Review paper

Sucker production in banana

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Received 6 August 2015; received in revised form 12 November 2015; accepted 22 December 2015

Abstract

Quality planting material is the key to successful cultivation of all crops. Sucker is the primary and major source of propagation material in banana. Continuity of the production process can be maintained only by balancing good bunch yield and optimum number of quality suckers. The research work on the initiation and the development of suckers indicated that its genesis could be in the cortex part of the mother corm. Both internal factors (ploidy levels, genomic constitution etc.) and external factors (planting seasons, depth, spacing etc.) affect the sucker production. Sucker production increases with decrease in ploidy levels and with increase in *M. balbisiana* genomic group in the genomic constitution of the particular clone. Intra-clonal variability in suckering habit of different banana clones is much clear. Physical methods of sucker activation techniques like goose necking, mattocking, decapitation, false decapitation are reported to enhance the sucker production. Influences of mattocking on translocation of nutrients from mother plant to daughter suckers at various physiological stages of the mother plant and under the different systems of planting have been explored by many scientists. Cultural methods (like Ascenso's method, use of different organic manures, biofertilizers, fertilizers, micronutrients etc.) and hormonal methods (application of ethrel, GA_3, Pachlobutrazol, BA and IAA etc.) were found to be effective. Newer techniques like split corm, split bud, minisetting, *PIF* etc. can also be useful in salvaging underdeveloped suckers.

Key words: Quality suckers, Factors, Ploidy levels, Genomic constitution, Intra-clonal variability, Sucker activation techniques, Mattocking

Introduction

Studies solely focused on sucker production in banana are meager. They have mostly been recorded as a concomitant aspect of other studies. Several types of planting materials are being used in banana and innumerable reports exists on yield as a function of quality planting material like the comparison of different planting materials, the influence of age, size and weight of planting materials on yield. Propagation techniques in banana can broadly be classified into macropropagation and micropropagation or as conventional and *in vitro* (tissue culture) methods.

Ideally, a good sucker is one that possesses the potential for vigorous growth, free from inherent pests, diseases and at the same time sustains high bunch yield. Simmonds (1960) observed three distinct stages in the course of sucker development namely the peeper, the sword and maiden sucker.

Sucker: as a quality planting material

The banana is genetically old, decrepit and the fruit is a sterile, seedless mutant and therein lies a major problem. Monocropping of a single clone (as in recent past with Grand Naine) makes banana ripe for disease infestation like no other crop in the world, as evidenced in the historic case of Latin American Gros Michel (Pearce, 2008). Thus, there is urgent need to provide alternative varieties with

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potential for export. Number of native varieties has high export and domestic potential, but they are on the brink of extinction primarily due to non-availability of the planting material (Bohra et al., 2013). In many cultivars, particularly the heavy suckering types, sucker affects plant growth and bunch yield. Under the conventional production system the aim is always to balance good yield and assured finger quality with an optimum number of quality suckers.

The advantages of propagation through suckers are mainly the low planting material cost, easy availability, lesser input requirements, scope for immediate planting in the field, higher longevity of plants, less prone plants to physical damages and easiness in conserving native and rare varieties (Simmonds, 1962 and Swennen et al., 1984).

Rhizome and suckers: a closer look at the origin of suckers

The true stem of the banana plant is either partly or wholly underground, and hence is often technically referred as a 'tuberous rhizome'. Bananas do not have extended horizontal growth like most rhizomatous crops but, nevertheless, suckers grow successively outwards. Suckers themselves make small initial horizontal growth before they turns upwards. Thus, there is much misunderstanding here because the term 'corm' is being used in common parlance, whereas others have used both the terms rhizome and corm together. Few others have also used the term 'bulb'. Simmonds (1987) botanically described the banana stem as a 'short rhizome' which is nowadays mostly accepted.

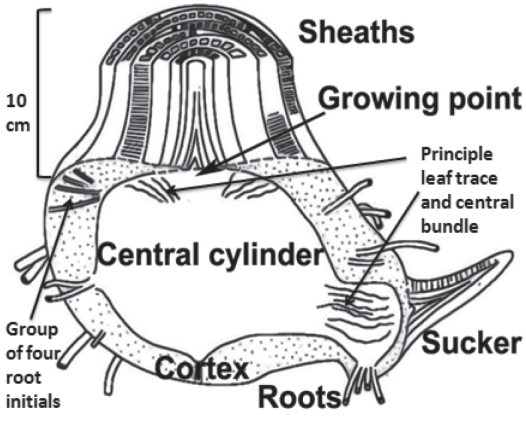

Figure 1. Genesis of sucker from mother corm

The rhizome has extremely short internodes covered externally by closely-packed leaf scars. Internally, it is differentiated into the central cylinder and cortex whereas, the ground tissue is starchy parenchyma. Thus, the rhizome is an important storage organ for sustaining growth of the bunch and the developing sucker. Analysis of literature available on the sucker origin reveals that there is no much work on the initiation and development of corm except that of a passing mention about its genesis could be in the cortex part of the corm (Simmonds, 1960). Externally they are first observed as 'eye' or 'buds' on the corm.

Factors governing sucker production

Factors influencing the sucker production can broadly be categorised under the major heads as internal and external.

Internal

Ploidy level

In banana, ploidy levels reported are diploid (2n), triploid (3n) and tetraploid (4n). Turner (1972) observed early suckering in diploid and triploid bananas which attributed to the early development of lateral buds. This because of the high nutrient availability from the mother plants to daughter suckers. Sucker production was indirectly proportional to the level of ploidy (Balakrishnan, 1980). Alagiamanvalan (1979) reported that the diploid Anaikomban (AA) within *M. accuminata* group produced more suckers.

Blomme et al. (2000) reported that all diploid bananas had a non-regulating suckering behaviour (i.e. all suckers grow vigorously), while triploids and tetraploids had a regulated (i.e. 2 or 3 suckers grow vigorously) or an inhibited suckering (i.e. no sucker grows vigorously).

Table 1. Effect of different plant spacing on sucker production

Plant spacing (m)	Sucker ha^{-1}	Sucker plant^{-1}	Clone	Authority
1.20 x 1.20	24027.8	3.46	Robusta	Reddy (1982)
2.10 x 2.10	15260.7	6.73		
2.25 x 2.25	12541.4	6.35	Robusta	Rajeevan and Geetha (1989)
2.00 x 2.00	14500.0	5.80	Nendran	Anil (1994)
1.75 x 1.75	15835.4	4.85		
1.50 x 1.50	20664.4	4.65		
1.25 x 1.25	21440.0	3.35		
1.50 x 1.50	4444.0	7.80	Jahaji	Chaudhuri and Baruah (2004)
2.40 x 2.40	6076.4	3.50	Rajapuri	Athani et al. (2009a)

Genomic constitution

The edible bananas in the section *Eumusa* have their origins from two wild progenitors *M. accuminata* and *M. balbisiana*. Among the genomic traits *M. balbisiana* genome constitution influence suckering. Simmonds (1960) reported that within the triploid ploidy level more *balbisiana* genome increases the suckering ability. Balakrishnan (1980) reported that triploid Monthan (ABB) within its ploidy level produced more number of suckers.

External

Planting season

Seasonal effects on suckering behavior of banana are very explicit and reported to differ with varieties. Ghose and Hossain, (1992) reported that banana rhizomes planted in September produced more number of suckers compared to February and May in cv. Amritsagar and Sabri. Yadav et al. (2011) reported that in a study with ten planting seasons and with four clones (Dwarf Cavendish, Grand Naine, Robusta and Kullan), maximum numbers of suckers were produced in the May planting in Dwarf Cavendish and least in Robusta during October-November.

Plant spacing

The major reports on the above aspect are presented in Table 1.

Planting depth

Correct planting depth will increase the nutrient absorption rate of the rhizome of mother plant from the particular active root zone resulting in the better sucker production. Planting of suckers at a depth of 30 cm was found to be optimum for cv. Nendran under irrigated conditions as evidenced by trial conducted at BRS, Kannara during 1964 whereas, Bakhiet and Elbadri, (2004) reported that among the different planting depth tried (30, 40, 50 and 60 cm), 40 cm depth recorded the highest number of suckers at 4 MAP and at shooting.

Intra-clonal variability and sucker production

Different accessions of the same clones have been reported to show differences in suckering habit. Sunilkumar (1997) reported that among the different accessions of 'Kaliethan' Nendran banana, maximum number of suckers were produced by Venjarmoodu (7.66) followed by Neyyattinkara (7.14) and Kaliyoor (6.43) at the time of harvest whereas, Palode, Vellayani and Anad produced only 4.00, 5.50 and 5.50 number of suckers respectively.

Sucker activation techniques

Different techniques have been adopted to invigorate the underdeveloped suckers. All such techniques are sucker activation / invigoration techniques. The objective is to salvage the underdeveloped suckers and thereby to have more number of quality suckers from a mother plant, without affecting the bunch yield. These techniques can broadly be classified as physical, cultural, hormonal methods and newer techniques.

Physical

It includes cutting the pseudostem of mother plant at different heights or arresting the apical dominance or suppressing the growing point at different physiological stages.

Cutting back

Borel (1952) tried cutting back in Gros Michel at 0.6 m above the collar after fruiting for the development of underdeveloped suckers. The underlying physiology involved in these being 'increased flow of nutrients from mother plant to the daughter suckers'. Goose necking (nicking the pseudostem and bending it over) was found to stimulate sucker production in his study. Osborne (1963) doubled sucker production in the tetraploid, Bodles Altafort by goose necking, within six month. Eckstein and Robinson (1999) reported that partial removal of the mother plant canopy after flowering was useful for accelerating ratoon sucker growth.

Cutting height of parent pseudostem

Cutting the parent pseudostem at a height of 200 cm could activate sucker growth (Daniells and O'Farrell, 1987; Rodriguez et al., 2006). Mathew et al. (2000) reported that retention of un-topped parent pseudostem gave maximum height and girth of the suckers.

Decapitation

De Langhe (1961) studied sucker production in cv. Bousa and reported that six to eight suckers can be obtained during a period of six months by cutting off six month old mother plants at the ground level and elimination of central bud. Noupadja (1995) reported that suckers harvested within nine months were significantly greater in natural suckering than that of total decapitation of pseudostem in plantain (*Musa* AAB). Weerasinghe et al. (2003) decapitated four to five month-old plants and then suppressed the growing terminal point. Sucker emergence initiated at seven to ten days after decapitation and continued up to six weeks.

False decapitation

In this method a hole is bored into the pseudostem of five to six month old plant to destroy the inner part at the level of the stem. The upper part of the plant will automatically die enabling the stock at the ground level to produce suckers. This practice is normally taken up in cv. 'Ebanga', 'Ngumba' and 'Nyale'. This method can give up to 15 suckers in just two months (Anon., 2009).

Baiyeri and Ndubizu (1994) compared the suckers produced by six cultural methods (including decapitation techniques and mulching) revealed that 98 % of the suckers survived in the first six months after planting. The fastest growing suckers were those produced by using false decapitation technique. Noupadja (1995) subjected *in vitro*-cultured plantain cv. French Sombre to different decapitation treatments and noted that suckers harvested within nine months by false decapitation were significantly greater than suckers obtained by all other treatments.

Cultural Methods

Different cultural methods were tried for sucker activation in banana.

Ascenso's method

Ascenso (1967) developed a simple technique for the rapid multiplication of Gros Michel banana. Mother plants were earthed up and fertilized with N @ 720 g ammonium sulphate plant^{-1} year^{-1} in four equal dressings to force suckering. A rapid multiplication rate of 15.5:1 was obtained in nine months. Ravichandran (1983) obtained a mean multiplication rate of 16.9:1 by this method.

Trials at Agricultural College, Vellayani also proved that this method was useful but lacks field relevance as farmers want both bunch yield and suckers. A combination of foliar spray of ethrel @ 400 ppm at 15 days interval starting from 120 DAP till shooting and Ascenso's method both at 30 and 60 cm of cutting height resulted in better sucker production (Shridhar, 1986).

Table 2. Use of organic manures and biofertilizers for sucker production

Best manure/ biofertilizer treatment	Cultivar	Authority
180: 108: 225 g NPK plant^{-1} + VAM fungus (*Glomus fasciculatum*) @ 50 g pit^{-1} + *Trichoderma harzianum* @ 50 g pit^{-1}	Rajapuri	Sabarad et al. (2004)
Azospirillium @ 20 g plant^{-1} + Phosphorus solubilizing bacteria @ 20 g plant^{-1}	Giant Cavendish	Kumar et al. (2013)
Chicken manure @ 20 kg plant^{-1} +16:16:16 NPK fertilizer mixture @ 250 g plant^{-1}	Kamphaeng Phet Emperor	Chaichuay et al. (2013)
Bacillus subtilis @ 0.9 mg sucker^{-1} + BAP (6-Benzylaminopurine) @ 4 ml sucker^{-1}	Bangladesh Malbhog	Sajith et al. (2014)

Table 3. Use of different fertilizers and micronutrients for sucker production

Best fertilizer /micronutrient treatment	Cultivar	Authority
190: 115: 300, 240: 140: 360 and 300: 140: 450 g NPK plant^{-1}	Nendran	Beena (1987)
400 g nitrogen plant^{-1}	Williams	Saad (1997)
800 g K_2O plant^{-1}	Grand Naine	Saad and Atawia (1999)
Zn (1 %) + B (0.5 %)	Giant Governor	Mandal et al. (2002)
17:17:17 NPK mixture @ 10 g and 20 g nitrogen equivalent plant^{-1}	Nendran	Kurien (2008)
180: 108: 225 g NPK plant^{-1}	Rajapuri	Athani et al. (2009b)

Use of organic manures and biofertilizers

Organic manures like vermicompost provides nutrients which are readily available to mother banana plant rhizome resulting in well developed banana clump with better suckers. Several reports exist on use of VAM fungi for enhancing growth and yield by improved colonization of VAM fungi with roots. The reports are summarized in Table 2.

Use of fertilizers and micronutrients

Use of micronutrients for sucker production is the area where further studies are necessary. The reports on the above aspects are summarised below in Table. 3.

Combination of physical and cultural methods

Doses of 0 to 240 g N and 0 to 2.2 g B plant^{-1} combined with pruning and without pruning of pseudostem tried in 'Pacovan' banana. Results revealed that pruning of the mother plant pseudostem with elimination of apical meristem and application of N increased sucker production (Nobrega et al., 2010).

Hormonal methods

Ortiz and Vuylsteke (1994) from International Institute of Tropical Agriculture, Nigeria, reported that sucker growth rates are generally the result of gibberellic acid (GA_3) levels and *Ad* gene regulates

Table 4. Effect of different hormones on sucker production

Hormonal doses	Cultivar	Authority
Ethrel @ 400 ppm	Njalipoovan, Poovan, Palayankodan, Nendran, Robusta, Red Banana and Monthan	Shridhar (1986)
GA_3 @ 200 ppm	Barjahaji	Barman and Das (2002)
BA @ 250, 500 and 750 ppm	Nendran	Kurien (2008)
Paclobutrazol @ 1.0 and 1.5 g a. i.	Prata Anã and FHIA-01	Maia et al. (2009)

GA_3 production. Increased frequency of the *Ad* gene and commensurate improvement in the suckering behavior of the diploids can be achieved by phenotypic recurrent selection. Apical dominance in plantain is genetically controlled by a major recessive *ad* gene. Most bananas have the alternative dominant allele *Ad*, which improves the suckering in plantain–banana. The *Ad* allele has incomplete penetrance, genetic specificity and variable expressivity.

Newer techniques

Different newer techniques have also been reported for salvaging the underdeveloped suckers such as split corm (Adelaja, 1995), split buds techniques, minisetting, *PIF* (*plantes issues de fragments de tiges*) meaning plants resulting from stem fragments/ bits (Lefranc et al. 2010).

Influence of mattocking on translocation of ^{32}P

On the belief that there was translocation of nutrients from the mother plant after harvest to suckers in the clump, the practice of 'mattocking' was developed. After the harvest, the whole or a part of mother plant was retained so as to nurse the follower. Nayar et al. (1956) found that the yield of ratoon crop was significantly higher than the parent when the mother pseudostem was half removed or untouched after harvest. According to Martin-Prevel (1964), the banana growers believed that one plant in a clump obtained water and nutrients from another to varying extent and that the young developing plants were nourished by the older plants. This nursing continued until the young plant is separated after reaching sufficient growth.

Morez (1960) reported that leaving a portion of the pseudostem attached to the mother corm resulted in lesser number of suckers but with longer and stouter shoots of around 26 % more leaf surface than suckers in all other methods, three months after harvest. Morez and Gullemot (1962) reported that sucker growth was improved by leaving 1.5 m of the pseudostem in Poyo banana. Walmsley and Twyford (1968) and Teisson (1970) revealed that there was transfer of ^{32}P from the mother plant and vice versa. Turner and Barkus (1973) mentioned the weekly loss of mineral from banana pseudostem after harvest. They opined that if the lost nutrients were translocated to young suckers, they would contribute more than 40 % of its requirements for all the elements, except Mg and Zn. Balakrishnan (1980) observed that intact pseudostem after harvest continued to translocate nutrients to the developing suckers in cv. 'Robusta'.

Rajeevan (1985) studied the recovery of radioactivity in the leaf tissues of sucker in the early stages after inoculation of ^{32}P in cv. Palayankodan. He found that there was translocation of nutrients from mother plant to daughter sucker after harvest in both treatments involving cutting of half pseudostem and also in case of the retention of whole plant. He concluded that it was beneficial to retain the mother plant pseudostem for one month after harvest. Murthy and Iyengar (1991) reported that at the pre-shooting stage, ^{32}P activity in the mother plant decreased with an increase in the number of suckers retained. The suckers derived 53-87 % of their P from the mother plant. Translocation of ^{32}P to the first sucker was 52, 47 and 41 % of the total P translocation when two, three and four suckers were retained respectively. During the post-harvest stage, the ^{32}P concentration and activity in both the mother plant and the sucker decreased with an increase in time of retention of the mother plant from 15 to 45 days. The P derived from the mother plant in the sucker was 44 % when the mother plant was retained for 15 days and decreased to 19 % after 45 days. The results show the deleterious effect of allowing suckers to develop during the early vegetative and pre-shooting phases due to depletion of the P content of the mother plant, and the beneficial effect of retaining the mother plant up to 45 days after bunch harvest due to mobilization of a considerable P quantity from the mother plant to the suckers.

Kurien et al. (1999) using ^{32}P confirmed that there

is a definite allocatory pattern of nutrient cycling from mother plant to daughter sucker with the first formed suckers receiving more initially and last formed suckers receiving the major share with passage of time. Kurien et al. (2002) studied the nutrient cycling from the mother plants to daughter suckers at various physiological stages of the mother plant. A combination of three spacing with five stages of sucker retention, were the treatment combinations and another similar plot was maintained without suckers in Mysore syn. Palayankodan. It was concluded that both the spacing and sucker development phases have influence on the nutrient cycling pattern. Nutrient cycling, if tapped efficiently, can result in reducing costly fertilizer inputs. Most importantly, the amount of tracer recovered from the neighboring border plants confirms beyond doubt that the tracer extruded out from the treated plant which in turn was absorbed by the neighboring plant. There is some form of nutrient sharing both within a clump and between clumps, confirming that, in banana, the system of giving recommendation on an individual basis needs to be coupled with a block or plot level.

Future thrust

Studies on clonal and intra-clonal variation with reference to the suckering habits are an absolute necessity. Understanding the genetics of sucker production, the genes coding for each aspect of quality sucker production and further genic level of manipulation should be the prime area of investigation. Though many sucker initials lie embedded in the cortex of the corm its development and activation within the corm has to be a major focal point. Physiological studies in this direction still remain as a much wanted area of research. Anatomical studies using electron microscope could throw more light on the sucker primordia development. There is a need to find out the most effective method of sucker invigoration, which can be recommended for farmers to fulfill their *in situ* planting material requirement. Further area that needs to be probed at length is sucker production in relation to biotic and abiotic stress. This will remain a priority area due to increase in arable area progressively stress prone. Standardization of enhanced sucker production techniques of each clone is also necessary and could be an easy way for genetic conservation of large variants observed in *Musa* spp.

Conclusion

Sucker production capacity varies in different banana clones and is a function of numerous internal and external factors. Large number of underdeveloped or immature suckers can be seen on the corm of a mother plant at the time of the harvest which have the potential for development as good planting material. Sucker invigoration techniques are found effective for salvaging the underdeveloped suckers. Different methods of sucker activation techniques have been followed in different locations. In real sense, the most acceptable method to the farmers will be one that ideally combines both good bunch yields with quality finger attributes and at the same time promote the production of maximum number of quality suckers.

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