Research Application Summary pp: 241 - 246

Effects of ethephon and potassium nitrate on off-season flower induction in mango

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Abstract

Mango (*Mangifera indica*) fruit production in Kenya is seasonal with peak and off seasons – one of the contributing factors to postharvest losses. Off-season flower induction is a strategy that can be used to address mango seasonality. Manipulation of mango trees to produce an off-season crop can be achieved through application of flower induction chemicals. In the present study, the two flower induction chemicals, potassium nitrate (KNO_3) and ethephon were evaluated on two mango varieties: 'Apple' and 'Ngowe'. The study was conducted in two agro-ecological zones (AEZs) of Kenya namely, Embu County (a high potential AEZ) and Makueni County (a low potential AEZ). The age of the trees used in the experiment were of similar size and vigor with an average age of 6 to 8 years. Potassium nitrate was applied at two concentrations (2 and 4%), while ethephon was applied at three concentrations (300, 600 and 1000ppm) and compared to a control (water). Prior to spraying, 100 terminal shoots were marked randomly on each tree for percentage flowering determination. After inflorescence development, 20 panicles per tree were marked randomly on each tree to monitor fruit set. The experiment was laid out in a randomized complete block design with three replicates and three trees per treatment. Effect of the treatments was established from reproductive growth parameters including days to flowering and fruit set, number of panicles per tree and average fruit set per 20 panicles. Potassium (4%) increased percentage flowering (% of tagged shoots) in both 'Ngowe' and 'Apple' in both AEZs. In Embu, 4% KNO_3 resulted in 46% flowering in 'Ngowe' compared to 4% in 'Apple'. On the contrary, in Makueni, the response was greater in 'Apple' (60%) compared to 'Ngowe' (27%). Response to ethephon increased with concentration with the 1000 ppm giving the best response; 22 and 28% flowering (% of tagged shoots) for Embu and Makueni, respectively, in 'Ngowe'. In both AEZs and varieties, flowering was d" 3% in untreated controls. Time to flowering was significantly shortened by both KNO_3 and ethephon treatments with 'Ngowe' being more responsive than 'Apple'. Significant treatment effect (pd" 0.05) was observed on fruit set with 4% KNO_3 and 1000 ppm ethephon resulting in the highest fruit set in both AEZs and varieties. The findings reveal the potential of KNO_3 and ethephon to induce off-season flowering in 'Apple' and 'Ngowe'. Further studies are on course to optimize the treatments for commercial application.

Key words: Flowering, flower induction, mango, seasonality

Résumé

La production de fruits de mangue (*Mangiferaindica*) au Kenya est saisonnière avec un pic et hors-saison - l'un des facteurs qui contribuent à des pertes post-récolte. L'induction florale hors saison est une stratégie qui peut être utilisée pour répondre à la saisonnalité de la mangue. La manipulation des manguiers pour produire une culture de contre-saison peut être atteinte par l'application d'introduction chimique de fleur. Dans la présente étude, les deux produits chimiques d'introduction de fleur, le nitrate de potassium (KNO_3) et l'éthéphon ont été évalués sur deux variétés de mangue: «Pomme» et «Ngowe ». L'étude a été menée dans deux zones agro-écologiques (ZAE) du Kenya à savoir, le comté d'Embu (un fort potentiel AEZ) et du comté de Makueni (un faible potentiel AEZ). L'âge des arbres utilisés dans l'expérience étaient de taille similaire et la vigueur avec une moyenne d'âge de 6 à 8 ans. Le nitrate de potassium a été appliqué à deux concentrations (2 à 4%), tandis que l'éthéphon a été appliqué à trois concentrations (300, 600 et 1000ppm) et comparée à un contrôle (eau). Avant la pulvérisation, 100 pousses terminales ont été marquées au hasard sur chaque arbre pour le pourcentage de détermination de la floraison. Après le développement de l'inflorescence, 20 panicules par arbre ont été marquées au hasard sur chaque arbre pour contrôler la mise à fruit. L'expérience a été aménagée dans une conception en blocs aléatoires complets avec trois répétitions et trois arbres par traitement. L'effet des traitements a été établi à partir des paramètres de croissance de la reproduction, y compris les jours à la floraison et à la nouaison, le nombre de panicules par arbre et la nouaison moyenne par 20 panicules. Le potassium (4%) a augmenté le pourcentage de floraison (% de pousses marqués) à la fois «Ngowe» et «Pomme» à la fois dans les ZAE. En Embu, 4% KNO_3 a donné lieu à 46% de floraison dans «Ngowe» comparativement à 4% dans « Pomme ». Au contraire, dans Makueni, la réponse était plus grande dans « Pomme » (60%) par rapport à «Ngowe » (27%). La réponse à l'éthéphon a augmenté avec la concentration de la 1000 ppm en donnant la meilleure réponse; 22 et 28% de floraison (% de pousses marqués) pour Embu et de Makueni, respectivement, dans «Ngowe ». Dans les deux zones agro-écologiques et des variétés, la floraison a été de 3% chez les marques non traités. Le temps de la floraison a été réduit de façon significative à la fois par KNO_3 et les traitements de l'éthéphon avec « Ngowe » étant plus réactif que «Pomme». L'effet significatif du traitement (pd "0,05) a été observée sur les fruits de sertie de 4% KNO_3 et 1000 ppm éthéphon résultant de l'ensemble des fruits le plus élevés dans les deux zones agro-écologiques et les variétés. Les résultats révèlent le potentiel de KNO_3 et l'éthéphon pour induire la floraison hors saison dans «Pomme » et «Ngowe ». D'autres études sont en cours pour optimiser les traitements pour une application commerciale.

Mots clés: Floraison, l'induction florale, la mangue, la saisonnalité

Background and Literature summary

While tropical climates are conducive for year-round vegetative growth of perennial tropical fruit crops, flowering and fruit set is seasonal. In Kenya, because seasonality of fruit production, the mango sub-sector faces problems of oversupply during peak season (November to April), resulting in high post-harvest losses. Scarcity during the off-peak

season (period) results in high commodity prices and below-capacity operations for processors. The oscillating supply cycles can be addressed by manipulating mango flowering in order to obtain off-season fruit set, hence year-round fruit production (Davenport, 2007).

Success has been achieved in stimulating off-season mango flowering using chemical/ hormone treatments such as ethephon, paclobutrazol, calcium nitrate, potassium nitrate and cultural practices such pruning (Davenport, 2009; Wilkie *et al*. 2008;Yashitela *et al*. 2006). The ethylene-generating agent, ethephon, has been used to successfully induce and increase flowering in various mango varieties in the Philippines and India. The efficacy was reported to be affected by concentration and the trees' developmental stage (Chanda and Pal, 1986). Potassium nitrate (KNO_3) has been shown to stimulate early flowering and increase numbers of panicles in trees growing in tropical and subtropical regions, thus ensuring increased and regular production (Adam, 1986). Potassium nitrate is used to induce off-season flowering and for synchronous flowering in mango. The effective spray concentration ranges from 1 to 10% KNO_3 with the optimum concentration varying with the age of the trees and climatic conditions (Kulkarni, 2004; Davenport, 2009).

Objectives

The objectives of this study was to determine the efficacy of two flower induction treatments (Potassium nitrate and Ethephon) on two mango varieties ('Apple' and 'Ngowe') produced under two contrasting agro-ecological conditions in Kenya.

Study description

The study was conducted in two agro-ecological zones (AEZs) of Kenya namely Embu County (a high potential mango production AEZ) and Makueni County (a low potential mango production AEZ). Two flower induction chemicals, potassium nitrate (KNO3) and Ethephon were evaluated in commercial farms in Embu and Makueni Counties. Test trees comprised of randomly selected 'Apple' and 'Ngowe' mango trees. The trees were of similar size and vigor with an average age of 6 to 8 years. Potassium nitrate was applied at two concentrations (2 and 4%), while ethephon was applied at three concentrations (300, 600 and 1000ppm) and compared to a control (water). Prior to spraying, 100 terminal shoots were marked randomly on each tree for percentage flowering determination. After inflorescence development, 20 panicles per tree were marked randomly on each tree to monitor fruit set. The experiment was laid out in a randomized complete block design with three replicates and three trees per treatment.

Effect of the treatments was established from reproductive growth parameters including days to flowering and fruit set; number of panicles per tree and average fruit set per 20 panicles. Internal ethylene of young fruits was determined in Ethephon-treated trees.

Results

Time to flowering was significantly shortened by both KNO_3 and Ethephon (600 and 1,000 ppm) treatments with 'Ngowe' being more responsive than 'Apple' (Table 1). In Embu,

flowering started 15 and 18 days earlier in 4% KNO_3 and 1000 ppm Ethephon treated trees respectively in 'Apple' fruits. Flowering was also hastened in 'Ngowe' fruits but the response was not at notable as in 'Apple'. In Makueni 4% KNO_3 and 1000 ppm resulted in earlier flowering by 40 and 36 days respectively in 'Apple'. Significant treatment effect was observed on fruit set with 4% KNO_3 and 1000 pm ethephon resulting in the highest fruit set in both AEZs and varieties.

Trees treated with 4% KNO_3 recorded the highest % flowering in both varieties and sites (Table 2). The percentage flowering induced by 4% KNO_3 in Embu was 46% and 4% in 'Ngowe' and 'Apple' respectively while flowering in the control trees was 3% and 0 % respectively. In Makueni, the percentage flowering induced by 4% KNO3 was 27% and 60% in 'Ngowe' and 'Apple' respectively while flowering in the control trees was 2% and

Table 1. Effects of potassium nitrate and Ethephon on the days between spraying and flowering in apple and 'ngowe' in Embu and Makueni Counties.

Treatments/Variety	Embu		Makueni	
	Apple	Ngowe	Apple	Ngowe
2% KNO3	70a	33a	65c	34b
4% KNO3	68a	30a	40a	29a
Ethephon 300 ppm	76b	42b	72d	35b
Ethephon 600 ppm	69a	35a	45b	36b
Ethephon 1000 ppm	65a	31a	44b	31a
Control	83c	40b	80e	48c
LSDs	4.235	3.843	3.081	2.813

*Means followed by different letters in a column are significantly different by LSD test at p=0.05.

Table 2. Effects of Potassium nitrate (KNO_3) and Ethephon on percentage flowering in 'apple' and 'ngowe' in Embu and Makueni Counties.

Treatments/Variety	Embu		Makueni	
	Apple	Ngowe	Apple	Ngowe
2% KNO_3	0a	5a	0a	10b
4% KNO_3	4c	46d	60d	27c
Ethephon 300 ppm	0a	3a	0a	4a
Ethephon 600 ppm	0a	16b	2b	9b
Ethephon 1000 ppm	2b	22c	5c	28d
Control	0a	3a	0a	2a
LSDs	1.624	4.108	1.049	3.407

*Means followed by different letters in a column are significantly different by LSD test at p=0.05.

0 % respectively. Ethephon at 300 ppm had no significant effect on percentage flowering in both varieties in Embu and Makueni compared to the control. Response to ethephon increased with concentration with the 1000 pm giving the best response; 22% and 28% flowering (% of tagged shoots) for Embu and Makueni respectively in 'Ngowe'. In both AEZs and varieties flowering was < 3% in untreated controls. Significant treatment effect ($p<0.05$) in internal ethylene levels was observed in immature fruits sampled from the trees treated with Ethephon at 1000 ppm compared to untreated control.

Discussion

Significant KNO_3 treatment effect on time to flowering and % fruit set was observed in both mango varieties regardless of the production location. KNO_3 at 4% induced early flowering in treated trees compared to control trees. This effect could be in part attributed to additional N from KNO_3. Increased nitrogen fertilization through the soil has been found to increase fruit retention and yield in mango (Smith, 1994; Yashitela *et al*. 2004).

Higher concentration of Ethephon (600 ppm and 1000 ppm) induced higher % flowering and fruit set. The ethylene-generating agent, Ethephon, has been used to successfully induce and increase flowering in various mango varieties in the Philippines and India (Chanda and Pal, 1986; Dutcher, 1972). However, the mode of action of Ethephon in flower induction is not clearly understood. The response to Ethephon is dependent on many factors including concentration, stage of development, growing conditions, variety, among others. This calls for extensive studies to establish effective and economical (cost-effective) treatment regimes for the different varieties produced in the various AEZs.

Acknowledgement

We thank the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) for giving us an opportunity to share our findings.

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