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Hormonal approaches in floral induction of mango

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Abstract
Mango exhibits a wide variation in flowering and fruiting habit due to varietal differences and diversity in agro-climatic conditions. Floral induction in mango is not once off happening, but rather a continuous process lasting during the early stages of bud differentiation. There are some correlative evidences for regulation of floral initiation in mango by plant growth regulators, GA, PBZ, Ethylene, Cytokinin, TIBA etc. PBZ could promote flowering in two ways by speed up and increase the synthesis of the floral stimulus in an inductive cycle and by affecting the ratio between flowering promoter and flower inhibiting promoter. Spraying of 500-1000 ppm ethephon and 100 ppm benzyl amino purine one month before the normal flowering resulted early bud break and increased flowering in mango. As a final consequence of efforts to elucidate the mechanisms of floral induction in mango becoming clearer at the hormonal balances play a major role in mango flowering and fruiting. Application of growth regulators in right dosages on and off year of crop helpful for getting good crop with excellent quality.

Keywords: Mango, flowering, PBZ, yield

Introduction
The Mango (*Mangifera indica* L.), member of family Anacardiaceae, is amongst the most important tropical fruit of the world. Indo – Burma-Siam regions and Philippines are considered to be the probable places of origin of mango. Besides delicious taste and excellent flavour, mango is rich in vitamins and minerals. Mango has been under cultivation for more than 4000 years in India. India continues to be the largest mango producing country of the world, accounting for more than 50 per cent of the world production. Flowering is the first of several events that set the stage for mango production each year.

Mango exhibits a wide variation in flowering and fruiting habit due to varietal differences and diversity in agro-climatic conditions. Fruiting in most of the commercially available varieties are restricted between April and July months due to its strong dependency on environment for flowering, particularly on cool winter temperatures and the age of the flowering shoots. (Rojas *et al*., 2010) [13].

India is the largest producer of mango but the productivity is very low. Low productivity in mango is mainly due to low plant population per hectare, absence of scientific methods of irrigation, inefficient nutrient management, improper orchard management practices and losses due to pests and diseases. The flowering mechanism in mango is poorly understood, although it clearly depends on environmental factors to bring about the transition from vegetative growth to reproductive growth, after causing a check in vegetative growth. Floral induction in mango is not once off happening, but rather a continuous process lasting during the early stages of bud differentiation. (Chada *et al*., 1993) [4] The various external factors are known to stimulate flowering such as water, low temperature and atmospheric stress seem to operate through putting a check on vegetative growth. Cultivars differ considerably in their growth and flowering behavior, especially the duration of the juvenile phase. (Ducher, 1972) [6]. There several reasons that can be attributed for low productivity of mango, but among them, the major cause is the dominance of vegetative phase over the reproductive phase especially under tropical conditions. The improvement in productivity in modern agriculture system is increasingly dependent on manipulation of the physiological activities of the crop by chemical means. In commercial mango plantations it is desirable to control the vegetative growth to get uniform and regular flowering.

Physiological approaches in floral induction
Hormonal approaches in floral induction
According to the proposed hypothesis of Chandler (1950) with the beginning of cell division

Flower induction in mango could occur only when the cell division had started and that a flower inducing hormone played no part in the initiation of growth; but when present in sufficient amount at the beginning of growth, it determined the course of differentiation of tissue in the auxiliary buds. He also proposed that if a hormone induced flowering in plants and the source of hormone was the leaf or some precursor formed in the leaf, then the leaf surface rather than the accumulation of carbohydrates might have the dominant influence on flowering. Singh (1961) [14] showed that the regular bearing cultivars such as 'Neelum' were capable for synthesis of flower inducing hormone in the shoots with the newly merged leaves.

There are some correlative evidences for regulation of floral initiation in mango by plant growth regulators, GA in particular. Evidences came from measurement of endogenous gibberellins, the effect of exogenous gibberellins and the effect of gibberellins biosynthesis inhibitors. In mango trees, flowering is often associated with reduced vegetative growth often induced by lower activity of gibberellins. Exogenous application of GA as well as high level of endogenous GA has proved a major hindrance in the way of flower bud differentiation in a number of temperate and tropical fruit crops including mango. Due to lack of pruning and other factors that reduce vegetative bios (water stress, cold temperatures etc.) trees become extensively vegetative particularly under tropical conditions. The yield obtained from those trees is very low and usually bears in alternative years. Thus the vegetative vigour of such trees should be suppressed. One of such methods is application growth regulators like PBZ.

Paclobutrazol

Paclobutrazol is a broad spectrum plant growth retardant that selectively controls tree vigor without marked effect on the size of fruit. The cropping manipulations possible with PBZ ranges from off-season or early season to simply increased yields (Voon *et al*., 1991). The hormonal concept of flowering in mango implies that cyclic synthesis of floral stimulus in the leaves and the difference between two such cycles would determine the flowering behavior of a cultivar (Kulakarni, 1986) [8].

PBZ could promote flowering in two ways by speed up and increase the synthesis of the floral stimulus in an inductive cycle and by affecting the ratio between flowering promoter and flower inhibiting promoter (Kulakarni, 1988). Paclobutrazol is having anti– gibberellins activity which blocks the conversion of ent kaurene to ent kaurenol in the terpenoid pathway. One of the major roles of gibberellins is the stimulation of cell elongation. When gibberellins biosynthesis is inhibited, cell division occurs, but new cells do not elongate resulting on suppression of vegetative growth. (burender *et al*., 1993) [2].

Application of paclobutrazol to the soil has been commercialized for early and enhanced flowering in mango. The various effects of paclobutrazol on tree physiology have been discussed below. Paclobutrazol can be applied as foliar spray or soil application or soil injection or by incorporating in nutrient solution. Davenport and Nunez-Elisea (1997) elaborated that unlike the other classes of retardants that are normally applied as foliar spray, PBZ is usually applied to the soil due to its low solubility and long residual activity. PBZ is taken up through roots and transported through xylem to the stem and accumulates in the leaves and fruits (Wang *et al*., 1986).

PBZ is systemic and can be taken up by roots or lenticels or bark perforations and through shoot tips, young stems and leaves, if applied as foliar spray (Voon *et al*., 1990). It is evident from the results of Burondkar and Gunjate (1993) that PBZ application increased the number of flowering shoots. Tongumpai *et al*. (1991) noticed that the number of flowering shoots of all PBZ treated trees were twice as high as that of the control. Induction of early flowering also advanced the fruit maturity (Burondkar and Gunjate, 1993). Flowering in mango is associated with reduced vegetative growth often induced by low activity of gibberellins (Voon *et al*., 1991). Exogenous application of GA as well as high levels of endogenous gibberellins has proven to be a major hindrance in the way of flower bud differentiation in a number of temperate and tropical fruit crops including mango (Tomer, 1984). Considering the inhibitory role of GA in flower development in mango, paclobutrazol owing to its anti-gibberellin activity (Voon *et al*., 1990) could induce or intensify flowering by blocking the conversion of kaurene to kaurenoic acid. Such alterations could be important in restricting vegetative growth and enhancing flowering by altering the source–sink relationship. Reduction in gibberellins induced by paclobutrazol application has been reported in mango by Flesher and Gilley (2000), Abdel Rahim *et al*. (2011), [2] Kulakarni (1988), Protacio *et al*. (2000), Upreti *et al*. (2013). [17]

Ethylene

Ethylene is unique that it is the only gaseous phytohormone, usually presents in minute quantities and affects various physiological activities like flowering, fruit ripening, abscission etc. in plants. Ethylene generating agent, ethephon spraying at 125– 200 ppm induced flowering in Carabo mango in Philippines within six weeks after treatment (Dutcher, 1972). Ethephon has also been successful in India for increasing flowering of Langra and Dashehari during 'on' years (Chacko *et al*., 1974; [3]. Nunez-Elisea *et al*., (1980) [9] reported that spraying of 500-1000 ppm ethephon one month before the normal flowering increased the flowering by 40-55 per cent in ten years old Haden mango.

Cytokinin

The flowering mango tips were associated with higher levels of cytokinins, particularly Zeatin and Zeatin ryboside was reported by (Agarwal *et al*., 1980) in eleven mango cultivars. Chen (1983) extensively studied the importance of cytokinins in the regulation of flower bud differentiation in mango. Elevated cytokinins have been implicated in breaking dormancy in adventitious and axillary buds (Stafstrom, 1995). Chen (1987) reported, application of 100 ppm benzyl amino purine during themonth of October, resulted early bud break and flowering in mango and concluded that elevated levels of cytokinins found prior to and during flowering and applied BA led to conclusion that cytokins are involved in stimulation of bud break.

TIBA (Tri Iodo Benzoic Acid) It was well known that the spraying of different bio regulators like TIBA, cycocel, Alar etc. during the period of critical fruit bud differentiation resulted in induction of flowering during 'off' year (Rao and Ravisankar, 1992). Among them TIBA @ 100 ppm promoted 100 per cent flowering.

Conclusion

Floral induction in mango is very critical stage and play vital role in producing the crop and it is also indirectly related to the overall productivity of mango. A number of factors are involved in the floral induction of mango such as age of the shoots, climatic conditions, physiological, biochemical conditions. In addition, anthropogenic factors such as pruning, irrigation, application of nitrogenous substances and/or fertilizers and exposure to ethylene can also stimulate the floral initiation. Although a period of low temperature (less than 18 ^{0} C) during the pre-flowering period is thought to be involved in floral initiation. Some floral promoter and some inhibitors are also involved in the initiation of flowering of mango. Likewise, a flowering stimulus is synthesized in leaves which induce floral initiation in buds of mango. Relatively higher levels of some inhibitors (abscise acid) was recorded during the flower-bud-initiation in the 'on' year shoots of mango trees compared to shoots of 'off' year trees. It indicates that in the flowering of mango, promoters and inhibitors might be actively involved. As a final consequence of efforts to elucidate the mechanisms of floral induction in mango becoming clearer at the hormonal balances play a major role in mango flowering and fruiting.

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