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FLOWERING, FRUITING, BREEDING TECHNIQUES AND BIOTECHNOLOGICAL APPROACHES IN MACADAMIA NUT

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Abstract

For development of macadamia cultivar germplasm identify with huge tree size, broadened adolescent period, cultivar life span, verifying stable subsidizing and long haul field preliminaries for estimation of efficiency. Macadamia has been financially developed for under 160 years and current cultivars are just two to four ages expelled from nature. There is critical potential for arrival of improved cultivars with proceeded with particular reproducing. We are contemplating strategies to improve reproducing effectiveness using quantitative hereditary qualities, genome-wide choice, and agreeable field preliminaries with business makers and elective rearing populace structures through utilization of polycrosses. Past reproducing has chosen essentially for nut-in-shell yield, portion recuperation and tree size. We are investigating chances to choose for different attributes including elective tree design, changed conceptive science, piece quality qualities and infection obstruction. Some portion of this procedure includes abuse of the wild germplasm that is local to Australia in the quest for novel qualities and expanded decent variety.

Key words: Breeding, Biotechnology, Germplasm and Macadamia nut

Introduction

Macadamia nut is originated in Australia. It was introduced to Hawaii in 1878 and to Brazil in 1931. Actually there were 10 known species, but just three were used as food (*Macadamia integrifolia, Macadamia tetraphyla and Macadamia ternifolia)*. Its culture expansion occurred from the 80's, precisely to the beginning of the 90's. It found good growing conditions in South America, from Bahia (NE, Brazil) to Uruguay. Macadamia is one of the few international food crops domesticated from the Australian flora. but developed as a crop in Hawaii after the First World War. The Hawai'ian cultivars are responsible for the majority of the world production.In Kenya, macadamia nut was introduced from New South Wales inAustralia in 1946. According to Harris, (2004) six*M. tetraphylla* seeds wereplanted at Kalamaini estate in Thika district of central province More seeds of *M. integrifolia, M. tetraphylla*and hybrids of the two were introduced in 1964from Australia, Hawaii and California. In 1968, graftedseedlings were produced using scion material of superior*M. integrifolia*varieties which were imported from Hawaii.The grafted Hawaiian varieties were planted in differentagro-ecological zones. Since most of the trees were seed-propagated,there was wide variation in yield and quality of nuts. In addition, knowledge of the pedigree of advanced selections can be used to improve prediction accuracy in analysis of breeding trials. Finally, improved knowledge of the domestication pathway will assist ongoing conservation and genetic improvement of the genus.

Area and Production

Macadamia is mainly grown extensively in commercial plantations in Australia in around 20,000 hectares of macadamias with about 40% in Queensland and 60% in New South Wales. Macadamia is also commercially produced in South Africa,Brazil, California, CostaRica, Israel, Kenya, Bolivia, NewZealand, Colombia, Guatemala and Malawi and the country that cultivate the crop on a small scale include New Zealand, Mexico, Jamaica, Fiji, Argentina, Venezuela and Tanzania (Wasilwa*et al.*,2003; Hardner*et al.,* 2009).

Breeding objective

- To develop cultivars suitable to various agro ecological zones.
- To Identifying opportunities to improve productivity of the existing cultivars.
- To develop the climate resilient variety.
- To increase the sustainable use and conservation of macadamia genetic resources through biotechnology applications.
- To improve prediction of genetic value, and selection index to maximise gain from multi-trait selection.
- To identify elite candidate cultivars for improving the breeding population over generations to maintain the genetic diversity.
- To assess whether pollination is a limiting factor in nut production at tree and orchard sites.

Problems in breeding

- Trees are large and long-lived of orchard life i.e. more than 50 years.
- Slow maturity of the crop pose particular problems for breeding and selection.
- Lack of or little information about heredity/linkage associated with different economical traitsis available which makes the macadamia breeding difficult.
- Poor knowledge of crossability.
- Low percentage of fruit set and high percentage of fruit drop gives an uncertainresult in artificial crossing.
- Time of stigma receptivity and anther dehiscence is markedly influenced environmental factors. Few nut set and is followed by extensive drop, limit thehybridization work.
- Controlled crosses are very difficult to make and the stigma of the macadamia floweris extremely small, reducing the changes of successful pollination. In Hawaii, 300individual crosses were made but failed to produce acceptable progeny
- Low and inconsistent yields.

Flowering

Macadamia is an annual-flowering, evergreen tree that is bee-pollinated, partially self-incompatible and predominantly outcrossing.

Inflorescence

Macadamia nut has raceme inflorescences which develop from a node, each with whorls of between 100 and 300 tubular florets that are 6–12 mm long (Heard and Exley, 1994; Trueman, 2013). According to Heard, (1993) the flowers in inflorescence open over a period of 6–12 days generally starting from the top of the raceme and then proceeding downwards until the last flowers open near the base (Schroeder, 1959). The number of racemes per tree is reported as 2500–15,000, depending on variety and tree size (Urata, 1954a; Rhodes, 2001). The inflorescence (Racemes) are produced variably on one and two-year-old growth (Sedgley*et al.,* 1985; Rhodes, 1986).

Anthesis and Anther dhescience

Peak anthesis occurs early in the morning on flower opening (McGregor, 1999). Anthesis often progresses basipetally along racemes (Pisanu*et al.,* 2009) but it may also progress acropetally, from the centre, or from both ends depending on the cultivar and environmental conditions. Heard (1993) noted that pollen availability peaks mid-afternoon on the day of anthesis.

Pollen viability and Pollen germination

The pollen quantity and viability varies from variety to variety, with pollen germination in artificial media varying between 45 and 84% (Lavi*et al.*, 1996).In macadamia, pollen germination does not occur until 1–2 day after anthesis and pollen collected from a flower at one day before anthesiswill germinate on the stigma of flower which was opened three daybefore (Sedgley*et al.,* 1985).

Fruit set

In macadamia nut, initial fruit sets 7–21 day after pollination when swelling of the ovary takes place.The final fruit set in wild populations of *M. tetraphylla* resulted high cross-pollination (3.25–6.79%) than the self-pollination (0.67%) indicating that partial self-incompatibility in the species (Pisanu*et al.,* 2009).

Inheritance pattern

Scanty information of inheritance pattern is available. Hardner*et al*. (2001) estimated broad sense heritability, genotype and phenotypic correlations for nut and kernel traits. High broad sense heritability (H =0.63) for nut, kernel mass and kernel recovery, moderate for percentage whole kernels (H ≈0.30) and low for 1st grade kernel (H ≈ 0.20) was observed. There was little interaction between cultivar and location or age; however, for 1st grade and whole kernels, there were large 3-way and 4-way interactions. Strong correlation for nut and kernel mass (rg=0.80) and little for cultivar and location or age. There was also a large phenotypic correlation between these two traits (rp = 0.68). Kernel mass and kernel recovery exhibited some degree of genetic and phenotypic correlation (rg= 0.48; rp =0.49), however, there was virtually no genetic or phenotypic correlation for other trait combination. The prevailing variation has been effectively used in selection of cultivars with wide adaptability good nut and kernel characteristics, but very less on the inheritance pattern of traits through planned crossing is known or achieved. Some interspecific crosses between *M. integrifolia x M. tetraphylla* were developed by Storey and Saleeb (1970). Character three leafed whorls and petiolate leaves was dominant while leaf arrangement (Phyllotaxi) and leaf attachment under a single pair of genes. Complementary gene interaction of two pairs of alleles was responsible for trait spines & colour of young flush. Gene(s) for margin serrations and colour appears to be linked.

Marker-assisted selection

Marker assisted selection or marker aided selection (MAS) is a process whereby a marker (morphological, biochemical or one based on DNA/RNA variation) is used for indirect selection of a genetic determinant or determinants of a trait of interest (e.g. productivity, disease resistance, abiotic stress tolerance, and quality). The need of marker-assisted selection (MAS) in breeding of macadamia is essential for improvement of important traits. Marker assisted selection for enhanced breeding of macadamia considerable developments in biotechnology have led plant breeders to develop more efficient selection systems to replace traditional phenotypic-pedigree-based selection systems (Ribaut and Hoisington, 1998). Marker assisted selection (MAS) is the indirect selection process where a trait of interest such as disease resistance, abiotic stress tolerance, and/or quality is selected based not on the trait itself but rather on a marker linked to it. MAS will be useful in macadamia where selected characters like yield are expressed late in plant development due to long juvenile period. Selection of genotypes for such traits will not wait until fruiting time. Selection for high nut yield and quality of macadamia from an array of cross-bred population would also benefit from MAS such that useful crosses can be selected and advanced early enough. MAS can also be used to select for disease and pest resistance. However, limited molecular mapping work on macadamia has been reported. The first molecular linkage map of macadamia (*M. integrifolia and M. tetraphylla*) based on 56 F_1 progeny of cultivars `Keauhou' and `A16' was reported by Peace et al. (2003).

Transgenic

In present era, microbial induced food poisoning is a major issue to the food production industry. According to Mead *et al* (1999) incidences of food-borne illnesses in USA alone were estimated at 76 million cases, with at least 5000 deaths annually directly attributed to food poisoning.Later on scientific studies have examined the therapeutic potential of *M. integriflora*. Cock (2008) found that antibacterial activity of methanolic extracts of *M. integriflora* leaves and flowers against a panel of bacteria whereas other studies have reported that MiAMP1 protein which has been detected in macademia nuts, is also present in some other plant species with antimicrobial activities (Marcus et al., 1997). Natural antimicrobial alternatives are increasingly being sought to increase the shelf life and safety of processed foods. Later Gurel (2001)transferred a novel gene into the Agrobacterium tumefaciens strain (LBA4404) using plasmid (pPCV91)through a triparental mating system. The 5W gene was recently isolated from macadamia, a native nut tree species of Australia, and has been shown to have an antimicrobial effect against certain fungi in vitro. Secondly, this gene was tranferred into tobacco (*Nicotianatabacum cv. Xhantii*) using leaf explants to develop a system which could then be used for transferring this antimicrobial peptide into sunflower cultivars

References

Cock IE. (2008). Antibacterial activity of selected Australian native plant extracts.The Internet Journal of Microbiology.4, 2.

Gürel, E. (2001). Insertion of an antimicrobial gene into Agrobacterium and its further use in transforming tobacco. Turkish Journal of Botany, *25*(4), 169-175.

Hardner, C. M., Peace, C, Henshall, J. and Manners, J. (2005).Opportunities and constraints for marker-assisted selection in macadamia breeding. In: R. Drew, ActaHorticulturae: Proceedings of the International Symposium on Harnessing the Potential of Horticulture in the Asian-Pacific Region. International Symposium on Harnessing the Potential of Horticulture in the Asian-Pacific Region,Coolum, Queensland, Australia, (85-90). 1-3 September, 2004.

Hardner,C.M., Peace,C., Lowe,A.J., Neal,J., Pisanu, P., Powell,M., Schmidt,A., Spain,C., Williams, K., (2009). Genetic resources and domestication of macadamia.Hortic. Rev. 35, 1–125.

Harris M (2004). Involvement of the Harries family in the development of macadamia in Kenya, 1946-1974).Proceedings of the Macadamia Stakeholders meeting. 15th June, 2004. KARI HQTs. Nairobi, Kenya.

Heard, T.A., (1993). Pollinator requirements and flowering patterns of Macadamia integrifolia. Aust. J. Bot. 41, 491–497, http://dx.doi.org/10.1071/bt9930491.

Heard, T.A., Exley, E.M., (1994). Diversity, abundance, and distribution of insect visitors to macadamia flowers. Environ. Entomol. 23, 91–100.

Lavi, U., Sahar, N., Barucis, I., Gaash, D., Kadman, A., (1996). The effect of pollen donors and pollen viability on fruitlet drop in Macadamia integrifolia (Maiden &Betche). Trop. Agric. 73, 249–251.

Marcus JP, Goulter KC, Green JL, Harrison SJ, Manners JM. (1997). Purification, characterisation and cDNA cloning of an antimicrobial peptide from M. Integriflora.European Journal of Biochemistry.244(3):743–9

McGregor, S.E., 1999. Insect Pollination of Cultivated Crop Plants, (1999). Yearbook. California Macadamia Society, Fallbrook, CA, pp. 41–44

Mead PS, Slutsker L, Dietz V, McCaig LF, Breese JS, Shapiro C, Griffin PM, Tauxe RV. (1999). Food related illness and death in the United States. Emerging Infectectious Diseases 5:607–25.

Peace, C., Vithanage, V., Carrroll, B.J. and Turnbull, C. (2003). A genetic map of macadamia based on randomly amplified DNA fingerprinting (RAF) markers. Euphytica 134:17-26

Pisanu, P.C., Gross, C.L., Flood, L., (2009). Reproduction in wild populations of the threatened tree Macadamia tetraphylla: interpopulation pollen enriches fecundity in a declining species. Biotropica 41, 391–398.

Rhodes, J., (1986). Macadamia pollination. Aust. Macadamia Soc. News Bull. 13, 1–4.

Rhodes, J., (2001). Macadamia pollination.CalMac News 2, 10–19.

Schroeder, C.A., (1959). Some Observations on the Pollination of Macadamia in California, 5.California Macadamia Society, pp. 49–53, Yearbook, Vista.

Sedgley, M., Blesing, M.A., Vithanage, H.I.M.V., (1985). A developmental-study of the structure and pollen receptivity of the macadamia pistil in relation to protandry and self-incompatibility. Bot. Gaz. 146, 6–14, http://dx.doi.org/10. 1086/337494.

Trueman, S.J., (2013). The reproductive biology of macadamia.Sci. Hortic.150, 354–359, http://dx.doi.org/10.1016/j.scienta.2012.11.032.

Urata, U., (1954a). Pollination and Self-Sterility in Macadamia, 29. University of Hawaii, p. 70.

Wasilwa LA, Ondabu N, Watani G (2003). Adaptability of Kenyan macadamia selections and Hawaiian varieties in four agro ecological zones. A paper presented at the 1st KARI Adaptive Research Conference, Nairobi, Kenya