)	2.84^{d} (1.82)
H6	4.04^{e} (2.13)	2.05^{f} (1.59)	3.19^{e} (1.92)	3.77^{c} (2.06)	1.67^{e} (1.47)
H7	11.14^{a} (3.41)	1.58^{g} (1.44)	2.77^{f} (1.80)	2.93^{f} (1.85)	2.68^{d} (1.78)
H8	7.60^{c} (2.84)	5.62^{c} (2.47)	3.55^{d} (2.01)	2.91^{f} (1.84)	3.32^{c} (1.95)
CD (0.05)	0.079	0.065	0.04	0.04	0.103

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

When the third leaf was given the activity the maximum per cent activity in different hand were in the order H3>H5>H4>H2>H8>H6>H1>H7. Statistical superiority in per cent means of hands were observed at each level of order also, except in the fourth and the fifth hands which were at par.

When the fourth leaf was given the activity, the maximum per cent recovery in different hands on a whole plant basis was observed in the fourth hand. This was followed by the second hand, fifth hand, sixth hand, seventh hand, eighth hand and the first hand. Significance of superiority between mean per cent was also observed at each level in the order, except in the two sets of the fifth and the fourth hand and the seventh and the eighth hand which were at par with each other.

When the fifth leaf was given the activity, the maximum per cent recovery in different hands on a whole plant basis was observed in the third hand and the first hand which were at par with each other followed by the second hand, the eighth hand, the fifth hand, the seventh hand, the sixth and the fourth hand and the least in the fourth hand. Significance of superiority between the mean per cent was also observed at each level in the order except in case of the sixth and the fourth hand and the seventh and the fifth hands which were at par with each other. In general, there was a similar trend observed in the case of per cent partitioning on the whole plant basis as in unit gram basis.

4.1.9. Percentage partitioning of photosynthates to various tissues when different source leaves are labelled fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AAB Palayankodan)

A comparison of the efficiency of the source leaf in Table 9 revealed that among the source leaves maximum retention of photosynthates was observed when the third leaf was given activity. This was significantly superior over the younger leaves namely the second and the first leaf which recorded the second and the third efficiency. This was followed by the older leaves namely the fifth and the fourth leaves in the older leaves.

Table 9. Percentage recovery of activity showing photosynthates accumulated in various tissues when different source leaves are fed with radioactive carbon dioxide on a whole plant dry weight basis in banana Palayankodan (Musa AAB)

	Source leaves					
Tissues	(L1)	(L2)	(L3)	(L4)	(L5)	CD
Source leaf	0.90^{b} (1.18)	0.91^{b} (1.18)	2.20^{a} (0.97)	0.64^{d} (1.06)	0.82^{c} (1.15)	0.03
Sink leaf	1.58^{c} (1.44)	3.01^{b} (1.87)	3.11^{b} (1.90)	1.70^{c} (1.48)	3.71^{c} (2.05)	0.047
Hand	42.79^{a} (6.67)	33.89^{b} (5.86)	34.18^{b} (5.88)	31.66^{c} (5.67)	29.13^{d} (5.44)	0.15
Petiole	1.50^{c} (1.41)	2.33^{b} (1.68)	2.18^{b} (1.63)	1.46^{c} (1.40)	2.58^{a} (1.75)	0.047
Pseudo stem	42.24^{b} (6.53)	41.94^{b} (6.51)	32.88^{c} (5.77)	43.17^{b} (6.6)	46.62^{a} (6.86)	0.18
Peduncle	0.62^{b} (1.06)	0.54^{bc} (1.02)	1.15^{a} (1.28)	0.46^{c} (0.98)	1.22^{a} (1.31)	0.04
Corm	6.24^{e} (2.95)	15.99^{c} (4.06)	22.57^{a} (4.8)	20.11^{b} (4.53)	14.5^{d} (3.87)	0.15
Root	0.83^{c} (1.15)	1.35^{b} (1.35)	1.69^{a} (1.47)	0.75^{c} (1.12)	1.36^{b} (1.36)	0.04

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

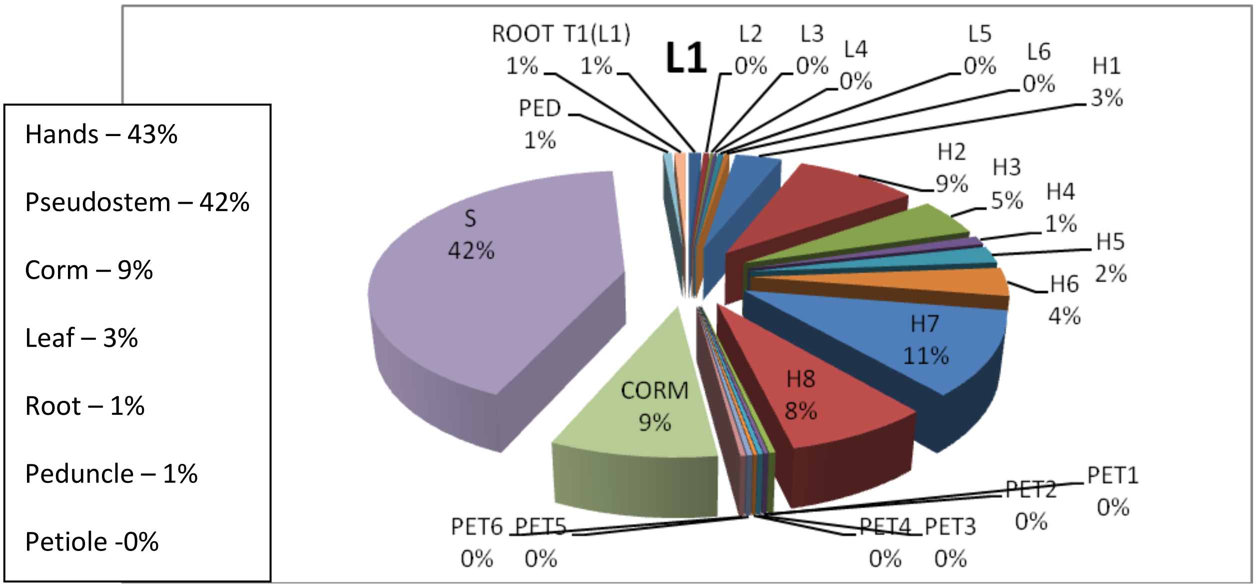


Figure 12 Partitioning of photosynthates among tissues when the first leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AAB Palayankodan)

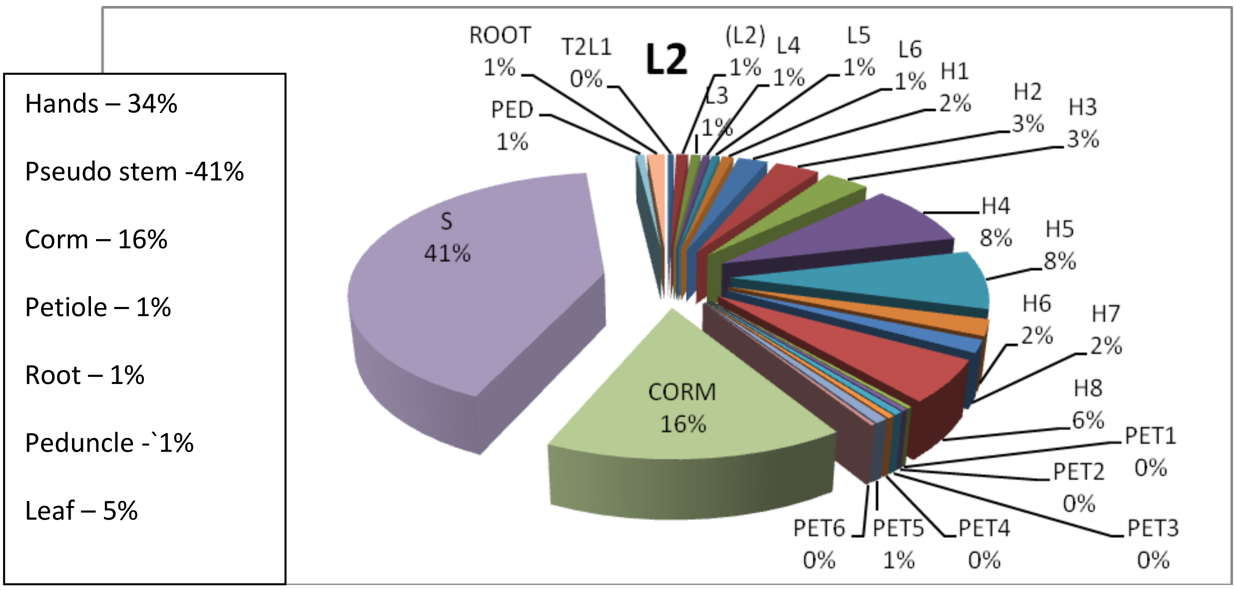


Figure 13 Partitioning of photosynthates among tissues when the second leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AAB Palayankodan)

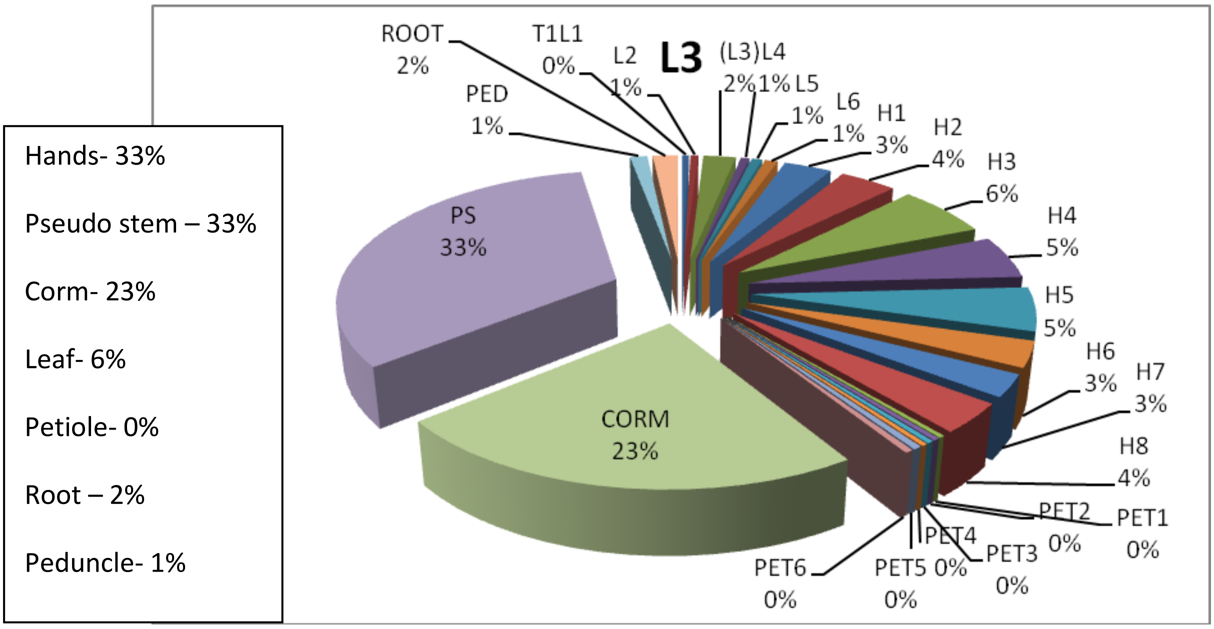


Figure 14 Partitioning of photosynthates among tissues when the third leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AAB Palayankodan)

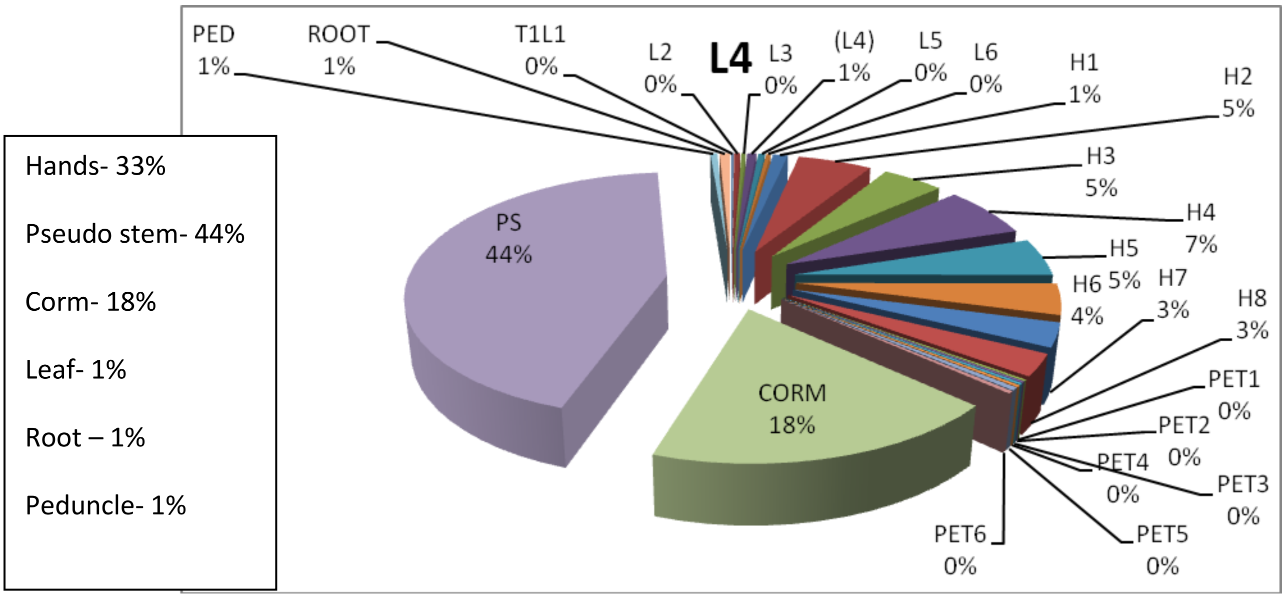


Figure 15 Partitioning of photosynthates among tissues when the fourth leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AAB Palayankodan)

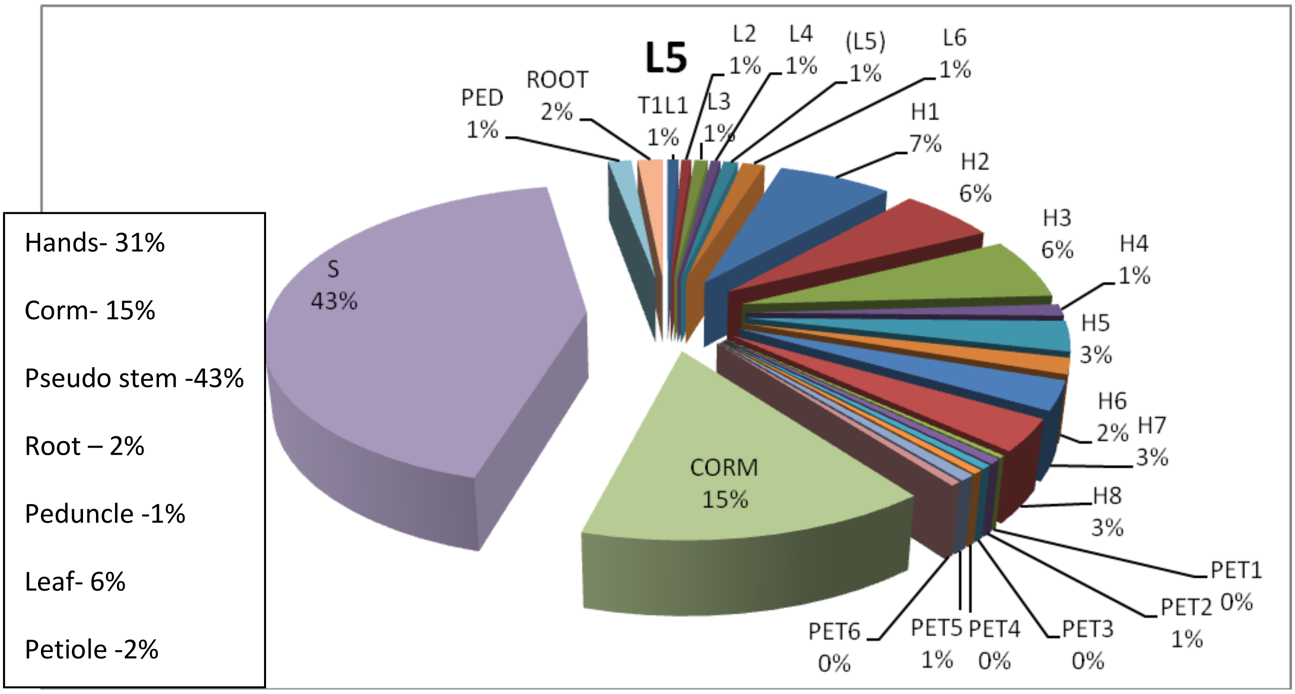


Figure 16 Partitioning of photosynthates among tissues when the fifth leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AAB Palayankodan)

In the case of the sink leaves, maximum apportion was seen in the case of the fifth leaf which was significantly superior over the third and second leaf. This was followed by the fourth and the first leaf which recorded only less than half accumulation observed in the fifth leaf.

In case of sink leaves, maximum apportion was in the fifth leaf which was significantly superior over the third and the second leaf. This was followed by the fourth and the first leaf which recorded only less than half the accumulation observed in the fifth leaf.

In the case of hands maximum apportion occurred when the first leaf which was also significantly superior was given the activity followed by the third and the second leaf which were at par with each other. This was followed by the fourth and the fifth leaves. A comparison revealed apportion into hands in the first leaf was more than half than compared to the fifth leaf.

In case of petiole maximum partitioning occurred in the fifth leaf which was superior over the next best second and third leaf which were at par with each other. This was followed by the first and the fourth leaf.

In case of the pseudostem maximum partitioning was observed in the case of the fifth leaf which was superior over the fourth, the second and the first leaf which was at par with each other. The least partitioning was observed in the third leaf.

In case of peduncle, maximum partitioning was occurred in the fifth leaf which was at par with next best the third. This was followed by the first, the second and the fourth leaf recorded the least partitioning.

In case of the corm, maximum partitioning was observed in the third leaf followed by the fourth, the second, the fifth and the first leaf in the order respectively. Statistical significance in superiority of means over the other also followed an identical trend.

In case of roots maximum partitioning was again observed in the third leaf which was significantly superior over the fifth and the second leaf. Next best means which were at par with each other. The partitioning in the first and fourth leaf was less than half that was recorded in the third leaf.

4.2. NJALIPOOVAN

Carbon partitioning studies on banana (*Musa* AB Njalipoovan)

4.2.1. Partitioning at the Source Leaves

The efficiency of different leaves in the retention of photosynthates in Njalipoovan as presented in (Table 10) reveals that among the source leaves studied, the fourth leaf followed by the third leaf, the first leaf and the second and the fifth leaf yielded the maximum recovery of C^{14}. The differences in the means were also statistically significant. However the third leaf was superior to first leaf which was superior to the second and the fifth leaf that were at par with each other.

4.2.2. Partitioning from source leaf to different sink leaves

The partitioning of photosynthates from the source leaves to the various sink leaves are presented in (Table11) revealed that when the first leaf was given the radioactive source, the maximum recovery among the different leaves was noticed in the second leaf followed by the eighth leaf which was also significantly superior to the next best eighth leaf. This was followed by the third leaf and the first leaf, the fourth leaf, the fifth leaf, the seventh and the sixth leaf. However, the third and the first leaf were at par. Similarly the fifth, the seventh and the sixth were also at par with each other.

When the second leaf was given the activity, maximum recovery among the sink leaves were noticed in the sixth and the fourth which recorded equal recovery and was at par with the second leaf but significantly superior over

Table 10 Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in source leaves when source leaves are fed with labelled carbon dioxide in banana (*Musa* AB Njalipoovan)

	Source leaves				
Treatment	(L1)	(L2)	(L3)	(L4)	(L5)
Source leaf	422.75[c] (20.57)	369.75[d] (19.24)	650.75[b] (25.51)	737.75[a] (27.16)	369.75[d] (19.24)
CD (0.05)	0.36	0.36	0.36	0.36	0.36

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table11. Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in other leaves when the different source leaves were fed with labelled carbon dioxide in banana (*Musa* AB Njalipoovan)

	Source leaves				
Sink leaves	(L1)	(L2)	(L3)	(L4)	(L5)
L1	L1	146^{bc} (12.10)	146^{d} (12.09)	173.5^{b} (13.18)	95^{c} (9.76)
L2	182.75^{a} (13.53)	L2	157^{cd} (12.54)	134.5^{c} (11.60)	130^{b} (11.42)
L3	141.25^{c} (11.89)	157.5^{ab} (12.56)	L3	123.25^{cd} (11.12)	96.75^{c} (9.85)
L4	111^{d} (10.54)	160.25^{a} (12.67)	147.5^{d} (12.16)	L4	144.75^{a} (12.04)
L5	94.25^{e} (9.73)	133.5^{cd} (11.57)	168.5^{bc} (12.99)	281.5^{a} (16.75)	L5
L6	85.25^{e} (9.25)	160.25^{a} (12.67)	124^{e} (11.15)	134^{c} (11.58)	148.75^{a} (12.21)
L7	87^{e} (9.34)	120.75^{d} (11.01)	363.75^{a} (19.08)	147.75^{bc} (12.16)	73.25^{d} (8.58)
L8	162.5^{b} (12.76)	140.5^{c} (11.87)	172.25^{b} (13.13)	99.75^{d} (10)	140.75^{ab} (11.87)
CD (0.05)	0.56	0.53	0.53	0.93	0.611

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

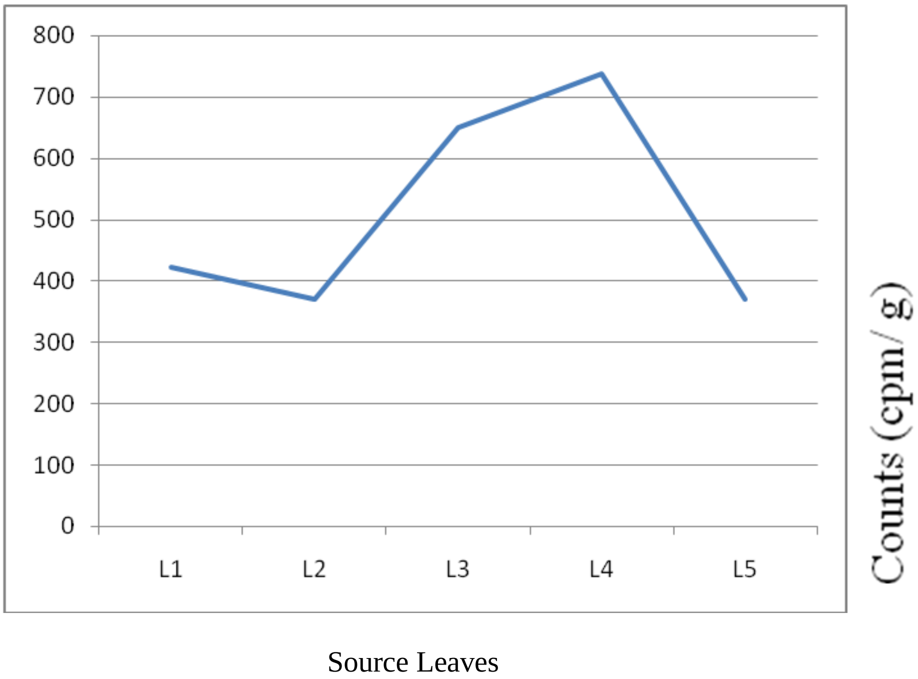


Figure 17 Retention of photosynthates in different source leaves in Njalipoovan

all the mean recovery in the other leaves. This was followed by the first and the fifth leaf which were also at par with each other but superior over the mean recovery in the seventh leaf.

When the third leaf was given the activity maximum recovery was observed in the seventh leaf which was superior to the mean recovery of all the other leaves. This was followed by the eighth leaf which was at par with the fifth leaf but superior over the mean of recovery in the second leaf followed by the fourth leaf and the first leaf which were at par with each other. The least recovery was observed in the sixth leaf.

When the activity was given to the fourth leaf, maximum recovery was observed in the fifth leaf which was significantly superior to the next best mean recovery observed in the first leaf, followed by the seventh leaf which was also at par with the second leaf and the sixth leaf. The next maximum recovery was observed in the third leaf which was also at par with the least mean of recovery observed in the eighth leaf.

When the fifth leaf was given the activity, maximum recovery was observed in the sixth leaf followed by the fourth leaf and the eighth leaf which was at par with each other. The next best was observed in the second leaf which was superior over the mean recovery observed in the third and the first leaf. The least recovery was observed in the seventh leaf.

4.2.3. Partitioning from source leaf to different hands

When the first leaf was given the activity, the mean recovery of activity was highest in the eighth hand which was significantly superior over the means recorded in the other hands. This was followed by the seventh and the sixth hands which were at par each other and superior over the other means. The next best was observed in the first hand followed by the second hand which was also at par with the recovery in the third and the fourth hand. The least was recorded in the fifth hand (Table 12).

Table 12 Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in various hands when the different source leaves were fed with labelled carbon dioxide in banana (*Musa* AB Njalipoovan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	184[c] (13.57)	284.25[c] (16.86)	826.5[a] (28.75)	354[e] (18.82)	460.5[c] (21.46)
H2	153.5[d] (12.39)	301.75[c] (17.38)	378.25[c] (19.44)	411.5[d] (20.29)	260[f] (16.16)
H3	172.25[cd] (13.12)	273.5[c] (16.55)	473[b] (21.75)	370.7[e] (19.26)	246[f] (15.69)
H4	169.5[cd] (13.03)	196.75[d] (14.03)	241.5[fg] (15.54)	662.5[b] (25.74)	348.5[d] (18.67)
H5	156.5[d] (12.52)	168[d] (12.99)	273[de] (16.53)	617.75[c] (24.86)	752.5[b] (26.56)
H6	204 (14.29)	347.25[b] (18.64)	258[cf] (16.07)	704 (26.54)	853.25[a] (29.21)
H7	220[b] (14.84)	737.5[a] (27.12)	228.25[g] (15.12)	248.75[f] (15.78)	300.5[e] (17.34)
H8	289.75[a] (17.03)	717.5[a] (26.79)	297[d] (17.24)	401.5[d] (20.04)	362.25[d] (19.04)
CD (0.05)	0.73	1.11	0.66	0.511	0.44

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

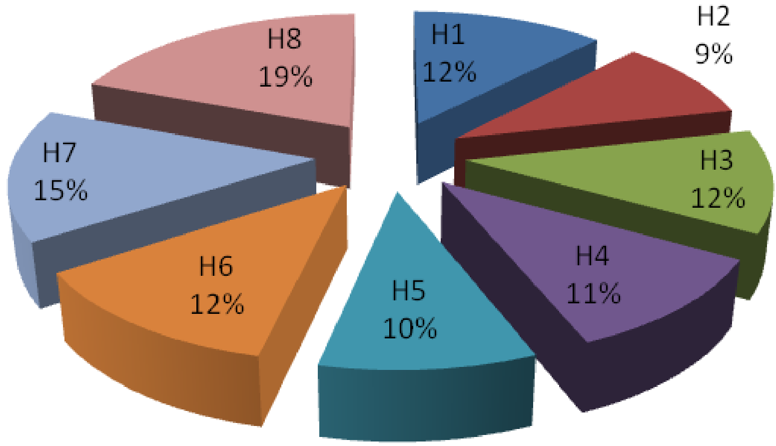


Figure 18 Partitioning of photosynthates in hands when the first leaf (L1) is fed with activity in (*Musa* AB Njalipoovan)

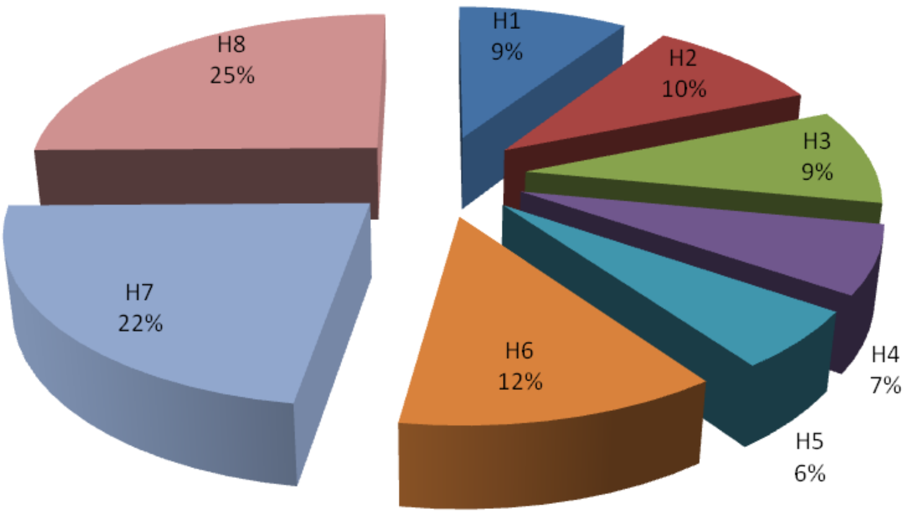


Figure 19 Partitioning of photosynthates in hands when the second leaf (L2) is fed with activity in (*Musa* AB Njalipoovan)

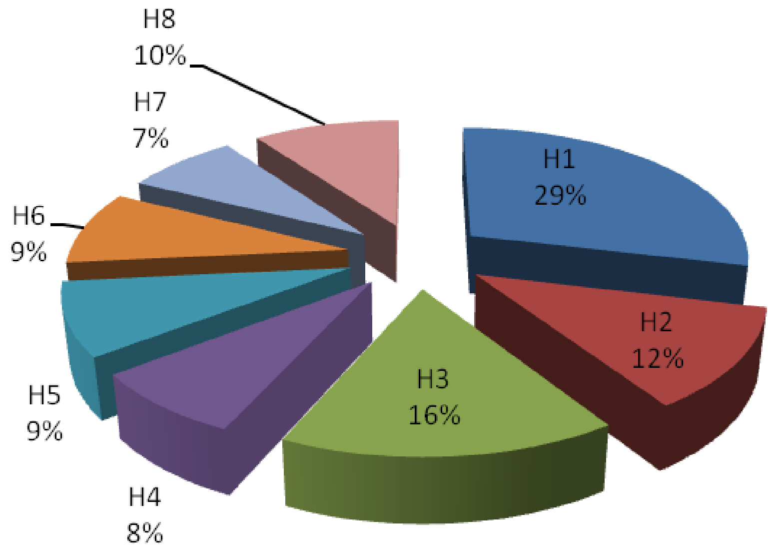


Figure 20. Partitioning of photosynthates in hands when the third leaf (L3) is fed with activity in (*Musa* AB Njalipoovan)

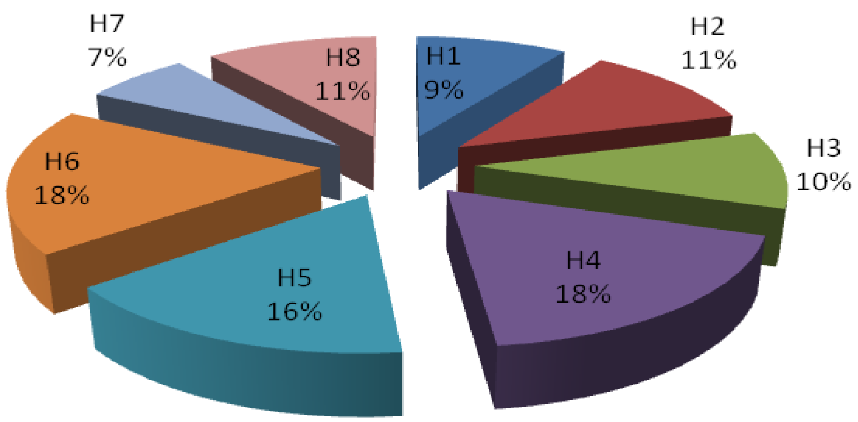


Figure 21. Partitioning of photosynthates in hands when the fourth leaf (L4) is fed with activity in (*Musa* AB Njalipoovan)

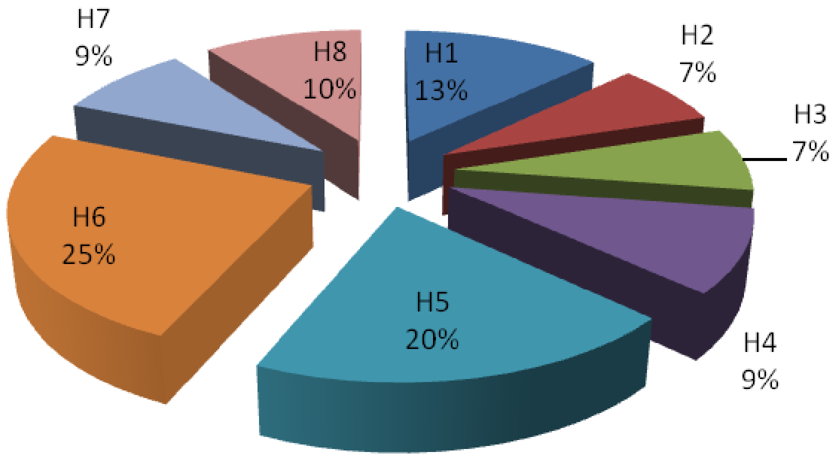


Figure 22. Partitioning of photosynthates in hands when the fifth leaf (L5) is fed with activity in (*Musa* AB Njalipoovan)

When it came to partitioning from the second leaf, maximum recovery was observed in the seventh and the eighth hand which were at par with each other superior over the means recorded in the other hands. The next best was the sixth hand followed by the second hand, the first and the third hand respectively. The fourth and the fifth were at par with each other and recorded lower partitioning.

In the case of partitioning from the third leaf, maximum recovery was observed in the first hand followed by the third and the second hand. Statistical significance was also observed in the means of the above. The next best was the eighth hand which was at par with the fifth hand. Next best partitioning was observed in the fourth and finally the seventh hand which recorded the least.

When the fourth leaf was given the activity, maximum partitioning was observed in the sixth hand followed by the fourth, third, eighth, second, third, first and seventh hands. Significant differences were observed in the gradation except in the two sets of cases (the second and the eighth hands and the third and the first hand) which were at par with each other.

When the fifth was given activity again, maximum partitioning was observed in the sixth hand that was significantly superior over the means of partitioning to all the other hands. This was followed by the fifth, the first, the eighth, the fourth, the seventh, the second and the third. Statistical significance of superiority was observed as in the above order except in the two sets of cases (the eighth and the fifth hand and the third and second hand) which are at par with each other.

A totally different picture emerges at the level regulation. The first leaf presents a situation where the regulation is clearly at the source level. This means that the last fully formed leaf in the life cycle of the plant is endowed with the regulation at its level that makes it capable of distribution at the later stages of the crop cycle when the oldest formed leaves senesce and reach the stage of functional termination or death. The situation is totally different in the case of the second leaf where regulation is seen at the sink level. In both the third and fourth leaf the regulation is observed at the transport level with sizeable recovery observed at the petiole and peduncle level. At the fifth leaf level again a case is observed where regulation is sink dominated.

As the study was undertaken at the half maturity level the bunch is more than half mature or half aged and hence partitioning of synthesised photosynthates to the sink points to the efficiency of carbon partitioning to the economic parts.

4.2.4. Partitioning of photosynthates from source leaves to petioles

A critical analysis of the data presented in (Table 13) reveals that when the case of the first leaf, partitioning to the petiole was maximum in the first petiole followed by the fifth leaf. The difference in the means was also significant. This was followed by the fourth, the fifth, the third, seventh and eighth and the least in the second petiole. However the means of recovery of the seventh and the eighth petiole at par with each other.

When the second leaf was given the activity maximum recovery was observed in the first leaf followed by the fourth, fifth and the sixth which were at par with each other. The next best was in the third, followed by the second, seventh and the least in the eighth.

When the activity was given in third leaf the maximum recovery was observed in the third petiole followed by the sixth, the differences in means were also significant. The next best was second and the fifth which was at par with seventh and first followed by the fourth and the least in the eighth.

When the fourth leaf was given the activity, maximum recovery was observed in the first petiole followed by the fifth petiole and the mean differences were significant. This was followed by the fourth, the eighth, the seventh, the second and the least in the sixth petiole.

Table13. Recovery of radioactivity showing photosynthates (cpm/g of dry tissue sample) accumulated in petiole when different source leaves are fed with labelled carbon dioxide

	Source leaves				
Petiole	(L1)	(L2)	(L3)	(L4)	(L5)
Pet1	245[a] (15.66)	217.5[a] (14.74)	213[bc] (14.61)	2.955[a] (17.2)	282.25[a] (16.81)
Pet2	125.75[f] (11.23)	172.8[cd] (13.12)	206[c] (14.36)	184.25[d] (13.58)	279[b] (16.71)
Pet3	193[de] (13.9)	183.4[bcd] (13.55)	235[a] (15.34)	108.75[f] (10.44)	151.25[de] (12.31)
Pet4	211.5[bc] (14.55)	213.2[ab] (14.61)	184.25[d] (13.59)	202.25[bc] (14.23)	196[c] (14.01)
Pet5	199.25[cd] (14.13)	198.6[abc] (14.09)	201[c] (14.19)	211.25[b] (14.54)	224[b] (14.98)
Pet6	224[b] (14.97)	197.2[abc] (13.99)	213.75[bc] (14.63)	164.25[e] (12.83)	186[c] (13.65)
Pet7	178.25[e] (13.38)	158.8[de] (12.6)	213.75[bc] (14.63)	191[cd] (13.83)	144[e] (12.01)
Pet8	178.25[e] (13.36)	141.2[e] (11.8)	149.5[e] (12.24)	191.5[cd] (13.85)	159.75[d] (12.65)
CD (0.05)	0.51	1.23	0.41	0.52	0.4

in banana (*Musa* AB Njalipoovan)

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

When the activity was given in fifth leaf, the maximum partitioning among the petiole occurred to the first leaf followed by the second which was at par with each other and significantly superior over the means observed in the other petiole. The next best was in the fifth petiole followed by the fourth and the sixth, eighth, third and the least in the seventh. However no significant differences were observed in the means of partitioning observed in the fourth and the sixth leaf.

A general picture that emerged was that except in the case of third leaf, the maximum recovery among the petioles was observed in the first petiole. The next best recovery was in the first, followed by the second and third leaf was observed in the eighth petiole. The fourth and the fifth leaf fed with activity yielded comparatively lower recovery values.

4.2.5. Partitioning from source leaf to different tissues

The data presented in (Table 14) revealed that in the case of leaves maximum recovery was observed when the third and the fourth leaf which was at par with each other and significantly superior over the second leaf. This was followed by the first and the fifth leaf and the differences were also significant.

In the case of hands, maximum recovery was again noted in the fourth leaf followed by the fifth, the second, the third and the first. Significant differences were observed in the means of partitioning to hands except in case of the differences in mean of the second and the third leaf which were at par with each other.

In the case of petioles, maximum recovery was observed in the case of the third leaf followed by the fifth and the first leaf, the fourth and the second leaf which are at par with each other and the fourth and the second which were also again at par with each other.

Table 14. Mean recovery of radioactivity of photosynthates (cpm/g of dry tissue sample) in various tissues when different source fed are with labelled carbon dioxide in banana (*Musa* AB Njalipoovan)

	Source leaves					
Tissue	(L1)	(L2)	(L3)	(L4)	(L5)	CD (0.05)
Leaf	160.84^{c} (12.70)	173.56^{b} (13.19)	241.22^{a} (15.54)	229^{a} (15.14)	141.47d (11.91)	0.26
Hand	193.69^{d} (13.93)	378.38^{c} (19.46)	371.94^{c} (19.29)	471.34^{a} (21.72)	442.12^{b} (21.03)	0.33
Petiole	198.75^{b} (14.12)	176.88^{c} (13.32)	203.13^{a} (14.27)	193.75^{c} (13.940	199.50^{b} (14.14)	
Corm	79^{d} (8.89)	125.25^{b} (11.2)	120.75^{c} (11)	144^{a} (12.01)	85.25^{d} (9.46)	0.66
Peduncle	110^{e} (10.5)	126.5^{d} (11.26)	280^{b} (16.74)	139.75^{c} (11.83)	315.75^{a} (17.78)	0.49
Pseudo stem	186.25^{b} (13.66)	73.25^{d} (8.57)	148.5^{c} (12.2)	185.5^{b} (13.63)	212.5^{a} (14.59)	0.47
Root	171.25^{b} (13.1)	135.5^{d} (11.65)	286.75^{a} (16.94)	112^{e} (10.6)	151.25^{c} (12.31)	0.49

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 15. Percentage recovery of activity showing photosynthates accumulated in various hands when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (Musa AB Njalipoovan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	3.72^{e} (2.05)	4.49^{c} (2.29)	11.43^{a} (3.45)	4.57 (2.25)	6.52^{c} (2.65)
H2	3.11^{d} (1.89)	4.76^{c} (2.29)	5.22^{c} (2.39)	5.32^{d} (2.41)	3.69^{f} (2.04)
H3	3.48^{cd} (1.99)	4.32^{c} (2.19)	6.54^{b} (2.65)	4.79^{e} (2.30)	3.48^{g} (1.99)
H4	3.43^{cd} (1.98)	3.11^{d} (1.89)	3.33^{fg} (1.95)	8.56^{b} (3.01)	4.93^{d} (2.33)
H5	3.17^{d} (1.91)	2.66^{d} (1.77)	3.77^{de} (2.06)	7.98^{c} (2.91)	9.98^{b} (3.23)
H6	4.13^{b} (2.15)	5.49^{b} (2.44)	3.57^{ef} (2.01)	9.10^{a} (3.09)	12.08^{a} (3.54)
H7	4.45^{b} (2.22)	11.65^{a} (3.48)	3.15^{g} (1.91)	3.21^{f} (1.92)	4.25^{e} (2.18)
H8	5.86^{a} (2.52)	11.34^{a} (3.44)	4.10^{d} (2.14)	5.19^{d} (2.38)	5.13^{d} (2.37)
CD (0.05)	0.09	0.138	0.079	0.046	0.046

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

In the case of peduncle, maximum recovery was observed in the fifth leaf followed by the third leaf, the fourth leaf, the second leaf and the least in the first leaf. The mean differences observed were also significant.

In case of pseudostem also maximum partitioning occurred in the case of the fifth leaf followed by the first and the fourth which were at par with each other. The next best was observed in the third leaf and the least in the second leaf.

In the case of roots, the maximum partitioning was observed in the third leaf followed by the first leaf, the fifth, the second and the fourth leaf respectively. The mean differences were also significant.

4.2.6 Percentage photosynthates to various hands when different source leaves are labelled fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AB Njalipoovan)

Percival of the data in (Table 15) on partitioning to various hands revealed that in the case of the first leaf, maximum recovery was observed in the newly formed hands namely the eighth followed by the seventh, the sixth and the means of the hands being at par with each other. This was followed by the first hand, the third hand and the fourth hand, the fifth hand and the least in the second hand.

In the case of the second leaf, maximum partitioning occurred in the seventh hand followed by the eighth hand, which were at par with each other and superior over the means observed in the other hands. The next best was observed in the sixth hand followed by the second hand, the first hand, the third hand, the fourth hand and the least in the fifth hand.

In the case of the third leaf, maximum partitioning occurred in the first hand followed by the third and the second. The differences between means were also significant. The first hand had almost two times more partitioning than the next best third hand. The third inturn revealed almost a quarter times more than the second hand. This was followed by the eighth and the fifth hand, the sixth and the fourth and the least in the seventh hand.

In the case of the fifth leaf, maximum partitioning occurred in the sixth hand followed by the fifth hand, the first hand, the fourth hand, the seventh hand, the second, and the least in the third hand. The differences in the mean were also significant except in the eighth and the fourth hand which were at par with each other.

4.2.7. Percentage Photosynthates to various tissues when different source leaves are labelled fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AB Njalipoovan)

An analysis of the data presented in (Table 16a & 16b) on the per cent accumulation of photosynthates in the source leaf reveal that the maximum accumulation was observed in the case of the first leaf followed by the second leaf, the third, the fourth and the least in the fifth leaf. The differences in the means were also significant except in the case of means of the accumulation of the second and the fourth leaf.

In the case of sink leaves, maximum accumulation was observed in the third leaf fed with activity which was followed by the fourth leaf, the second leaf, the first leaf and the fifth leaf in the order respectively. The gradation in the treatment means also revealed significant statistical difference.

In the case of accumulation to hands, maximum was observed in the case of the fifth leaf followed by the fourth leaf which was also statistically at par with each other. This was followed by the second leaf, the third leaf and the least in the first leaf. The differences were also statistically significant.

In the case of petioles, maximum recovery was observed in the first leaf followed by the fifth, the second and the third which was statistically at par with each other and the least in the fourth leaf fed with the activity.

Table 16(a). Percentage recovery of activity showing photosynthates accumulated in various hands when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AB Njalipoovan)

	Source leaves					
Tissue	(L1)	(L2)	(L3)	(L4)	(L5)	CD
Source Leaf	8.56[a] (3.01)	2.30[b] (1.67)	2.01[c] (1.58)	2.24[b] (1.65)	1.34[d] (1.35)	0.047
Sink leaves	17.49[d] (4.24)	19.64[c] (4.48)	24.68[a] (5.01)	21.44[b] (4.68)	14.67[e] (3.89)	0.095
Hands	31.37[d] (5.64)	47.85[c] (6.95)	41.15[c] (6.45)	48.76[ab] (7.01)	50.10[a] (7.11)	0.106
Petiole	31.50[a] (5.65)	22.91[b] (4.83)	22.43[b] (4.78)	20.02[c] (4.53)	22.97[b] (4.84)	0.116
Pseudo stem	3.76[a] (2.06)	1.15[e] (1.28)	2.05[d] (1.59)	2.39[c] (1.70)	3.00[b] (1.87)	0.04
Peduncle	2.22[c] (1.64)	1.99[d] (1.57)	3.87[b] (2.09)	1.80[d] (1.51)	4.46[a] (2.22)	0.067
Corm	1.59[c] (1.44)	1.97[a] (1.57)	1.66[bc] (1.47)	1.86[ab] (1.53)	1.26[d] (1.32)	0.067
Root	3.46[b] (1.99)	2.13[c] (1.62)	3.96[a] (2.11)	1.44[d] (1.39)	2.13[c] (1.62)	0.04

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 16(b). Percentage recovery of activity showing photosynthates accumulated in various hands when different source leaves are fed with radioactive carbon dioxide on a unit gram dry weight basis in banana (*Musa* AB Njalipoovan)

Treaments	(L1)	(L2)	(L3)	(L4)	(L5)
Source Leaf	8.55[c] (3.00)	5.84[d] (2.51)	9.00[d] (3.08)	9.54[d] (3.16)	4.28[d] (2.18)
Sink leaves	17.49[b] (4.24)	16.10[c] (4.07)	17.69[c] (4.26)	14.14[c] (3.82)	11.74[c] (3.49)
Hands	31.3[a] (5.64)	47.85[a] (6.95)	41.15[a] (6.45)	48.76[a] (7.01)	50.10[a] (7.11)
Petiole	31.50[a] (5.65)	22.91[b] (4.83)	22.43[b] (4.78)	20.02[b] (4.53)	22.97[b] (4.84)
Pseudo stem	3.76[d] (2.06)	1.15[e] (1.57)	2.05[f] (1.59)	2.39[e] (1.70)	3.00[e] (1.87)
Peduncle	2.22[e] (1.64)	1.99[e] (1.57)	3.87[e] (2.09)	1.80[f] (1.51)	4.46[d] (2.22)
Corm	1.59[f] (1.41)	1.97[e] (1.27)	1.66[f] (1.47)	1.86[f] (1.53)	1.26[g] (1.32)
Root	3.46[d] (1.99)	2.13[e] (1.62)	3.96[e] (2.11)	1.44[g] (1.39)	2.13[f] (1.62)
CD(0.05)	0.065	0.103	0.103	0.046	0.065

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

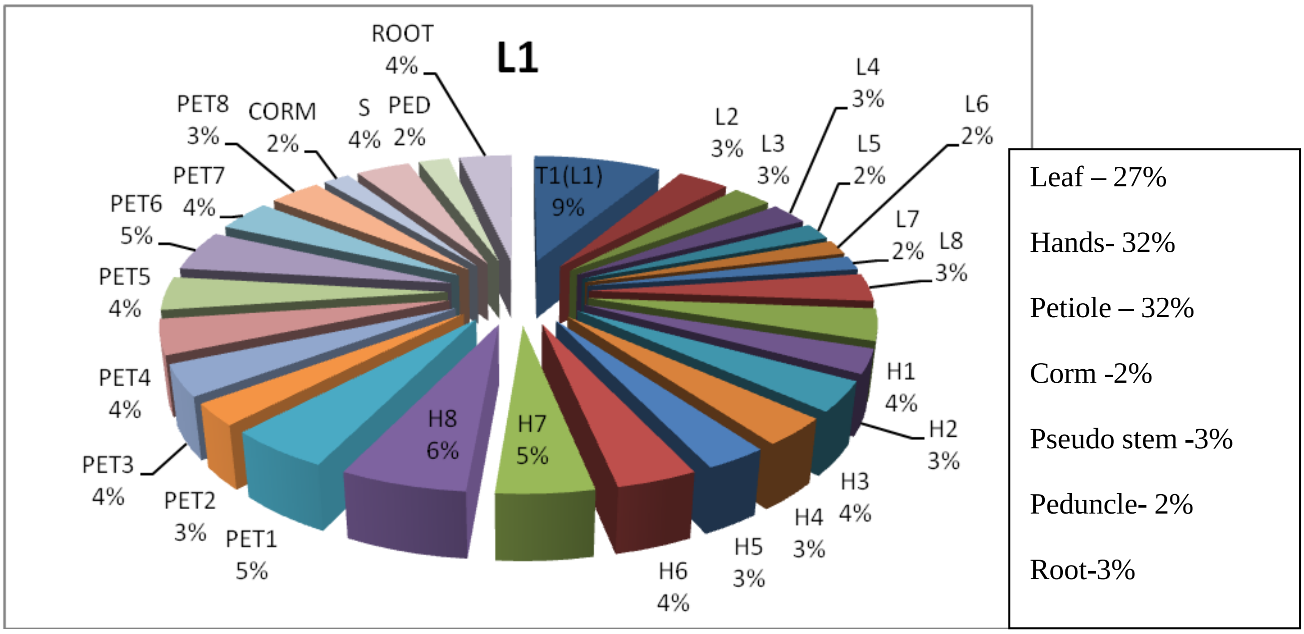


Figure 23 Partitioning of photosynthates among tissues when the first leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AB Njalipoovan)

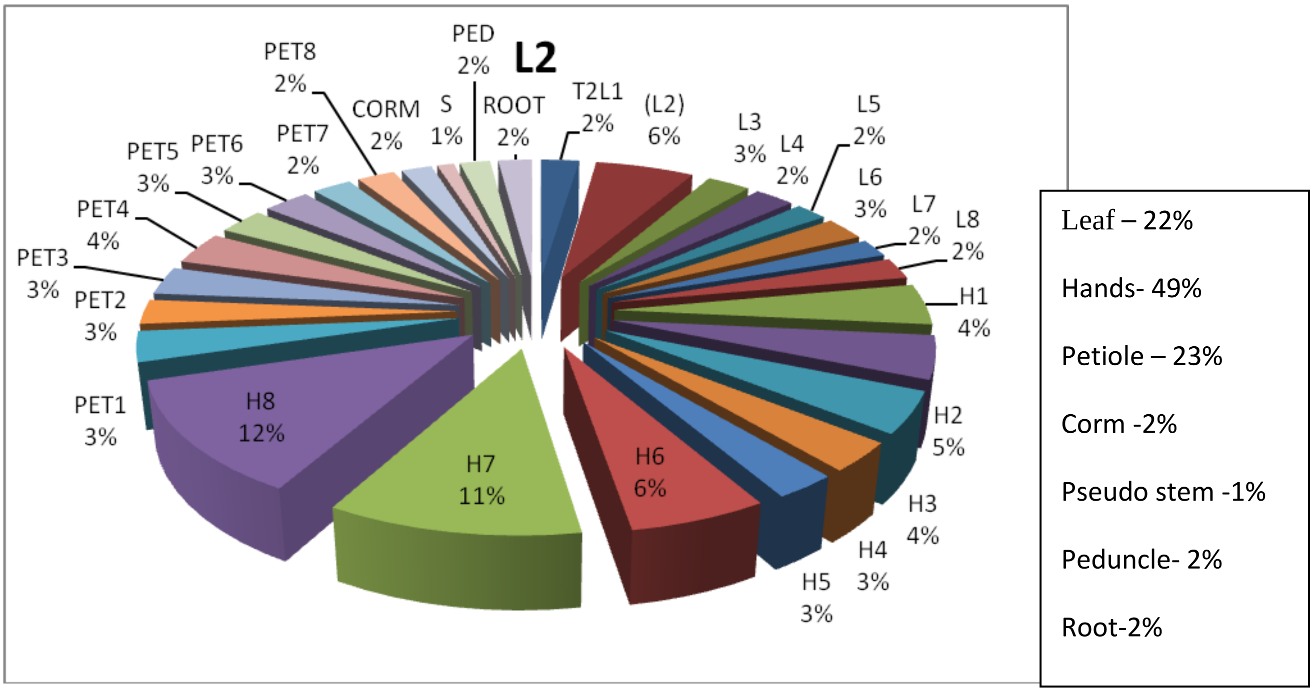


Figure 24 Partitioning of photosynthates among tissues when the second leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AB Njalipoovan)

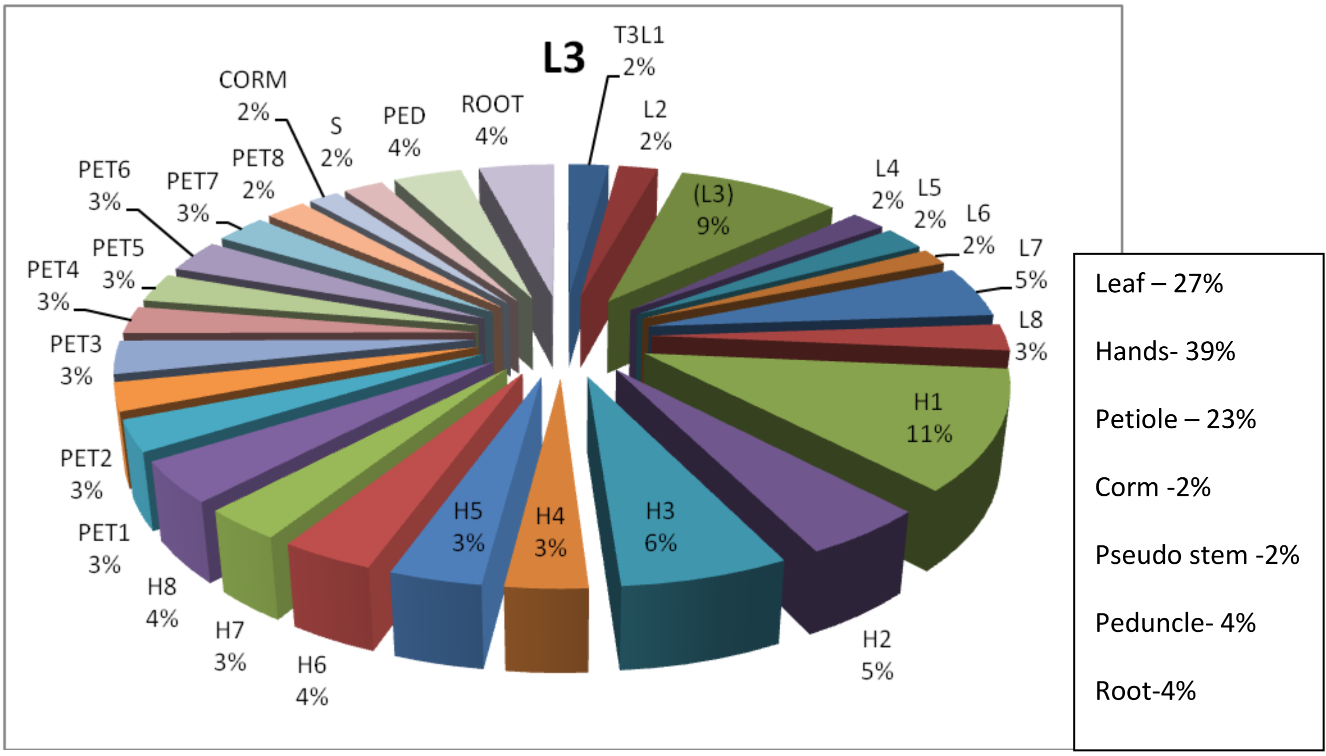


Figure 25 Partitioning of photosynthates among tissues when the third leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AB Njalipoovan)

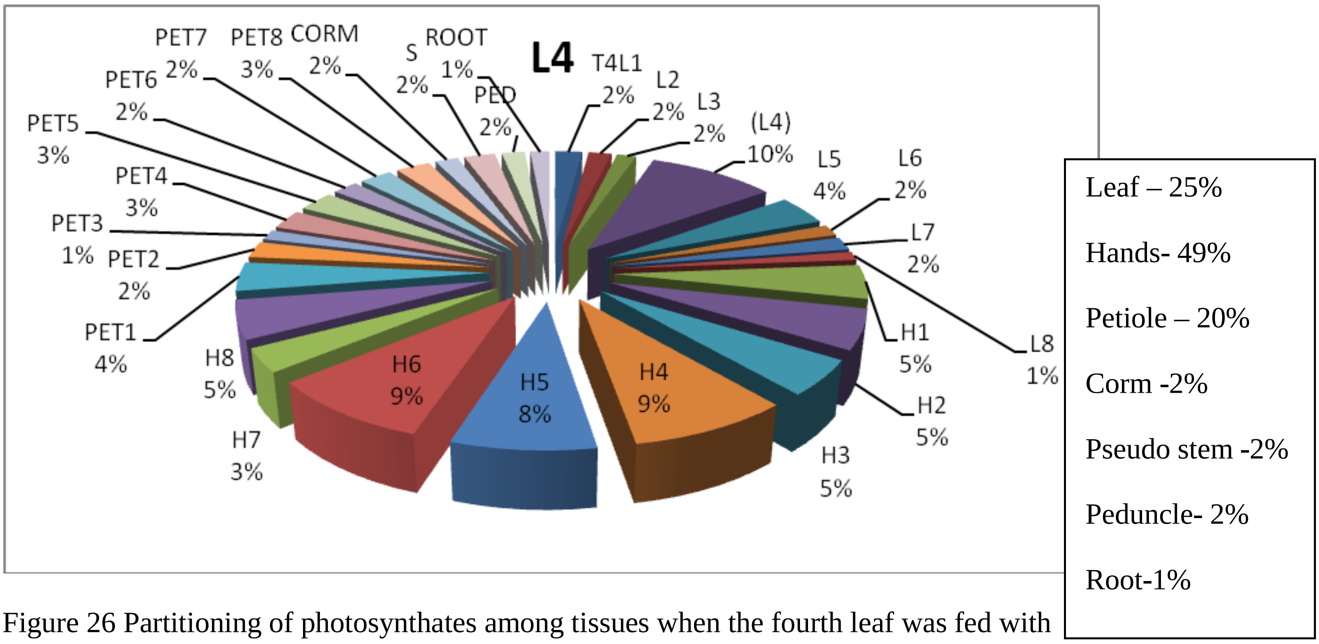


Figure 26 Partitioning of photosynthates among tissues when the fourth leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AB Njalipoovan)

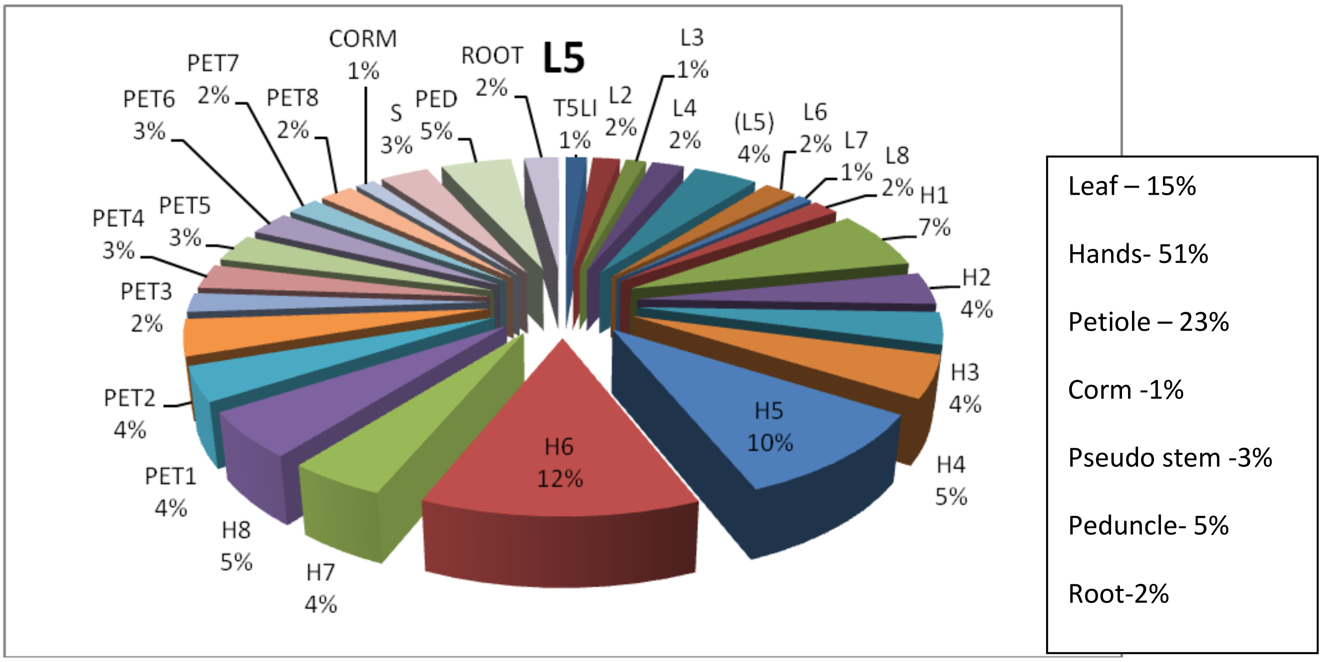


Figure 27 Partitioning of photosynthates among tissues when the fifth leaf was fed with the activity on a unit gram dry weight basis in (*Musa* AB Njalipoovan)

In the case of the pseudostem, maximum per cent partitioning was observed when the first leaf was given the activity followed by the fifth, the fourth, the third and the second respectively. Statistically superiority in the differences among the means was also observed in the order of gradation.

In the case of peduncle, maximum per cent of partitioning was observed in the case of the fifth leaf fed with activity followed by the third, the first, the second and the fourth. Statistical significance in the mean differences was also observed.

With respect to corm, maximum partitioning occurred in the case of the second leaf followed by the fourth leaf which was at par with each other. This was followed by the third and the first leaf which were again at par but significantly superior over the means of accumulation in the fifth leaf.

In the case of roots, maximum accumulation was observed in the third leaf followed by the first leaf, the second leaf, the fifth and fourth leaf. However there was no significant difference between the means in the case of the second and the fifth leaf fed with the activity.

4.2.8. Percentage photosynthates to various hands when different source leaves are labelled fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AB Njalipoovan)

The data presented in the (Table 17) revealed that when the first leaf was given the activity, maximum partitioning occurred in the last newly formed hands which were at par with the first hand and significantly superior as a sink over all other hands. The first hand was statistically par with the other newly formed hand namely the seventh and the sixth hands. This was followed by the fourth, the third, the fifth and the second hand which recorded the least accumulation.

A critical analysis of data on the partitioning when the second leaf was given the activity revealed that maximum partitioning again occurred in the

Table17 Percentage recovery of activity showing photosynthates accumulated in various hands when different source leaves are fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AB Njalipoovan)

	Source leaves				
Hands	(L1)	(L2)	(L3)	(L4)	(L5)
H1	3.39^{ab} (1.97)	5.17^{cd} (2.38)	11.93^{a} (3.52)	4.40^{c} (2.21)	5.71^{c} (2.49)
H2	2.34^{e} (1.68)	5.30^{cd} (2.04)	5.36^{c} (2.42)	4.27^{cd} (2.18)	3.11^{f} (1.90)
H3	2.82^{d} (1.82)	4.68^{d} (2.27)	6.54^{b} (2.65)	4.12^{d} (2.15)	2.86^{g} (1.83)
H4	2.93^{cd} (1.85)	3.28^{c} (1.94)	3.25^{e} (1.93)	7.68^{a} (2.86)	3.95^{d} (2.10)
H5	2.75^{d} (1.80)	2.76^{e} (1.80)	3.61^{d} (2.02)	7.39^{b} (2.86)	7.87^{b} (2.89)
H6	3.25^{bc} (1.93)	5.55^{c} (2.46)	3.33^{de} (1.95)	7.64^{a} (2.85)	9.27^{a} (3.12)
H7	3.23 (1.93)	11.18^{a} (3.41)	2.80^{f} (1.81)	2.45^{f} (1.71)	3.10^{f} (1.89)
H8	3.69 (2.04)	10.16^{b} (3.26)	3.39^{de} (1.97)	3.29^{e} (1.94)	3.48^{e} (1.99)
CD	0.09	0.13	0.065	0.04	0.04

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

last formed hands namely the seventh which recorded the highest and was significantly superior over the eighth which was significantly superior over the next best sixth hand. This was followed by the second, the first, the third, the fourth, and the fifth revealing that the mid hand again accumulated lesser proportion of the photosynthate.

In comparison when the third leaf was given the activity, maximum accumulation occurred in the first formed hands namely the first, the third and the second in each case the significant superiority being very explicit. This was followed by the mid hands namely the fifth, the fourth and the sixth which again was superior over the eighth and the seventh hand.

On the contrary, when the fourth leaf was given the activity maximum partitioning occurred in the fourth and the sixth hand which were at par and significantly superior over the other. This was followed by the fifth hand again being superior over the other two. Thus, revealing that the middle hands partitioned the most proportion of photosynthates among the various hands. This was followed by the first formed hands namely the first, the second, the third whose means were again superior over the newly formed eighth and the seventh hand.

A more or less similar picture as the fourth leaf emerged when the fifth leaf was given the activity, the mid hands namely the sixth and the fifth accounting for the highest proportion of photosynthate assimilate accumulation. The differences in the means of the two were also significant. The third highest was again in the first formed hands followed by the eighth hand, the second hand and the least in the seventh hand which was the most inferior in the case.

4.2.9. Percentage photosynthates to various tissues when different source leaves are labelled fed with radioactive carbon dioxide on a whole plant dry weight basis in banana (*Musa* AB Njalipoovan)

A comparison of the efficiency of different source leaves presented in (Table 18) revealed that the first fully opened leaf was the most efficient in the

Table 18. Percentage recovery of activity showing photosynthates accumulated in various tissues when different source leaves are fed with radioactive carbon dioxide on whole plant dry weight basis in banana (Musa AB Njalipoovan)

	Source leaves					
Tissue	(L1)	(L2)	(L3)	(L4)	(L5)	CD
Source leaf	1.65^{a} (1.46)	0.67^{b} (1.08)	0.45^{c} (1.00)	0.50^{c} (0.97)	0.29^{d} (0.89)	0.02
Sink leaf	4.70^{c} (2.28)	6.89^{a} (2.71)	6.29^{b} (2.60)	6.10^{b} (2.56)	3.56^{d} (1.03)	0.11
Hands	24.43d (4.99)	48.12^{a} (6.97)	40.24^{bc} (6.38)	41.28^{b} (6.46)	39.38^{c} (6.31)	0.106
Petiole	12.07^{a} (3.54)	4.98^{c} (2.32)	4.10^{d} (2.14)	7.79^{b} (2.87)	3.69^{d} (2.04)	0.067
Pseudo stem	43.45^{a} (6.67)	21.27^{d} (4.66)	34.92^{b} (5.95)	29.68^{c} (5.49)	42.03^{a} (6.52)	0.178
Peduncle	1.44^{a} (1.39)	0.71^{e} (1.10)	0.98^{d} (1.21)	1.19^{c} (1.28)	1.24^{b} (1.31)	0.03
Corm	10.99^{c} (3.38)	16.52^{a} (4.12)	11.64^{bc} (3.48)	12.90^{b} (3.66)	8.63^{d} (3.03)	0.202
Root	1.21^{b} (1.31)	0.74^{c} (1.11)	1.33^{a} (1.35)	0.56^{d} (1.03)	0.56^{d} (1.03)	0.02

The values in parenthesis are the square root transformed values of percentage accumulation of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

retention of photosynthates. This was followed by the second, the third, the fourth and the fifth leaf in the order statistical significance in the superiority of the one over the other in the order was also observed.

When the per cent partitioning into the sink leaves was observed, the maximum partitioning was when the second leaf was given the activity. This was followed by the third, the fourth, the first and the fifth in the order. Statistical significance in the superiority of one over the other in the order was also observed. A critical scrutiny revealed a marked reduction of photosynthates both in the source and sink level in the case of the fifth leaf.

In the case of hands, maximum aportitioning into the hands occured in the case of the second leaf which was significantly superior over the fourth leaf. This was followed by the third leaf and was at par with the second and the fifth leaf. The least partitioning occurred in the case of the first leaf.

In the case of the petiole, a trend almost similar to that of the source leaf was observed with the first leaf partitioning more accumulates which was significantly superior over the next best fourth leaf. This was followed by the second, the third and the least in the fifth and the differences were also statistically significant.

In the case of pseudostem, maximum aportitioning of photosynthates was observed to be in the case of the first leaf followed by the fifth leaf which was at par with each other and which was significantly superior over next best third leaf. This was followed by the fifth and the least in the second leaf. The differences in the means were also significant.

In the case of the peduncle, maximum partitioning was observed in the case of the first leaf followed by the fifth leaf, the fourth and the third and second leaf. The differences in the mean were also significant in the above order.

In the case of the corm, the maximum partitioning was observed from the second leaf which was significantly superior over the fourth leaf the next

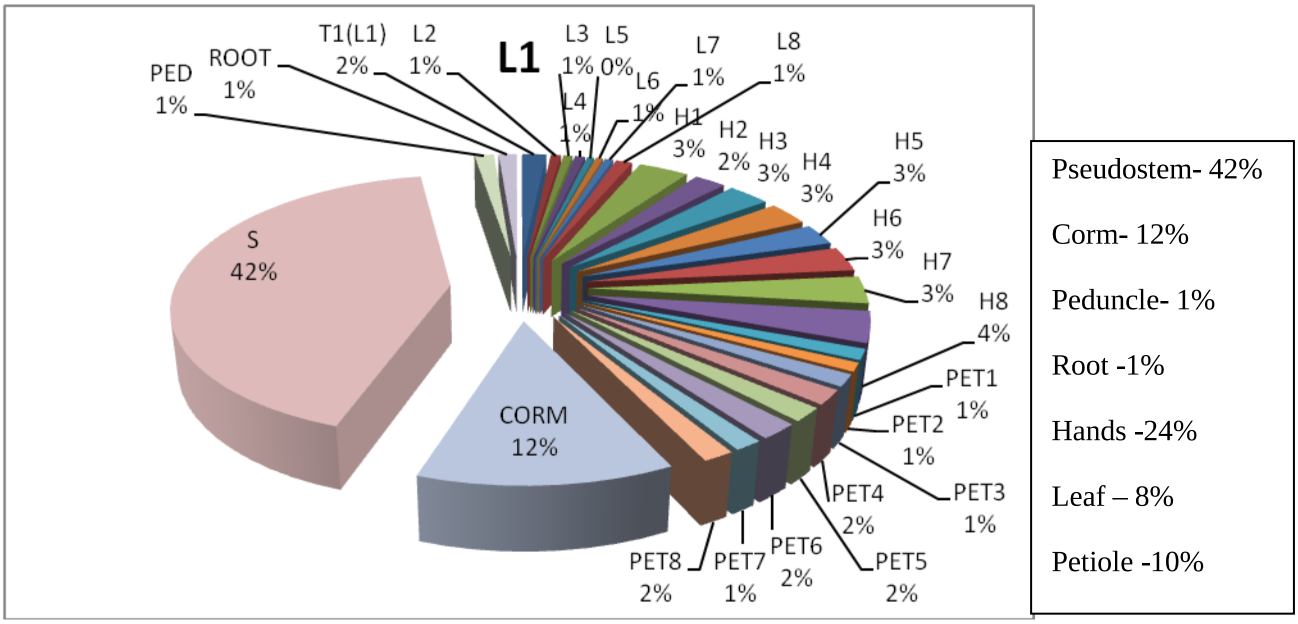


Figure 28 Partitioning of photosynthates among tissues when the first leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AB Njalipoovan)

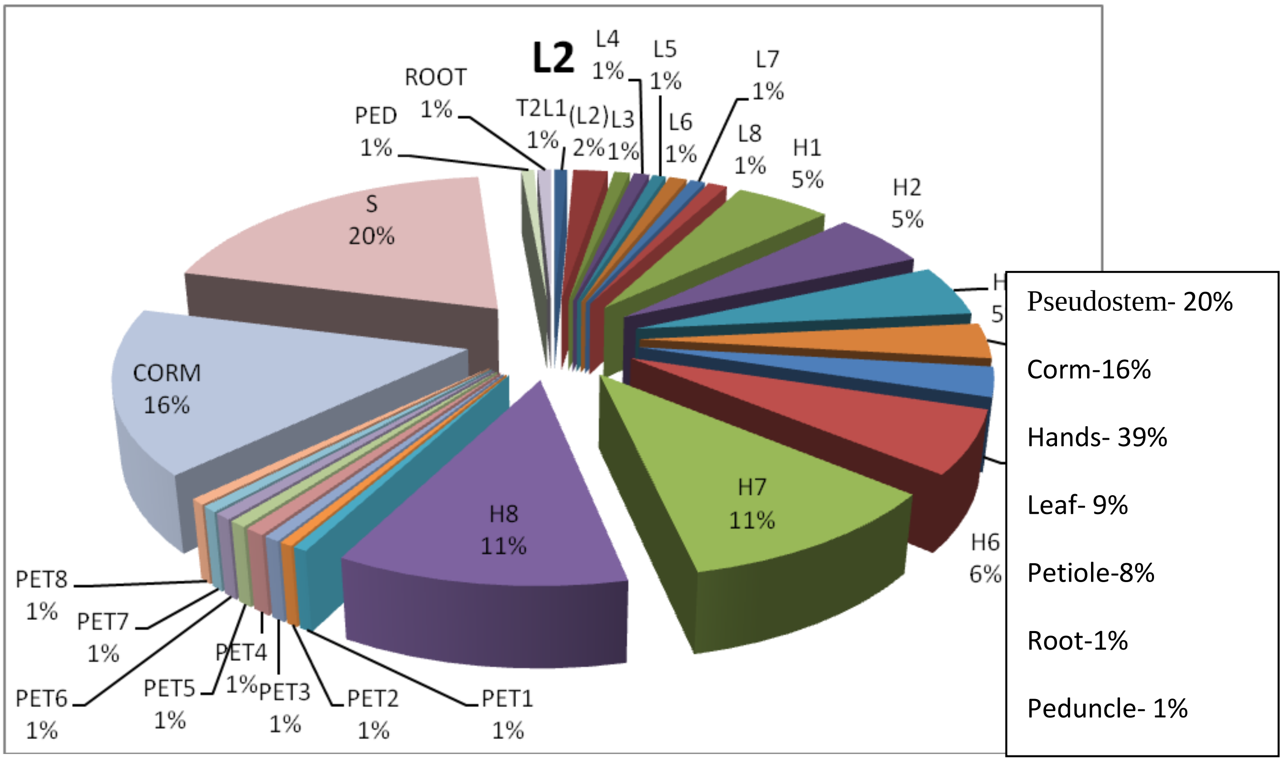


Figure 29 Partitioning of photosynthates among tissues when the second leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AB Njalipoovan)

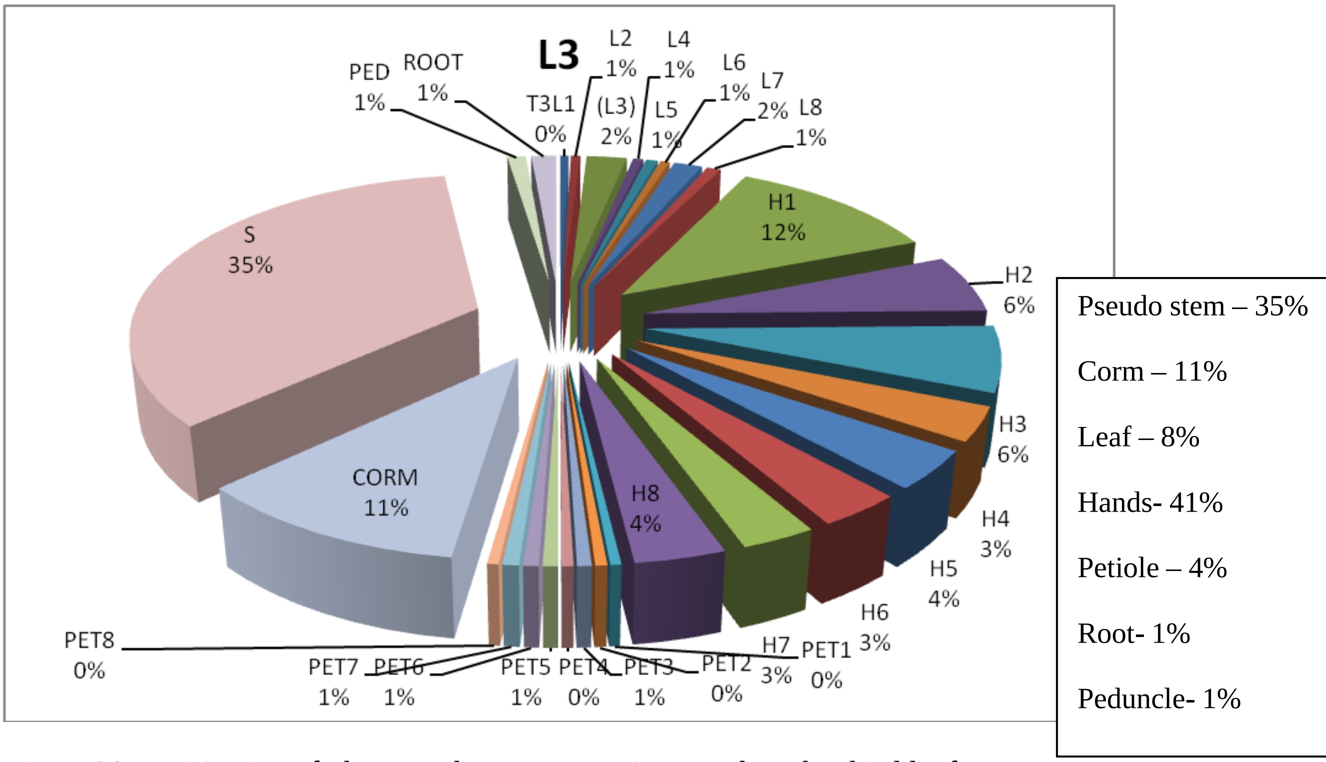


Figure 30 Partitioning of photosynthates among tissues when the third leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AB Njalipoovan)

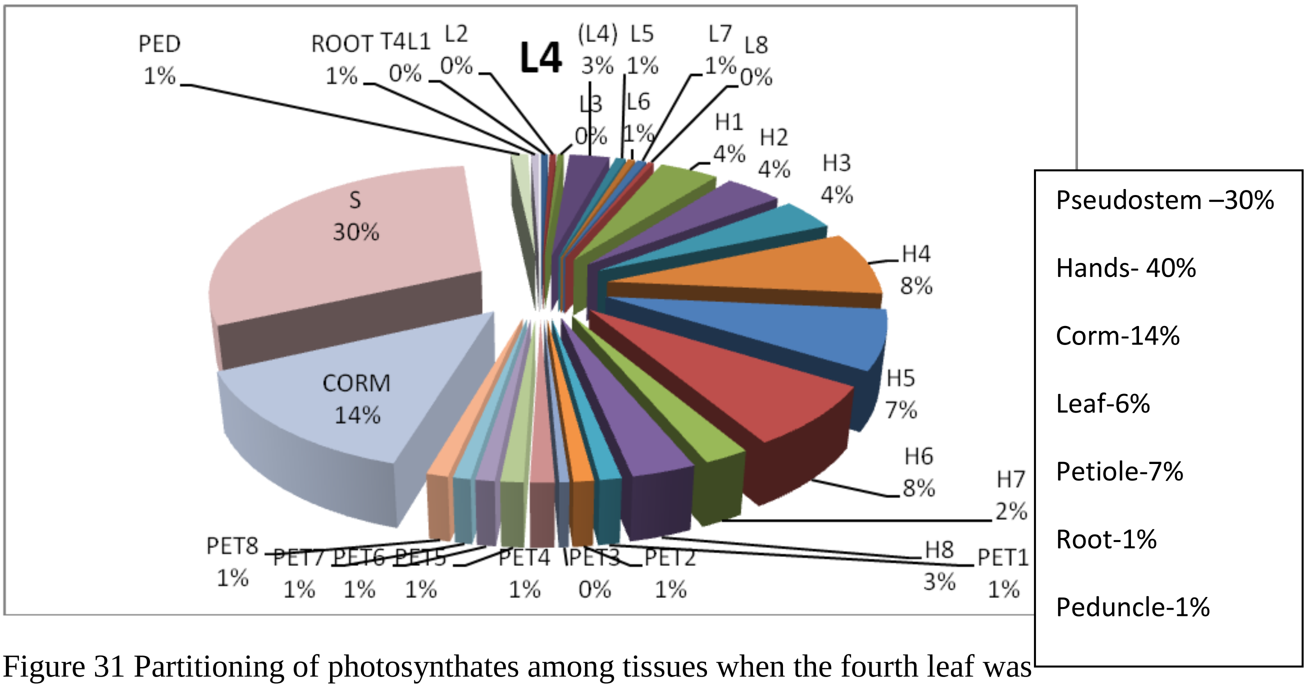


Figure 31 Partitioning of photosynthates among tissues when the fourth leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AB Njalipoovan)

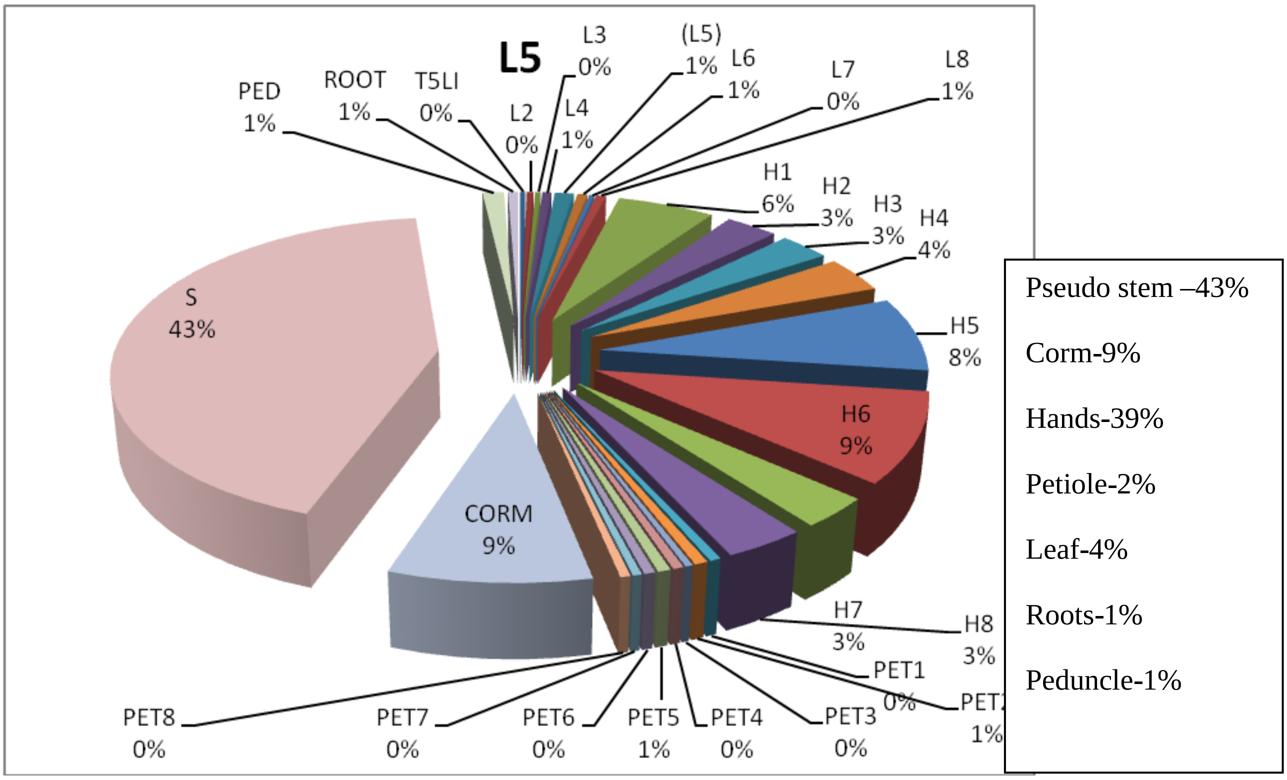


Figure 32 Partitioning of photosynthates among tissues when the fifth leaf was fed with the activity on a whole plant dry weight basis in (*Musa* AB Njalipoovan)

best. However, the fourth leaf was at par with the third leaf which was followed by the first and the fifth leaf.

In the case of the roots, maximum partitioning occurred in the case of the third leaf followed by the first leaf. This was followed, the fourth and the fifth leaf fed with activity. A close look revealed that the younger leaves partitioned more into the older leaves which showed a marked reduction of nearly fifty percent.

4.2.10. Comparative efficiency of individual leaves in Palayankodan and Njalipoovan

The data on total production of photosynthate are presented in (Table19). Perusal of the data revealed that in Palayankodan among the leaves, the first leaf was the most efficient taking into consideration the total photosynthates retained in the leaves plus the total of the translocation to other parts of the plant. The order of efficiency is the fourth followed by the second, third and fifth. The superiority in the differences in the mean was also statistically significant.

In Njalipoovan the fourth leaf was the most efficient followed by the third, the fifth, second and first with difference in the respective mean also being significant.

4.2.11. Comparative efficiency of individual leaves of Palayankodan and Njalipoovan

The efficiency of individual leaves is presented in (Table 20) which reveals the significant differences in the mean values. In the case of the first leaf, Palayankodan was more efficient in production of photosynthates compared to Njalipoovan, whereas in all other cases *i.e.* from the second to fifth leaf the photosynthesizing efficiency of Njalipoovan was significantly superior over Palayankodan.

Table 19 Compararitive efficiency of different leaves in Palayankodan and Njalipoovan in photosynthetic production (cpm/g of dry weight of tissue sample)

Treatments	Palayankodan	Njalipoovan
(L1)	7141[a] (84.5)	4338.2[e] (70.27)
(L2)	4784[c] (69.16)	6325.2[d] (79.53)
(L3)	4564.2[d] (67.56)	7363[b] (85.8)
(L4)	5433.5[b] (73.71)	7732.8[a] (87.93)
(L5)	4224[e] (64.99)	7059.8[c] (84.02)
CD (0.05)	0.33	0.88

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

Table 20 Comparative photosynthetic efficiency of individual leaves as evident by total photosynthesis (production and translocation) in (cpm/g of dry tissue sample)

Treatments	Palayankodan	Njalipoovan	T value
(L1)	7141 (84.50)	4938.25 (70.27)	27.66
(L2)	4784 (69.13)	6325.25 (79.53)	-25.14
(L3)	45.64 (67.56)	7363 (85.8)	-40.34
(L4)	5433.50 (73.71)	7732.75 (87.93	-66.13
(L5)	4224 (64.99)	7059.75 (84.02)	-41.45

The values in parenthesis are the square root transformed values of cpm/g of the dry tissue sample.

Different alphabets as superscripts show statistical significance at 5%

4.3. EFFECTS OF BUNCH TRIMMING ON YIELD AND FINGER CHARACTERS

The results of the study on ‘effects of bunch trimming on yield and finger characters’ were done in Palayankodan and Njalipoovan from July 2010 to January 2011 at RARS research farm Kumarakom are summarised under the broad sub heading.

4.3.1. PALAYANKODAN

4.3.1.1. Bunch yield

The results of the study on bunch trimming on yield is presented in (Table 21) revealed that in case of Palayankodan a nine hand system was the best as far as yield was concerned followed by ten hand and eight hand system. The next best was observed in the treatment of the male bud pruning followed by seven hand, then six hand and the least yield was observed in the control. The decreasing order of the yield was as follows.

Nine hand> Ten hand> Eight hand> Male bud pruned >seven hand> six hand> control

This shows that the removal of the male bud itself helped increasing the yield, as the male bud itself acts as a sink and competes with the fingers for photoassimilates.

4.3.1.2. Hand Weight

In case of hand weights the data presented in (Table 21) reveal that the maximum weight was obtained by the hands in the six hand system followed by the seven and eight. A similar trend was observed the case of finger size which increased with the intensity of pruning and the least finger size was observed in no pruning hands. The decreasing order of the hand weight observed was as follows

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control

Table 21 Yield and finger characters in banana (*Musa* AAB Palayankodan) as influenced by different pruning regimes

Treatments	Bunch yield (g)	Hand weight (g)	Finger Characters		
			weight (g)	length (g)	girth (g)
T1	9150^{f}	1197.80^{a}	88.75^{a}	17.65^{a}	12.30^{a}
T2	9977.50^{e}	1170.20^{b}	86.75^{b}	17.37^{b}	12.00^{b}
T3	11225^{c}	1092.50^{c}	81^{c}	17.05^{d}	11.82^{c}
T4	11752^{a}	1016.20^{d}	75.25^{d}	16.60^{e}	11.52^{d}
T5	11528^{b}	961.50^{d}	71.25^{e}	17.35^{c}	11.40^{e}
T6	11045^{d}	904.75^{f}	67^{f}	15.60^{f}	10.97^{f}
T7	8970^{g}	829.75^{g}	61.50^{g}	14.77^{g}	10.62^{g}
CD(0.05)	881.82	64.98	3.76	1.82	0.59
SE(m)	5253640.47	74791.34	411.64	4.52	1.36

CD – Critical difference

SE(m) – Sum error means

Degrees of freedom - 27

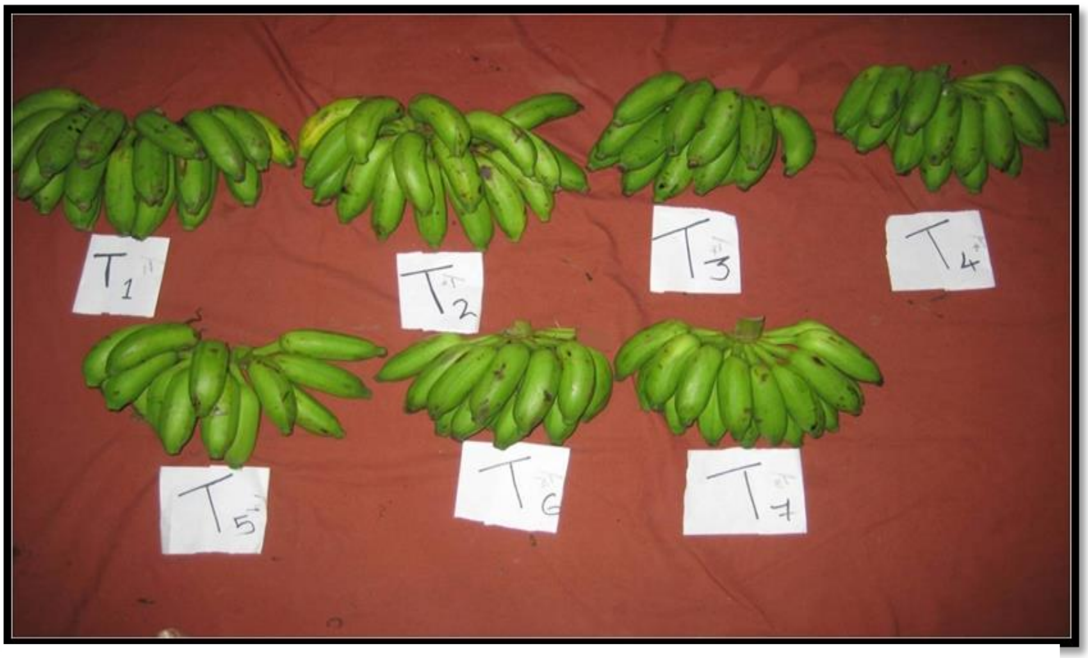


Plate 10 . Comparative effects of bunch trimming on ‘D’ hand size in banana (*Musa* AAB Palayankodan)

Plate 11 . Comparative effects of bunch trimming on ‘D’ finger size in banana (*Musa* AAB Palayankodan)

4.3.1.3. Finger Weight

The maximum pruning regimes of six hand yielded the best finger and gradual decrease in the finger weight was observed with increase in retention of hands. The decreasing order of finger weight is shown as follows.

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control

4.3.1.4. Finger length

Finger length was best in the case of maximum pruning regimes of six hand with gradual decrease with increase in retention of hands. The fingers of the six hand system showed the maximum length which is desirable character for export. The gradation in decreasing order of finger length is as follows

Six hand> Seven hand >Ten Hand> Eight Hand> Nine Hand> Male bud pruned> Control

4.3.1.5. Finger Girth

The maximum pruning regimes with the retention of six hand system gave the best girth and a gradual decrease in girth was observed with increase in retention of hands. The gradation of the finger girth was as follows

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control

4.4. NJALIPOOVAN

The effect of the pruning regimes on yield and finger characters are presented in the table 22

4.4.1. Bunch Yield

The results of the study reveal that the yield was best in the ten hand retention system followed by nine hand and eight hand system. This was

Table 22. Yield and finger characters in banana (*Musa* AB Njalipoovan) as influenced by different pruning regimes

Treatments	Bunch yield (g)	Hand weight (g)	Finger Characters		
			weight (g)	length (cm)	girth (cm)
T1	8050.50^{g}	1004.50^{a}	71.75^{a}	13.80^{a}	10.92^{A}
T2	8542.50^{e}	980^{b}	70^{b}	13.72^{b}	10.77^{b}
T3	9057.50^{d}	938^{c}	67^{c}	13.75^{c}	10.60^{c}
T4	9655^{c}	899^{d}	64.25^{d}	13.45^{d}	10.42^{d}
T5	10152^{a}	882^{e}	63^{e}	13.37^{e}	10.30^{e}
T6	9662.50^{b}	840^{f}	60^{f}	12.85^{f}	10.02^{f}
T7	8510^{f}	757^{g}	53.50^{g}	12.15^{g}	9.47^{g}
CD	535.50	38	3.05	1.33	0.30
SE(m)	2329106.81	28758.23	154.70	1.45	0.96

CD –critical difference

SE(m) – Sum error means

Degrees of freedom - 27

Plate 12 . Comparative effects of bunch trimming on 'D' hand size in banana (*Musa* AB Njalipoovan)

Plate 13 . Comparative effects of bunch trimming on 'D' finger size in banana (*Musa* AB Njalipoovan)

followed by the male bud pruning alone followed by seven and then six hand. The least yield was recorded in the control. The decreasing order of the yield is given as follows

Ten hand> Nine hand> Eight hand> Male bud pruned >control>seven hand> six hand>

4.4.2. Hand Weight

In case of hand weights, the results presented in the (Table22) revealed the overwhelming superiority in the six hand system followed by the seven and eight hand system. In general a decreasing order of the hand weight is observed with increase in number of hand retention. The gradation is as follows

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control

4.4.3. Finger Weight

Finger weight was best in the maximum pruning regime of retention of six hands. The decreasing order of finger weight obtained was as follows.

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control

4.4.4. Finger length

The maximum pruning regimes with the retention of six hands yielded fingers of highest length and this was significantly superior over the other treatments. A gradual decrease was observed with increase in retention of hands. The decreasing order of finger length observed was as follows

Six hand> Eight hand >Seven Hand> Nine Hand> Ten Hand> Male bud pruned> Control

4.4.5. Finger Girth

Finger girth was the best at the level of highest pruning intensity with retention of six hands. A gradual decrease in finger girth was observed with increase in retention of hands. The decreasing order of finger length observed was as follows

Six hand> Seven hand >Eight Hand> Nine Hand> Ten Hand> Male bud pruned> Control.

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DISCUSSION

5. DISCUSSION

The accumulation in source leaves or in other words the leaves fed with the activity revealed the accumulation and retention of photosynthates in Njalipoovan whereas a clear of translocation of photosynthates from most efficient first leaf to various other parts in the case of Palayankodan. The study revealed that maximum accumulation in Palayankodan occurred in the third leaf and the fourth leaf in the case of Njalipoovan. On the other hand this points to the functional efficiency on the more important side a relative picture of accumulation *vs.* translocation *vs.* utilization. The study undertaken where on the recovery on the fifteenth day of application and this roughly corresponds to two months after bunch emergence or a stage after mid stage development of fingers and about one month before harvest.

The higher rates of accumulation can be argued from more than one angle. Firstly it's an accepted phenomenon that by the stage of harvest in Palayankodan the normal retention of functional leaves are in the range of three, four and rarely five leaves whereas in the case of Njalipoovan it is in between six to eight leaves. The corresponding figure at the stage of sampling where six in the case of Palayankodan and eight in the case of Njalipoovan justifying the fact that in both cases the mid leaves showed maximum accumulation of photosynthates. Another worthy point in this direction is that in both cases there is a gradual build up in the accumulation up to the mid leaf and thereafter a reduction. This reveals another important aspect that as the leaves mature the functional efficiency reached its peak and thereafter showed a reduction as it set on the march to senescence. A third possible reason is the distinct orientation of the respective leaves. The retention of only five leaves in Palayankodan made it in such a way that all leaves could capture light whereas in Njalipoovan the more number of leaves on the crown made the mid leaves oriented in such way that they almost get inclined so that is due to its specific orientation such that it can capture maximum sunlight (Ekanayake *et al*1994) Aestivation of leaves also permit maximum capture of sunlight as there is practically no overlapping. The mid leaves should also have reached a stage of defined maturity in not only absorbing maximum sunlight but in its proven efficiency of photosynthetic production and translocation as mentioned but the case of source leaf of regulation of Carbon transport in third leaf of Palayankodan and more production and translocation observed in the fourth leaf of Njalipoovan . The decline in photosynthetic accumulation beyond the mid leaves clearly reveal that the effect of age and the ontogenic switch over to senescence was also another reason where in Palayankodan it is 2/1 and in Njalipoovan 3/1 which when coupled with the number of leaves retained presents the case.

Some of the reasons for the better efficiency of the mature leaves and the relative less efficiency of the old leaves points to the basic effects of ageing and senescence. Most of the evidences for such change have their basis on

1. The biosynthetic side of protein turnover in relation to leaf senescence are from the studies of photosynthetic apparatus.

2. Loss of capacity for chloroplast protein synthesis in course of leaf senescence (Callow *et al.,* 1972) declining chloroplast protein synthesis with the loss of polysomes and cessation of chloroplast synthesis in the chloroplast being traced to disappearance of RNA polymerase activity (Ness and Woolhouse, 1980a; 1980b).

There is another school of thought which argues that the rate of respiration actually increases with yellowing and senescence (Arney, 1947; Hardwick *et al.,* 1968) and this is supported by works of Butler and Simon (1972) as they are based on electron microscopic studies confirmed that mitochondria of yellowing leaves retain their structural integrity even at an advanced stage of senescence when chloroplast showed complete degradation and rate of photosynthesis decline. The decline photosynthesis of the fifth leaf should necessarily be due to this reason as there is reasonable amount of photosynthetic production even if yellowing had slowly started.

Again it is rational to hypothesise that the mitochondrial activity in senescence leaves has to fuel vein loading and the break down products are remobilised and also the synthesis of lipids, amides (Yemm, 1950) and specific enzymes (Farkas and Stahmana, 1966; Sacher and Danies, 1974). It is also reported that the shut down of organelles take place at different times (Wool house and Jerkins, 1987). However there are substantial references to confirm that though there is decrease in protein content with senescence there is nonetheless an active synthesis of proteins on 80S cytoplasmic ribosomes throughout the period (Callow and Woolhouse, 1973). This explains the reasons that even though there is reduction in total photosynthate production in the fifth leaf there is still comparatively fair amount of photosynthate production and translocation to other tissues.

5.1. Partitioning from source leaves to sink leaves

A critical analysis of the results in both Palayankodan and Njalipoovan points more or less points to an identical trend. In both cases when the first and the second were given the activity maximum partitioning among leaves occurred to the immediately lower leaves. A similar case was observed in the case of the fifth leaf in Palayankodan and fourth and fifth leaf in Njalipoovan. However, in the case of the fourth leaf in Palayankodan the immediately lower leaves recorded only the second highest accumulation in the immediately lower leaf. In both cases in the fifth leaf there was variation in the case of Palayankodan it was in the immediately upper leaf whereas in Njalipoovan it was in the lowest seventh leaf. Evaluation of the trend further reveals that the proximity of the source leaves to the individual leaf caused higher accumulation in the fifth leaf. Marcelis (1972) in his classical work had reported that if sink is situated closer to source cells, the sink can accumulate and it gets enough quantity of assimilates whenever needed and it is due to the close vascular connection between the source and the sink. The results of the study also points to this direction.

Overall picture is the same irrespective of the clones. Further introspection reveals that by this apportioning a more or less equitable distribution of photosynthates from the experimental leaves to the others occurred, justifying that there was a reasonable accumulation towards the structural make up of the photosynthetic apparatus of the plant. This also made it certain that another older leaf was nourished in such a way that it was reasonably strengthened in structure to act as a more efficient photosynthetic apparatus for further photosynthate production on its own.

5.2. Partitioning from source leaves to various hands

The crux of the study and the area of practical relevance is on this particular aspect. Critical examination reveals that the first leaf invariably contribute to the maximum accumulation of photosynthates in the last formed seventh and the eighth hand. In the case of the second leaf there was a distinct variation in Palayankodan its contribution was more towards mid hands namely the fifth and the fourth whereas in Njalipoovan it continued to maximum nourish the last formed seventh, the eighth and the sixth hands. In the case of the third leaf the continuation of maximum mean accumulation in the mid hand occured but with a change in the prioritisation of the accumulation in the third hand followed by the fifth and the fourth hands occurred. This change in prioritisation is also evident where it came to the fourth leaf, where the first, the fifth and the third hand recorded maximum accumulation. When it came to the fifth leaf the change in prioritisation of accumulation occurred to the first formed hand in the order the third, the first and the second. Contrary to this in the case of Njalipoovan the third leaf showed maximum accumulation in the first formed hands. When it came to the fourth and fifth leaf maximum accumulation were observed in the mid hands namely the sixth, the fourth and the fifth in the case of the fourth leaf and sixth in and fifth in the case of the fifth leaf.

It should be inferred that the first and the second leaf contribute to the development of the last four hands in Njalipoovan whereas in Palayankodan the first leaf only contribute to the last formed hands. The overall more production and translocation of photosynthates from the most efficient first leaf of Palayankodan thus justifies a synchronised translocation where the last formed hands are getting nourished by the younger leaf which normally retains its capacity even at the first stages of harvest. This should be the reason as to why in the eighth hand system there is sufficient development of the last formed hands.

The second and third in Njalipoovan and the fifth leaf in Palayankodan was seen mostly contributing to the first formed hands. Whereas the fourth and the fifth in Njalipoovan and third and the fourth in Palayankodan leaves partitioned more to the mid hands and hence resulted more accumulation in the above hand. Thus we arrive a definite picture of in partitioning. Almost all hands are being nourished by one or the other leaf in such way that there is a fair distribution of photosynthates from different leaves to the various hands in such a way.

Average recovery hand wise revealed that in Palayankodan the maximum recovery was in the eighth hand the last formed hand whereas in Njalipoovan the highest recovery was seen in the sixth hand followed by the eighth hand. This again reveals that the first formed hands have already reached a fair size and stage of development hence there was more partitioning into the underdeveloped new hands. It can also be explained in terms of cell division and cell elongation of individual fingers. In the development physiology of a finger the early stages are in active cell dividing phase wherein the development of fingers tend to remain curved followed by a cell expansion stage wherein the fingers tend to become straight and towards the last stages of maturity is the peak stage of starch filling where pulp take place. The first formed hands would have already reached an advance stage of cell expansion and an early filling phase whereas the last formed hands would have been in the interphase of cell division ad cell expansion, thereby siphoning more photoassimilates the mid hand were in a stage on between the two and hence showed lesser recovery of photosynthates than the last formed hands.

5.3. Recovery of mean radioactivity in various other parts or tissues

In the case of mean accumulation in the leaves the maximum accumulation and retention was observed when the third leaf was given the activity in case of Palayankodan and the fourth and the third leaf in the case of Njalipoovan revealing that the overall efficiency of the respective leaf in retaining and in accumulating more photosynthates.

Irrespective of the number of the leaf given activity in all case the mean recovery was highest in hand showing that it was potentially and practically the best and the most efficient sink. A comparison with respect to the leaf fed with the activity revealed that the mean recovery was highest in the first leaf in Palayankodan and fourth and fifth in Njalipoovan. However when put on a per cent unit gram basis the order in Njalipoovan was the fifth leaf followed by the fourth leaf.

In case of petioles it was more of a reflection of the accumulation observed in the respective leaves. In Palayankodan among the leaves the third leaf accumulated maximum was in the case with respect to petiole. However there was a shift in Njalipoovan. Both of these cases can only be explained in terms of translocation from leaf to the other tissues via the petiole and in Njalipoovan as the subtending leaves were more the rate of movement should be deemed to have been faster.

In case of the peduncle in both the clones the oldest fifth followed by the third recorded maximum mean recovery. This can be explained only with respect to translocation , the oldest leaf mobilising more to the hands as its own requirement began to diminish with age Another theory that can be advanced in this direction is that remobilisation of existing reserves also take place to hands gradually. The third leaf being in its correct stage of maturity produced more photosynthates but translocation to fruit is comparatively low but it has to be inferred that it has reached up to the peduncle and is on its way to the bunch or in the translocation pathway to the hands.

The translocation into the pseudostem is a need based requirement to perform the complimentary function of support and sustain the bunch (Kurien *et al 2000)*. This should be more seen as a structural support system holding the bunch in position.

In case of roots maximum accumulation is observed in case of third leaf. It should be configuring that the last flushes of roots are at this stage as reported by Kurien, 2004 and must have been sustained by mature third leaf and the younger leaves. Again the older leaves seen to nourish the roots most. In Palayankodan the older is the fourth, the third and the fifth whereas in Njalipoovan it is the fifth and the third again revealing that translocation of older leaves occur maximum to the furthest end of plant part. This should be seen as an internal arrangement made by the plant itself as all the reserves in the older leaves are remobilised to other part before functional termination or death.

In case of hands,leaves and petiole the mean cpm/g of tissue was taken so that it is on unit gram basis and represent the mean. The general trend in Palayankodan with mobilisation of photosynthates on the basis of mean recovery of activity per gram of tissue from each leaf followed a trend as follows

(L1) – Hand>Peduncle>Pseudostem>Root>Petiole>Leaves>corm

(L2) – Hand>Leaves>Corm> Petiole>Root>Pseudostem> Peduncle

(L3) – Peduncle and Roots > Hands> Leaves> Corm> Petiole> Pseudostem

(L4) – Hands> Pseudostem> Corm> Peduncle> Leaves> Petiole> Root

(L5) – Peduncle> Hands> Root> Petiole> Corm> Pseudostem> Leaves

The general trend in Njalipoovan with mobilisation of photosynthates on the basis of mean recovery of activity per gram of tissue from each leaf followed a trend as follows

(L1) – Petiole>Hands> Pseudostem> Root> Leaves >Peduncle >corm

(L2) – Hand>Petiole>Leaf> Root>Peduncle> Corm>Pseudostem

(L3) – Hands>Root>Peduncle> Leaves> Petiole> Pseudostem> Corm

(L4) – Hand>Leaves>Petiole>pseudostem> Peduncle> Leaves> Corm> Root

(L5) – Hands> Peduncle>Pseudostem> Petiole>Root> Leaves>Corm

In both the above cases we can average out that the hands are potentially the most efficient sinks.

5.4. Percentage partitioning on a unit dry weight basis

The present partitioning on a unit dry weight basis gave abetter picture as it reflected the of per cent activity of accumulation in various parts where each leaf was given the activity.

Thus in Palayankodan the nature was

(L1) – Hand>Petiole>Sink leaves> Source leaf>Pseudostem> Root>Peduncle> Corm

(L2) – Hand>Petiole>Sink leaves> Root>Corm>Peduncle> Pseudostem> Source leaf

(L3) – Hand>Petiole>Sink leaves> Source leaf> Root>Peduncle> Corm>pseudostem

(L4) – Hand>Petiole>Sink leaves> Pseudostem> Corm>Root>Source leaf>Peduncle

(L5) - Hand>Petiole>Sink leaves> Peduncle>Root> Corm>Pseudostem>Source leaf

The most important aspect emanating from the above reveal that hand is the most important sink. Apart from that in case of all leaves the hand followed by the petiole and thereby sink leaves, with added sink activity of the first two being in the range of 78.32,70.17,61.32,67.87,66.25,and the tree together in the close range of 84.87,85.94,75.29,77.74 and 80.89 respectively. This throws light on two important aspects. The dominance of the source level of regulation in the third leaf and sink leaves accumulating 13.97. The redistribution of the photosynthates accumulated in the leaf and petiole offers another distinct area for future research as this could be either for total structural make up following a redistribution based on requirement with passage of time and in time with physiological requirement of growing fingers. Another important observation is that the source leaf in case of the fourth and the fifth leaves i.e. the older leaves are seen as retaining the second lowest and lowest share respectively reminding that with aging the process of translocation of photosynthates in taking place very fast.

This variation observed between the leaves could also be argued in another line i.e. the contribution made by the different leaves to various hands and different leaves nourished the hands with varying intensities such that impoverishment of the hands did not occur as some are seen to nourish the last formed hands as influenced late emergence of last hands.

In the case of Njalipoovan the trend is as follows

(L1) – Hand>Petiole>Sink leaves> Source leaf>Pseudostem> Root>Peduncle> Corm

(L2) – Hand>Petiole>Sink leaves>source leaf> Root>Peduncle>Corm> Pseudostem

(L3) – Hand>Sink leaves>Petiole> Root>Peduncle>Source leaf>Pseudostem>Corm

(L4) – Hand>Sink leaves>Petiole> Pseudostem> Source leaf>Corm>Peduncle>Root

(L5) - Hand>Petiole>Sink leaves> Peduncle>Pseudostem> Root>Source leaf

A distinct picture emerges in the case of Njalipoovan as well. The major sink is the developing hand itself leaf in comparison of the ratio apportioned it is comparatively less to Palayankodan thus explaining the relative smaller size of fingers and lower yield. Again the hand followed by the petiole in case of the first leaf, second and the fifth leaf followed by sink leaves and vice versa in the third and the fourth leaf where the hand was followed by the sink leaves and petiole respectively. The tree major sinks cumulatively added 80.36, 90.4, 87.6, 90.22 and 87.74 per cent in case of the fourth and the fifth leaf respectively.

Here again we have a specific case where there is fairly high mobilisation observed in the sink leaves again opening up fresh area for future research as to whether there is a redistribution or rationing or apportioning to hands at specific intervals which have to be probed further. In the first leaf there is a sizeable level of photosynthates retained and a lesser level in hands and more in the petiole confirming that regulation of photosynthates partitioning is not at source level and the more amount pushed into the petiole again confirms that the leaf is capable of nourishing at later stages of growth of the bunch.

In the case of the second, fourth and the fifth leaf the overriding dominance of hands in mobilising the photosynthates as it can be concluded that it is a clear case of sink domination whereas in the third leaf there was somewhat a share maintained at all levels, petiole, peduncle and comparatively lower level in hands and thus it can be confirmed that carbon partitioning is at transport level.

The differential types of regulation of partitioning of photosynthates exhibited by the various leaves points to a unique situation wherein same leaves are found to nourish the developing economic part or bunch, same are in the process (as shown by the regulation at transport level and the last formed fully developed leaf retaining the major part as that it can cater to the requirement at the later stages of bunch growth and maturity.

5.5. Percentage Partitioning on a whole plant basis

The per cent recovery on a whole plant basis is more a reflection of the dry weight variation observed in the various tissues and thus pseudostem which accounts for the major dry weight a predominant position. Another part also accounting for higher percentage is the accumulation in the corm. In Palayankodan, in case of the source leaves and sink leaves there is no much variation observed. In the case of the first leaf though there is slightly higher fraction in the hands it is almost equal to that in the pseudostem. A similar case is observed in the case of the third leaf also whereas when it comes to the case of the second, the fourth and fifth leaf the pseudostem rank on the top and the differences with per cent total accumulation in hands is clearly explicit in the older leaves. In the case of the corm the level of accumulation brought about by the first leaf is comparatively less whereas the mature leaves the third, the fourth and the second in the order contributed significantly superior shares. The accumulation in roots was in the order third leaf, followed by the second and the fourth leaf.

In the case of Njalipoovan again there is no much variation observed in the case of leaves as in Palayankodan. A comparison between the shares of accumulation in hands and pseudostem showed distinct variation with ratios in the latter accounting for more part of the share, in the latter accounting for more part of the share in the first leaf and marginally in the fifth leaf whereas in case of the second leaf, the third leaf and fourth leaf hands account for a higher share. In case of corm the share of accumulation in the fifth leaf is comparatively the least and that in the second leaf, the fourth leaf and the third leaf accounted for higher projection of shares and the former showing clear superiority.

All these changes and variation are nothing but a reflection of the variation in the dry weight of various tissues. The comparative dry weights of pseudostem, corm and bunch in relation to the other parts being higher showed higher proportion when it came to a whole plant basis. The actual level of recovery in hands on a unit gram basis being much higher than other tissues, the hands still retained the prime portion.

5.7. BUNCH PRUNING REGIMES

5.7.1. Palayankodan

The study revealed the overwhelming significance of removal of male bud both in improving the bunch yield and improving consumer preference by increasing the finger attributes namely the length and girth (grade) which are the two main characters governing consumer preference. The study revealed an increase in bunch yield by pruning beyond the ninth hand or retaining a nine hand system. A critical look at the hand weight and finger weight also reveals a gradual decrease from the maximum intensity of pruning regime (retaining six hands) to the control (of no pruning) in the order the superiority of difference of pruning was also statistically significant at each level implying that there is both an inter hand and inter finger competition for photosynthates. The present study goes beyond any doubt in confirming the same and reporting for the first time in the shade tolerant variety of banana based on actual photosynthetic translocation. Studies using released $^{14}CO_2$ and measuring the recovery of activity translocated to various hands in a eight hand system. Results of the study also showed the superiority of the removal of the male bud also support the findings of Daniels *et al.* (1984) who based on a study of dry weight apportioning inferred that the male buds act as a competing photosynthetic sink drawing in large resources. Another supporting study in this line causes from the findings of Walker and Ho (1979) as they reported that though the size of the male bud is small, the sink activity is high.

Again the study on the distribution pattern in hands revealed that the younger hands mobilise more photosynthates from the same leaves which when pruned or trimmed should have necessarily been partitioned more effectively in to the older hands making them more heavy and better in size, thereby increasing yield on the one side and consumer preference on the other side. A similar study based on phosphorus mobilisation from the roots and recovery of ^{32}P in different hand was reported by Kurien *et al.* (2000), another supporting in banana but in another variety Nendran based on photosynthate translocation was also made by the same way Kurien *et al.* (2004).A worthy point which supports this contention is established that in the early stages of growth of the finger the development growth is more focussed on the peel and after two weeks a shift on priority of development to the pulp takes place. The variety under this study has thicker peel and hence removal of terminal hands should have siphoned more photosynthates in to the fingers of the older hands.

There are many studies that supports our findings as in the cases of works of dehanding by Trupin as early as in 1959 and Perumal and Adam (1968) , Walker (1968) and Kurien *et al.* (2000). Reports contrary to the present findings have also came in from Hasselback and Jelo (1973) and Stevenson (1976) in Congo Banana and Amma *et al.* (1986) that pruning of hands did not increase yield, but increased finger size. Thus it should be inferred that increased finger size and yield have came in directly by avoidance of inter finger competition and as a direct consequence of reduction in reducing the number of competing sinks for photosynthates.

Finally, it has to be concluded that for indigenous local markets pruning beyond nine hands or in other words retention of a nine hand system is best and for export market it would be better to have an eight hand system where a slight compromise on yield is made for improve finger characters the prime aspect in international trade.

5.7.2. Njalipoovan

The results of the study on bunch trimming regimes in Njalipoovan revealed that pruning after ten hand or retention of ten hand system gave the highest yield. On the other hand, the hand finger weight, length and girth decreased with more retention of hands and difference in means were explicit and significant.

Two major works but on two defined system the first o seeded fruits (Cannell, 1985) and second in Parthenocarpic fruit (Kurien *et al.,* 2004) outline the intensity of sink activity of different parts or tissues of crops. Both the models suggest an order of competing sink. The present study on parthenocarpic fruit point to both the male bud and increased hand size as competing sinks in accumulation of photosynthates. The reports on male bud as sinks has come in from Walker and Ho, 1977, Daniells *et al,* 1994 and Kurien *et al* .(2000). Another time of thought is with that energy for opening of flowers and finger development there is considerable utilisation of energy which could have otherwise been saved by pruning of male bud (Simmond,1959; Sampaio and Simao, 1970; Walker, 1973; Mayor, 1975; Forarullo, 1982 and Amma *et al., 1994)*

Different patterns of mobilisation of photosynthates to the developing hands are confirmed in the study in which leaves contribute mainly to the last formed undersized finger. However small it may be on a relative recovery basis as all leaves contribute to the last formed hands but at varying proportions. This could be favourably partitioned to the older bigger hands making then more acceptable by increase in weight and size. Similar studies in this line in banana but in the variety Nendran has more accumulation in last formed hands been reported by Kurien (2004). The line of argument on more utilization of translocate for development of peel particularly in the early stage are of lesser consequence in the variety under study as it is one among the bananas with the thinnest peel size but however small, it maybe the amount partitioned into bigger older hands will result in an improved bolder bunch size and yield as observed in the present study. Numerous studies in this direction have already been reported but by hypothesising that it is increased translocation and accumulation of photosynthates that resulted in bunches of improved yield and finger size. The present study scientifically validates and confirms beyond doubt this hypothesis. The partitioning into the corm, pseudostem, leaf and other tissues for imparting structural support, and also to perform complimentary functions.

To summarise, it may be safely inferred that for local indigenous market a ten hand system is the best but for export market where the finger size outweighs all other characters pruning of hand to retain nine or eight hand will be ideal. On the whole the study has led to results of immense practical relevance in both the clones. It can be confirmed that when there is maximum retention of hands it let to the inter-hand and inter finger competition leading to impairment of hand development and pruning of hands at defined regime not only significantly increase the yield but overcame the impoverishment of photosynthates to retained hands.

SUMMARY

6. SUMMARY

Investigations on the experiment entitled "*Carbon partitioning in banana Palayankodan (Musa AAB) and Njalipoovan (Musa AB) intercropped in coconut gardens*" were carried out at Regional Agricultural Research Station (RARS) Kumarakom, Kottayam during the period from July 2010 to March 2011. The studies consisted of four separate experiments two each in Palayankodan and Njalipoovan. The experiments were laid out in a Completely Randomised Design (CRD) with four replication each in all the experiments. Two of the experiments were on carbon partitioning studies in Palayankodan and Njalipoovan. The second part of the research work consisted of another set of two experiments on the influence of different pruning regimes in on yield and finger quality in Palayankodan (*Musa* AAB) and Njalipoovan (*Musa* AB).

The summary results were as follows.

1. At mid stage of bunch development of crop beginning from the first leaf to the fifth leaf of the crop when the activity was given to individual leaves, the accumulation in the various sink were different for the different leaves. The third leaf was the most efficient leaf in terms of accumulation and retention of photosynthates followed by the first, the second, fourth and the least in the fifth leaf in case Palayankodan.

2. In case of Njalipoovan, the maximum retention of photosynthates was in the fourth leaf followed by third, the first, the second and the least in the fifth. The least was recorded in the fifth leaf in both the clones revealing that the old and senile leaf which is less efficient in retention of photosynthates.
3. When partitioning of photosynthates from source leaves to different hands were studied it was confirmed that in Palayankodan when the first leaf was given the activity the maximum recovery was seen in the

newly formed hands namely seventh and the eighth hand. When the second leaf was given the activity maximum recovery was observed in the mid hands namely the fourth and fifth hands whereas in case of third leaf the maximum recovery was seen in the mid hands namely the third, the fifth and the fourth hands with the source leaf itself a sizeable chunk of activity. In case of the fourth leaf maximum recovery was observed in the fourth, the second and the fifth hands and in the case of fifth leaf the maximum recovery was observed in the first formed hands namely the third, first and the second.

4. In Njalipoovan the trend varied from that of the Palayankodan. When the first leaf was given the activity maximum recovery was observed in the eighth and the seventh hand whereas in case the second leaf the maximum recovery was observed in the newly formed seventh and eighth hand. In case of the third leaf maximum recovery was observed in the first formed hands namely the third and the second hands. When the fourth leaf was given the activity the maximum recovery of activity was observed in the sixth hand followed by the fourth and the third hands. When the fifth leaf was given the activity the maximum partitioning was observed in the sixth, the fifth and the fourth hand respectively.

5. Studies on accumulation in various tissues revealed that in Palayankodan in the case of sink leaves the maximum recovery was observed when the activity was given in the second leaf followed by the third leaf. In case of Njalipoovan among source leaves the fourth leaf showed the maximum efficiency in accumulation of photosynthates.

6. When the per cent accumulation into hands were observed in Palayankodan it was found in case of first leaf partitioned the maximum followed by the fourth and the second whereas in case Njalipoovan it was observed that the fourth leaf followed by the fifth leaf accumulated the maximum photosynthates into hands.

7. The partitioning into the petioles was more of a reflection of the accumulation observed in the respective leaves.

8. In case of the peduncle in both the clones the maximum recovery was observed in case of the oldest fifth followed by the third.

9. In the case of pseudostem maximum per cent recovery of activity was observed when the fourth leaf was given the activity in Palayankodan whereas in Njalipoovan the maximum per cent of partitioning was observed when fifth leaf was fed with activity followed by the third.

10. In case of roots maximum accumulation is observed in case of the third leaf revealing that the last flushes of roots have been sustained by the mature third leaf and the younger leaves in Palayankodan. In Njalipoovan it is the fifth and the third which accumulated more photosynthates to the roots

11. The per cent recovery on a whole plant basis is more a reflection of the dry weight variation observed in the various tissue parts of the crop and hence the pseudostem which accounts for the major dry weight takes a predominant position. Another part also accounting for higher percentage of dry weight is the corm. In the case of the first leaves fed with activity there is slightly higher fraction in the hands which is almost equal to the pseudostem in Palayankodan. Whereas in the case of the second, the fourth and the fifth the pseudostem accumulated the most.

The per cent recovery observed on a whole plant basis in Njalipoovan shows that the shares of accumulation in hands and pseudostem showed distinct variation. When the first leaf was fed it showed more accumulation in pseudostem followed by hand which accumulated very less compared to pseudostem. A similar case observed when the fifth leaf was fed with activity where the pseudostem accumulated more followed by the hands. However, in the case of the second leaf, the third and the fourth leaf it was hand that accumulated more than the pseudostem.

The highest photosynthetic efficiency of leaves (retention & translocation) was observed in the first leaf in case of Palayankodan and fourth in case Njalipoovan. A comparison of the efficiency of leaves between the clones showed in the first leaf Palayankodan was more efficient whereas in case of second, third, fourth and fifth Njalipoovan was more efficient.

12. In the studies on standardisation of pruning techniques in Palayankodan the maximum bunch weight was observed in the bunch with nine hands followed by the ten handed bunch and the eight handed bunch and the least was recorded in the bunch with six hands. In case of the hand weight, the finger weight, finger length and the finger girth a general trend was observed. Thus it was inferred that nine hand system was best for domestic market and eight hand for export.

13. In case of Njalipoovan the maximum bunch weight was found in the ten handed system followed by the male bud pruned bunch and then the nine handed bunch. The least was observed in the six handed bunch. In case of the hand weight, the finger weight and finger girth showed the same trend. Maximum value was observed in the six hand bunch followed by the seven hand bunch to finally the least recorded in the bunch without pruning in the order.

14. In both the clones, all the three flows of regulation namely the source level sink level and translocation level of photosynthates was observed in case of one leaf or the other leaf fed with the activity.

Reference:

Allen, M. T., Prusinkiewicz, P., and DeJong, T. M. 2004. Using L-systems for modeling source–sink interactions, architecture and physiology of growing trees: the L-PEACH model. *New Physiologist.* 12: 23- 28.

Amma, S. P., Babylatha, A. K., Pushkaran, K., and Kurian, T. M. 1986. Studies on the effect of removing terminal hands and male bud on the yield and fruit size of banana Musa (AAB group) Palayankodan. *S. Indian Hort.* 34(4): 204- 209.

Ancy, T. K., Kurien, S., Augustin, A., and Balachandran, P. V. 1998. Urease activity in banana fruits cv. `Nendran'. *J. Plant. Nutr*. 21(10): 2127- 2140.

Aravindakshan, K. 1981. Effect of pre and post harvest treatments on storage and quality of banana cv. Nendran. MSc. Thesis, KAU, Vellanikkara, Thrissur, 112p.

Aravindakshan, M. and Pushkaran, K. 1996. *Banana Compendium.* Kerala Agricultural University, Thrissur, 160p.

Arney, S. L. 1947. The regulation of strawberry leaves attached to the plant. *New Physiol.* 46: 68-76.

Balasimha, D., 1989. Light penetration patterns through amcanut canopy and leaf physiological characteristics of intercrops. *J. Plantn. Crops* 16: 61-67.

Buragohain, R. and Shanmugavelu, K. G. 1985. A study on the translocation of plant nutrients from the sink towards the source in certain banana cutlivars using ^{32}P. *Banana Newsl*. 8: 31-33.

Buragohain, R. and Shanmugavelu, K. G. 1986. Studies on the effect of post-shooting application of urea on `Vayal Vazhai' banana (ABB). *Banana Newsl*. 9: 16-18.

Butler, R. D and Simon, E. W. 1972. Ultra structural aspects of senescence in plants. *Adv. Gerontol. Res.* 3: 73-129.

CaiXi, Z., Kenji. T., Fumio. T., Kazuhiro. M., and Akira. Y. 2005. C-photosynthate accumulation in Japanese pear fruit during the period of rapid fruit growth is limited by sink strength of fruit rather than by the transport capacity of the pedicel. *J. Exp. Bot.* 56(420):2713-2719.

Callow, J. A., Callow, M. E., and Woolhouse, H. W. 1972. In vitro protein synthesis, ribosomal RNA synthesis and polyribosomes in screening leaves of Perilla. *Cell Differentiation* 1: 79-80.

Callow, M. E. and Woolhouse, H. W. 1973. Changes in nucleic acid metabolism in regreening leaves of Perilla. *J. Exp. Bot.* 24: 285-294.

Cannell, M. G. R. 1985. Dry matter partitioning in tree crops. In: Cannell, M. G. R and Jackson, J. E. (eds.), *Attributes of Trees as Crop Plants.* Institute of Terrestrial Ecology, Huntingdon, England, 457p.

Chattopadhyay, P. K. and Jana, A. K. 1988. Effect of growth substances on fruit growth and development of Giant Governor Cavendish banana. (*Musa cavendishi*). *Progsv. Hort.* 20(1-2): 136- 139.

Coombe, B. G. 1992. Research on development and ripening of the grape berry. *Am. J. Enol. Vitic.* 43: 101-110.

Daniells, J. W., Lisle, A. T., and O'Farell, P. J. 1992. Effect of bunch covering methods on maturity, bronzing, yield and fruit quality of bananas in North Queensland. *Aust. J. Exp. Agric.* 32(1): 121-125.

Daniells, J. W., O'Farell, P. J., Mulder, J. C., and Campbell, S. J., 1987. Effect of bunch covering and bunch trimming on bananas in North Queensland. *Qld. J. Agric. Anim. Sci.* 44(2): 101-105.

Daniels, J. W., Lisle, A. T., and Bryde, N. J. 1994. Effect of bunch trimming and leaf removal at lowering and maturity, bronzing, yield and other aspects of fruit quality of bananas in North Queensland. *Aust. J. Exp. Agric.* 34(2): 259-265.

DeJong, T. M. 1999. Developmental and environmental control of dry matter-partitioning in Peach. *Hort. Sci.* 34(6): 1037- 1040

DeJong, T. M. and Goudriaan, J. 1989. Modelling of peach fruit growth and carbohydrate requirements: re-evaluation of double- sigmoid growth pattern. *J. Am. Soc. Hort. Sci.* 114: 800- 804.

DES [Department of Economics and Statistics]. 2010. Agricultural production in Kerala[online]. Available: http://kerala.gov.in.[22-07-2011].

Desmukh, V. G. and Chakrawar, V. R. 1980. Effect of preharvest application of growth regulators on the maturity, bunch and finger characters in banana fruit. *J. Maharashtra Agric. Univ.* 5(1): 15- 17.

Devi, D. D. 1991. Effect of macronutrient spray on leaf characters on cv. Nendran. *Banana Newsl.* 11: 34.

Ekanayake, I. J., Rodomiro, O., and Vuylsteke, D. R. 1994. Studies on Influence of leaf age, soil moisture, VPD and time of day on leaf conductance of various *Musa* genotypes in a humid forest-moist savannah transition site. *J. Ann. Bot.* 74: 173-178.

Evans, J. R. and Poorter, H. 2001. Studies on Photosynthetic acclimation of plants to growth irradiance: the relative importance of specific leaf area and nitrogen partitioning in maximizing carbon gain. *Plant Cell Environ.* 24: 755–767.

FAO [Food and Agricultural Organization]. 2010. FAO STAT year book on agriculture [online]. Available: http://www. fao.org/agristat.html. [22-07-2011].

Farkas, G. L. and Stahmana, M. A. 1966. On the nature of changes of peroxidase enzyme isoenzymes in bean leaves infected by bean mosaic virus. *Phytopathology* 56: 669- 677.

Firth, H. D. 1986. Foliar fertilizing bananas. *Banana Bull.* 50(8): 8.

Ganapathy, T. R., Sherkhawat, U.K.S., and Srinivas, L. 2011. Musa DHN-1 ,a novel multiple stress- inducible SK type dehydrin gene, contributes affirmatively to salt stress tolerance in Banana. *Planta* 234:

Gandhi, V. P. 1984. Effect of certain plant regulators, urea and sleeting on maturity, yield and quality of banana (*Musa cavendishi* L.) cv. Basrai. MSc. Thesis, Gujarath Agricultural University, 78p.

Gottreich, M., Bradu, D. and Haleway, Y. 1964. A simple method for determining average banana fruit weights. *Ktavim* 14: 161-162.

Grossman, Y. L. and DeJong, T. M. 1995. Maximum fruit growth potential following resource limitation during peach growth. *Ann. Bot.* 75: 561- 567.

Grossman, Y. L. and DeJong, T. M. 1995. Maximum fruit growth potential and seasonal patterns resource dynamics of peach growth. *Ann. Bot.* 75: 553-560.

Haigler, C. H., Datcheva, I. M., Hogan, P. S., Salnikov, V. V., Joon, H. I., Martin, K., and Delmer, D. P. 2001. Carbon partitioning to cellulose synthesis. *Plant Mol. Biol.* 47(1/2): 29-51.

Hardwick, K., Wood, M. E., and Woolhouse, H. W. 1968. Photosynthesis and respiration in relation to leaf age in *Perilla frutescens* L. Britt. *New Physiol.* 66: 545-552.

Hauser, S. 2010. Growth and yield response of the plantain (*Musa*. sp) hybrid' FHIA 21' shading and rooting by Inga Edulis on a Southern Cameroonian Utisol. *Acta Hort.* 879: 23- 24.

Hawker, J. S, and Jenner, C. F. 1993. High temperature affects the activity of enzymes in the committed pathway of starch synthesis in developing wheat endosperm. *Aust. J. Plant Physiol.* 20: 197-209.

Ho, L. C. 1992. Fruit growth and sink strength. In: Marshall, C. and Grace, J. (eds.), *Fruit and seed production. Aspects of development, environmental physiology and ecology.* Cambridge University Press, 213p.

Hosselbach, O. E. and Idoe, J. 1973. Dehanding of bananas in Surinam Surinaanse Landbouw. 21: 127- 132.

Humbert, R. P. and Hanson. 1952. Nutrition by foliar application. *Annu. Rev. Plant Physiol.* 5: 31- 54.

Irizarry, W. and Rivera, E. 1991. Proper bunch management of the French-type super plantain (*Musa accuminata M. bulbisiana* AAB) in Puerto Rico. *J. Agric. Univ. Puerto Rico* 75(2):163-171.

Israeli, T., Gazit, S., and Blumen, A. 1980. Influence of relative humidity on the type of fower in the Cavendish banana. *Fruits* 35(5): 275-279.

Israeli, Y., Plautb, Z., and Schwartzc. 2000. Effect of shade on banana morphology, growth and production. *Scientia Hort.* 62: 45-56.

Jaramillo, C. R. 1984. Las principales characteristicas morphologicas der fruto de banana variedad Cavevdish gigantia (*Musa* AAA) en Costa Rica UPEP Panama.

Johns, G. G. and Scott, K. J. 1989. Delayed harvesting of bananas with sealed covers on bunches. 2. Effect on fruit yield and quality. *Aust. J. Exp. Agric.* 29(5): 727-733.

John, T., Christopher, A. and Joseph. A. M. 1996. Carbohydrate partitioning in the leaves of Bromeliaceae performing C_3 photosynthesis or Crassulacean acid metabolism. *Aust. J. Plant Physiol.* 25:371-376.

KAU [Kerala Agricultural University]. 2007. *Package of Practices Recommendations: Crops*. Kerala Agricultural University, Vellanikkara, Thrissur, 334p.

Kozaki, A. and Takeda, G. 1996. Photorespiration protects C_3 plant from photo oxidation. *Nature* 384: 557- 560.

Kriedemann, P. E., Lenz, F. 1972. The response of vine leaf photosynthesis to shoot tip excision and stem cincturing. *Vitis* 11: 193-197.

Kumar, A. R., Kumar, N., and Kavino, M. 2006. Role of Potassium in Banana- A Review. *Agric. Rev.* 27(4): 11- 15.

Kurien, A., Augustine, A., and Nybe, E. V. 2003. *Economic Analysis of Resource Based Cropping in Selected Medicinal Plant Species*. CIMAP, Lucknow, 467p.

Kurien, S. 2004. *First annual report of the DST project on yield production models in banana*. DST, Govt. of India, New Delhi, 30p.

Kurien, S. 2007. *Final report of the DST project on yield production models in banana*. DST, Govt. of India, New Delhi, 67p.

Kurien, S., Anil,B. K., Rajeevan, P. K., Bharathan, V., and Krishnan, S. 2000. Phosphorus mobilisation to uneconomic tissues and effects of bunch trimming regimes in banana. *Scientia Hortic*. 83: 25-32.

Kurien, S., Sobhana, A., and Pushpalatha, P. B. 1999. Morphophysiological stages during various stages of finger development of banana cv. Nendran. *Infomusa* (in press).

LeRoux, X., Walcroft, A.S., Daudet, F.A., Sinoquet, H., Chaves, M. M., Rodrigues, A., and Osorio, L. 2001. Photosynthetic light acclimation in peach leaves: importance of changes in mass:area ratio, nitrogen concentration, and leaf nitrogen partitioning. *Tree Physiol*. 21:377–386.

Lockard, R. G. 1975. The effect of growth inhibitors and promoter on the growth, flowering and fruit size of banana plants. *Malaysian Agric. Res.* 4(1): 19-29.

Lyanage, M. 1994. *Coconut Based Agroforestry in Srilanka*. Peekay tree crops development foundation, Cochin, 232p.

Maluk. C. S., Bauser, M. G., and Yelenosky, G. 1986. Influence of growth regulator treatments on drymatter production, fruit abscission and ^{14}C assimilate partitioning in citrus. *J. Plant Growth Regulators.* 5(2): 111-120.

Marcelis L. F. M. 1996. Sink strength as a determinant of dry matter partitioning in the whole plant. *J. Ex.l Bot.* 47: 1281–1291.

Marcelis, L. F. M. 1992. Non- destructive measurement and growth analysis of the cucumber fruit. *J. Hort. Sci.* 67: 457- 464.

Meyer, J. P. 1975. Influence de l ablation de mains surlerendement en poides des regimes de bananas par categores, etc. conditionnement aux antilles. *Fruits* 30: 663-668.

Minchin, P. H. R., Thorpe M. R., Wunsche, J. N., Palmer, J. W., and Picton, R.F. 1997. Studies on carbon partitioning in apple fruits: short and long term response to availability on photosynthate. *J. Exp. Bot.* 48: 1401 – 1406.

Mishra, S. D. 1981. The effect of growth hormones in banana. In: Lahav, E. and Gottreich, M. (eds.), *Plant Growth Regulation.* Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel, pp. 15-30

Moorby, J. 1968. The effect of growth substances on transport in plants. In: Vardar, Y.(ed.), *Transport of Plant Hormones.* New Holland, Amsterdam, pp. 192- 206.

Mullins, M. G., Bouquet, A., and Williams, L. E. 1992. Biology of the grapevine. Cambridge University Press, Cambridge, 243p.

Ness, P. J and woolhouse, H. W. 1980a. RNA synthesis in phaseolus chloroplast II. Ribonucleic acid synthesis in chloroplast preparationsleaves and solubilsation of DNA polymerase. *J. Exp. Bot.* 31: 223- 233.

Ness, P. J. and Woolhouse, H. W. 1980b. RNA synthesis in Phaseolus chloroplast II. Ribonucleic acid synthesis in chloroplast from developing and senescence leaves. *J. Exp. Bot.* 31: 235- 245.

Patel, J. D. 1980. Effect of post shooting sprays of N, P, K on bunch weight. *Proc. Plant Sci.* 89(6): 491- 496.

Percival, D. C., Proctor, J. T. A., and Sullivan, J. A. 2001. Cultivar difference in carbon assimilation and partitioning of primo cane fruiting raspberry. *J. Am. Pomological Soc.* 55(2): 88-89.

Perumal, A. and Adam, A. V. 1968. Bagging of Giant Cavendish banana stems in Honduras. 1. Effect on number of days from flower emergence to fruit harvest. *Trop. Agric*. 45: 101-102.

Pradan, S. K., Bandyopadhyay, A., Mitra, S. K., and Sen, S. K. 1988. Effect of growth substances on fruit size, yield and quality of banana variety Giant Governor. *Progrv. Hort.* 20(3-4): 326- 330.

Robinson, J. C. and Nel, D. J. 1988. Plant density studies with banana (cv. Williams) in a subtropical climate. I. Vegetative morphology, phenology and plantation microclimate. *J. Hort. Sci.* 63: 303-313.

Robinson, J. C. and Nel, D. J. 1989. Plant density studies with banana (cv. Williams) in a subtropical climate. II. Components of yield and seasonal distribution. *J. Hort. Sci.* 64: 21 l-222.

Robinson, J. C. and Nel, D. J. 2003. Comparative morphology phenology and production potential of banana cultivar ‘ Dwarf Cavendish’ and Williams’ in the Eastern Transvaal lowvwld. *J. Hort. Sci.* 23: 111- 114.

Rodriguez, M. L., Quero, E., and Lopez, M. G. 2002. Carbohydrate differences in strawberry crowns and fruit (Fragaria x ananassa) during plant development. *J. Agric. Food Chem.* 50(11): 3317-3321.

Rodriguez, S. B. 1974. The effect of male inflorescence removal on the ripening and bunch weight of three banana cultivars in Teuman. *Colima. Agric. Technica en Mexico* 3(8): 295- 301.

Sacher, J. A. and Danies, D. P. 1974. Demonstation of demove synthesis of DNAase in Rheo leaf sections by deuterium labeling. *Plant Cell Physiol.* 15: 157- 160.

Salisbury, C.W. and Ross, R. 2007. *Plant Physiology*. Thomson Asia Publications, 719p.

Sam, B. J. 2011. Developmental physiology of banana corm(*Musa* AAB) Nendran in relation to phenology, yield and quality, PhD thesis, KAU, Vellanikkara, 160p.

Sampaio, V. R. and Simao, S. 1970. Removal of male flowers from new Banana inflorescences. *Rev. Agric. Picicaba*. 45: 93-95.

Schultze, E. D. and Hall, A. E. 1982. Stomatal responses, water loss and carbondioxide assimilation rates of plants. In: Lange, O. L., Nobel, P. S., and Osmond, C. D. (eds.), *Encyclopedia of Plant Physiology*. Springer-Verlag, Berlin, pp. 181- 230.

Senevirathna, A. M., Stirling, C. M., and Rodrigo, V. H. L. 2007. Studies on acclimation of photosynthesis and growth of banana to natural shade. *J. Exp. Agric*. 44: 301–312.

Sharma, S. B. 1984. Effect of soil and foliar application of urea on the growth and yield of banana *Punjab Hort. J.* 24(1/4): 89- 91.

Simmonds, N. W. 1959. *Bananas*. Longman, New York, 332p.

Sindhu, T. S. 1999. Influence of post- bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (*Musa* AAB Nendran) Fruits. MSc. Thesis, KAU, Thrissur, 86p.

Sobhana, A. and Aravindakshan, M. 1989. Translocation of phosphorus in banana after shooting. *J. Nucl. Agric. Biol*. 18(4): 243-245.

Stevenson, D. 1976. What colour to select for banana bunch covers. *Banana Bull.* 40(4): 2.

Stover, R. H. and Simmonds, N. W. 1987. *Bananas*. Longman, New York. 468p.

Taiz, L. and Zeiger, E. 2003. *Plant Physiology*. Panima Publishing Corporation, New Delhi, 687p.

Trupin, F. 1959. Coupe du bourgeon male sur l' inflorescence due bananaier Gros Michel. *Fruits* 14: 389-390.

Urban, L., Roux, L., Sinoquet, H., Jaffuel, S., and Jannoyer, M. 2003. A biochemical model of photosynthesis for mango leaves: evidence for the effect of fruit on photosynthetic capacity of nearby leaves. *Tree Physiol*. 23: 289–300.

Venkatarayappa, T., Narasham, B., and Venkatesan, C. 1976. Effect of post-shooting application of urea on development and composition of banana fruit. *S. Indian Hort.* 19: 109-117.

Walker, L. 1973. *Debudding trials.* Annual report 1969-1972. Jamaica Banana Board, Research and Development Department, pp. 31-33.

Walker, L. 1975. *The effect of debudding and pre-harvest dehanding on bunch weight and fruit quality.* Annual Report 1974. Jamaica Banana Board, Research and Development Department, pp. 31-33.

Wardlaw, I. F. 1990. The control of carbon partitioning in plants. *New Phytologist* 116: 341-81.

Wareing, P. F. and Patrick, J. 1975. Source-sink relations and the partitioning of assimilates in the plant. In: Cooper, J. P. (ed.), *Photosynthesis and Productivity in Different Environments.* University Press, Cambridge, 347p.

Warren-Wilson, J. 1972. Control of crop processes. In: Rees, A. R. (eds), *Crop processes in controlled environments.* Academic Press, London, 267p.

Whiley, A.W. and Schaffer, B. 1994. Avocado. In: Schaffer, B. and Andersen, P.C.(eds.), *Handbook of Environmental Physiology of Fruit Crops. Vol. 2. Subtropical and Tropical Crops*. CRC Press, Boca Raton, pp. 1–35.

Woolhouse, H. W. and Jerkins, G. I. 1987. Physiological repauses, metabolic changes and regulation during leaf senescencs. In: Dale, J. and Mitharge, F.L. (eds.), *The Growth and Functioning of Leaves*. CVP, Cambridge, 587p.

Wright, C. J. 1989. Interactions between vegetative and reproductive growth. In: Wright. C. J. (ed.), *Manipulation of fruiting.* Butterworths ,London, 134p.

Yemm, E. W. 1950. Respiration of barley plants N. Protein catabolism and the formation of amides in starving leaves. *Proc. Rag. Soc. Handb.* 136: 632-649.

CARBON PARTITIONING IN BANANA INTERCROPPED IN COCONUT GARDENS

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ABSTRACT OF THE THESIS

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7. ABSTRACT OF THESIS

Investigations on the experiment entitled "Carbon partitioning in banana intercropped in coconut gardens" were carried out at Regional Agricultural Research Station (RARS) Kumarakom, Kottayam from 2010 to 2011. The studies consisted of four experiments two each in Palayankodan and Njalipoovan. Two experiments were on basic studies on carbon partitioning in both the clones. The second part consisted of two experiments on the "Influence of bunch trimming regimes on yield and finger characters" in both the clones. Many theories on shooting and yield have been advanced and validated in bananas. One theory which has gained maximum importance is the number of leaves retained at shooting and at harvest, as it is these leaves that nourish and carry the bunch to logical maturity and consequent harvest. Hence, reduction or damage to leaves at and from the stage of shooting will adversely affect the finger characters and yield. The objective is to study the assimilate partitioning in two banana clones grown in coconut gardens at mid harvest stage, to understand how specific leaves contribute to yield and to know whether there is any variation between the two commonly grown clones of Njalipoovan and Palayankodan.

The studies revealed that when the activity was given to various different leaves the accumulation in the sink were different for each leaf. When the individual source leaves were examined in the case of Palayankodan it revealed that the third leaf was the most efficient leaf in retention of photosynthates followed by the first, the second, fourth and the least in the fifth leaf. In case of Njalipoovan the maximum recovery was seen in the fourth leaf followed by third, the first, the second and the least in the fifth. This shows that in both the clones Palayankodan and Njalipoovan the least was recorded in the fifth leaf showing that the old senile leaf is less efficient in producing photosynthates.

When partitioning of photosynthates from source leaves to different hands were studied in Palayankodan it was found that when the first leaf was given the activity maximum recovery was seen in the newly formed hand namely the seventh and the eighth hand. When the second leaf was given the

activity maximum recovery was observed in the mid hands namely the fourth and fifth hands. In case of third leaf the maximum recovery was recorded in the mid hands but in the order namely the third, the fifth and the fourth hands, the source leaf itself retained a sizeable chunk of the activity. In case of the fourth leaf maximum recovery was observed in the fourth, the second and the fifth hands whereas in the case of the fifth leaf the maximum recovery was observed in the first formed hands in the order third, first and the second respectively. In Njalipoovan the picture varied from that of Palayankodan. When the first leaf was given activity maximum recovery was recorded in the eighth and the seventh hand as in the case of Palayankodan but in the reverse order. In case of the second leaf maximum recovery was observed in the newly formed seventh and eighth hand. In case of the third leaf maximum recovery was observed in the first formed hands namely the third and the second hands whereas in the case of the fourth leaf, the maximum activity was observed in the sixth hand followed by the fourth and the third hand respectively. When the fifth leaf was given the activity the maximum partitioning was observed in the sixth, the fifth and the fourth hand.

In Palayankodan the studies on standardisation of pruning regimes, maximum bunch weight was observed in the bunch with nine hands followed by the ten hand and the eight hand system. The least was recorded in the bunch with six hands. On the contrary, in case of the hand weight, the finger weight finger length and the finger girth an identical trend was observed with maximum recorded in the most intensive pruning of retention of six hands to the no pruning control in the order. Slight variation in the order was observed in the case of finger length. Thus it is inferred that the nine hand system was best for domestic market and the eight hand for export.

In case of Njalipoovan the maximum bunch weight was found in the ten hand system followed by the pruning of the male bud only, nine hand bunch, the eight hand bunch respectively. The six hand retention bunch recorded the least bunch weight. In case of the hand weight, the finger weight and finger girth almost an identical trend was observed. Maximum value for the hand weight, finger weight and finger length and finger girth was observed in with the maximum pruning of the six hand bunch followed by the seven hand bunch to the control of no pruning. Thus it is inferred that the ten hand system was best for domestic market and the nine hand for export.

All forms of regulation of carbon partitioning is observed in both the clones which explains the reasons as to why both the clones are productive even under the shaded home garden conditions.