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Regulation of Flowering and Fruit Quality in Pineapple cv. Kew (*Ananas comosus* Merr.) Grown as Intercrops in Guava Orchard

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A B S T R A C T

A field trial was conducted to regulate flowering in pineapple cv. Kew by application of fertilizer, mulching and flowering hormone together to achieve maximum flowering and yield at ICAR–RCER, Ranchi Centre, India. The study was carried out infactorial RBD experimental design with three replications. All samples were analyzed through standard methods. Studies showed that in treatment T_6 involving F2 fertilizer dose for pineapple (100 per cent N: P:K= 600:400:400 kg/ha), plastic mulching and ethephon 30 ppm together, the final flowering per cent of pineapple were 70.42 and 69.11 during first and second year. The pineapple cv. Kew recorded the maximum average TSS of 14.85 ^{0}B under plastic mulch along with F2 fertilizer treatment in T_6. The highest average yield of pineapple was observed in F3 (100% standard fertilizer dose of pineapple + 50 % standard fertilizer dose of guava) and local weed mulching with ethephon 30 ppm treatment (T_8) and average yield was 8.9 t/ha as intercrop (TSS=13.9^{0}B). However, under T_8 treatment, mulching material when changed from plastic to local weed, the average yield of both the years was increased from 7.95 to 8.9 t/ha. On the contrary, the average TSS of the fruits decreased from 14.85^{0}B to 13.9^{0}B. In T_8, F3 treatment with local weed mulching also recorded the maximum average soil moisture was 20.94% during growing period which influenced the production of bigger fruit (1.41 kg) by affecting growth process. Regulated deficient irrigation under hill and plateau condition of India gave the promising results which paved the way for cultivation of pineapple with 100% standard dose of N: P: K fertilizer (600:400:400 kg/ha). T_6 treatment, i.e., F2 fertilizer dose, plastic mulching and ethephon (30 ppm) may be recommended for obtaining quality fruit (TSS=14.85^{0}B). On the other hand, T_8, i.e., F3 fertilizer treatment, local weed mulching and ethephon (30 ppm) was appropriate for obtaining maximum yield (8.9 t/ha) as intercrop in guava orchard.

Introduction

The pineapple is one of the most edible fruit crops of the family Bromeliaceae which embraces about 2,000 species, mostly epiphytic and ornamental. It is known as *Ananas comosus* Merr. (Morton 1987). The pineapple fruit has acquired few vernacular names like pinaby Spanish-speaking people, *abacaxi* in the Portuguese tongue, *ananas* by the Dutch and French and Asians (Paull and Duarte 2010, Elzibroek and Wind 2008). In

China, it is *po-lo-mah;* sometimes in Jamaica, sweet pine; in Guatemala often merely "pine" (Bembry, 2017). It is believe to be originated in Southern Brazil and Paraguay stretching from Parana-Paraguay river banks (Morton 1987). In India the total pineapple production during 2017-18 is about 1705.76 thousand MT from 102.96 thousand ha (Hort. Stat, 2018). Overall pineapple production around the world was all time high about 27.4 million metric tons (Shahbandeh, 2019). Quality and economic value of pineapple fruits are determined by the flavonoids present in fruits, which influences color, aroma, and antioxidant composition and astringent properties (He and Giusti, 2010). Accumulation of flavonoids in fruits of pineapple was due to internal factor e.g., hormonal regulation and external factors, including temperature, humidity light conditions like number of sunny days during growth period, nutritional status of soil rhizosphere and biotic stresses (Koes *et al.*, 2005; Jaakola and Hohtola, 2010; Azuma *et al.,* 2012). In higher rainfall area of eastern India, pineapple is a common fruit and it is fair source of vitamins, carbohydrates, crude fiber, water and different minerals like Ca, Mg and Zn (Kader *et al.,* 2010) and minimal in fat and sodium content (Sabahelkhier *et al.,* 2010). In main crop (up to 1st harvest), the most economic rate of N_2 application was 18 g N_2/plant resulted in highest fruit weight and size which were of best quality fruits harvested from the plants and 40 % of this dose was required for ratoon crop (Su, 1969). Kew variety of pineapple grown as intercrop with mango orchard in laterite soil of West Bengal showed the need of more nitrogen for growth and development (Ghosh and Tarai, 2009). Hassan *et al.,* (2008) also mentioned pineapple intercropped with jackfruit gave remarkable return in agro ecosystem of Madhupur district of Bangladesh. In Goa, India, it has been found that pineapple intercropping with cashew nut provides satisfactory income to the small and marginal farmer (Desai *et al.,* 2010). Regulation of flowering in pineapple using ethrel has been reported by Avila *et al.,* (2005) Cunha (2005). For synchronization of flowering and excellent yield, induction of flowering by chemical is gaining importance in recent times. It also facilitates the ease of harvesting and maintenance of uniform fruit quality in terms size and weight. For induction of flowering at a time in pineapple, several chemical have been reported to use. Ethrel/ethephon increases in protein and carbohydrates levels in bud and thereby enhances flowering (Avila *et al.,* 2005). Organic mulches particularly mulching with sudan grass conserved more soil moisture which increased infiltration and enhanced yield in sesame agronomical crop (Teame *et al.,* 2017). Commercial guava orchards are seen in the North eastern states like West Bengal, Jharkhand and Bihar, India (Maji and Das, 2013) and guava intercropped with pineapple is profitable crop combination in eastern and northeastern India. A study in this direction will provide an ample opportunity to the researchers to understand fruit growing and interaction study of soil, water and environment to pineapple plants. Therefore, an attempt has been made to induce profuse flowering and fruiting of pineapple growing as an intercrop with fruit crop like guava under rain-fed ecosystem of eastern plateau region of Jharkhand, India. Keeping above point in view, the present investigation was conducted to induce flowering in pineapple by different means such as application of fertilizer, mulching and flower inducing chemical to achieve the maximum yield and fruit quality.

Materials and Methods

The experiment was conducted at ICAR Research Complex for Eastern Region, Research Center, Ranchi, and Jharkhand,

India. This area was situated 620 m above mean sea level (msl) and at 230 25' N latitude and 850 20' East longitudes experiencing an average annual rainfall of 110-140 cm. Here guava was cultivated under rain-fed ecosystem. Plot Size was 2m x 5 m for pineapple bed while guava was planted in 5m x 5 m distance. In pineapple bed pineapple spacing was 1mx 0.45m. Fertilizer dose of guava was 260:320:260 g /plant/year N:P:K (Mitra and Bose, 1985) while this was 600:400:600 kg/ha for pineapple tree (Roy *et al.*, 1986). Statistical Design was Factorial RBD.

Treatments were in F1= 100 % guava (G) [i.e. no fertilizer dose for pineapple] only mulching of pineapple, F2=100 % fertilizer dose of pineapple (P) [no fertilizer dose for guava], F3=100% (P) +50 % (G) [i.e. for pineapple dose was 100 % but provision was such a that it (pineapple) may get additional moisture and soil nutrient from adjacent guava plots], F4=50 % (P) +50% (G) [i.e. for pineapple dose below 100%]. Mulching materials were Paddy straw (M1), Local weed [M2 – mulching by Deenanath grass (*Pennisetum pedicellatum* Trin.) and green dried grass] and Plastic (M3). Total 12 treatment (4X3) combinations and control (T_1-T_{13}) were developed for this study and replication was 3. Flowering induced hormone, ethephon, liquid was applied @ 20 ppm to half of the population of each replication and 30 ppm to the rest. The treatment combinations were as follows.

Treatments Combinations	M1 (Paddy straw)	M2 (Local weed)	M3 (Plastic)
F1=100 % guava (G)	T_1=FIM1	T_2=F1M2	T_3=F1M3
F2=100 % fertilizer dose of pineapple (P),	T_4=F2M1	T_5=F2M2	T_6=F2M3
F3=100% (P) +50 % (G)	T_7=F3M1	T_8=F3M2	T_9=F3M3
F4=50 % (P) +50% (G)	T_{10}=F4M1	T_{11}=F4M2	T_{12}=M4M3
Control: No fert., mulching &ethephon	T_{13}=Control		

*Half of the pineapple population of each replicated plot was treated with 20ppm and 30 ppm ethephon equally

Ethephon was applied in first week of January. No irrigation was provided except lifesaving irrigation of 1 or 2 spells given during May–June at one month interval to establish young orchard at their initial establishment as well as mature plants for flowering and fruiting.

The climate was sub-humid and subtropical type. High humidity (78.14%-84.14 %) and low evaporation rate were experienced after June and continues up to onset of winter (Singh, 1999). Soil was acidic and pH ranged from 5.0-6.5, which was ideal for pineapple and guava cultivation. TSS was measured by hand held re-fractrometer and expressed as degree brix (^{0}B) (Ranganna, 1977). Soil moisture was recorded from the sample taken at soil depth of 15 cm through standard method (TNAU-2013) in every month.

Results and Discussion

Data pertaining to Fig-1 revealed that in T_6, F2 fertilizer and plastic mulching, initial flowering percentage was 48.61 per cent while it was reported to be 70.42 per cent at final flowering stage in case of 30 ppm ethephon (application before flowering in January in first year). A close perusal of the Fig-2, expressed that in the same treatment, T_6, F2 fertilizer and plastic mulching initial flowering percentage was 39.82 and final flowering was 69.11 in case of 30 ppm ethephon application in second year. However in case of yield, the average highest yield (8.9

t/ha) was observed in pineapple in local weed mulching with F3 fertilizers and 30 ppm ethephon application (T_8). Local weed mulching conserve more soil moisture because of increased infiltration, optimum aeration and imparting organic matter to soil resulted in congenial rhizosphere and the maximum production of pineapple. Mulching material with high nitrogen content improves soil nitrogen status which finally increase the crop yield (Telkar *et al.,* 2017). In T8, combination of F3 fertilizer dose and local weed mulching treatment, pineapple plot may obtain additional soil moisture and nutrients from adjacent guava plotto boost production. These findings were corroborated by the findings of Teame *et al.,* (2017) while working on sesame crop with Sudan grass mulching. Local weed decomposed faster than paddy straw and plastic mulching. This could help in increasing water holding capacity of the soil and proving organic matter and nutrient to the soil (Ngosong *et al.,* 2018 and Ranjan *et al.,* 2017). In T8, F3-local weed mulching and ethephon 30 ppm treatment, the average TSS of the fruit was 13.9^0B. Under same treatment when mulching material was changed from plastic to local weed, average yield was increased from 7.95 t/ha to 8.9 t/ha but the average TSS of the crop was decreased from 14.85^0B to 13.9^0B. Regulated deficient irrigation under hill and plateau condition of India also gave the promising results for average quality fruit (TSS=14.85^0B), when pineapple was cultivated with standard N:P:K fertilizer (600:400:400 kg/ha) along with plastic mulching and ethephon (30 ppm) but yield was lower. A close look on the Fig-3 revealed that local weed mulching (M2) with F3 fertilization treatment (T_8) increased fruit weight due to sufficient availability of moisture and organic matter to plant under harsh condition.

Table.1 Pooled data on flowering, fruit weight and yield, as affected by different treatments with 30 ppm ethephon (best)

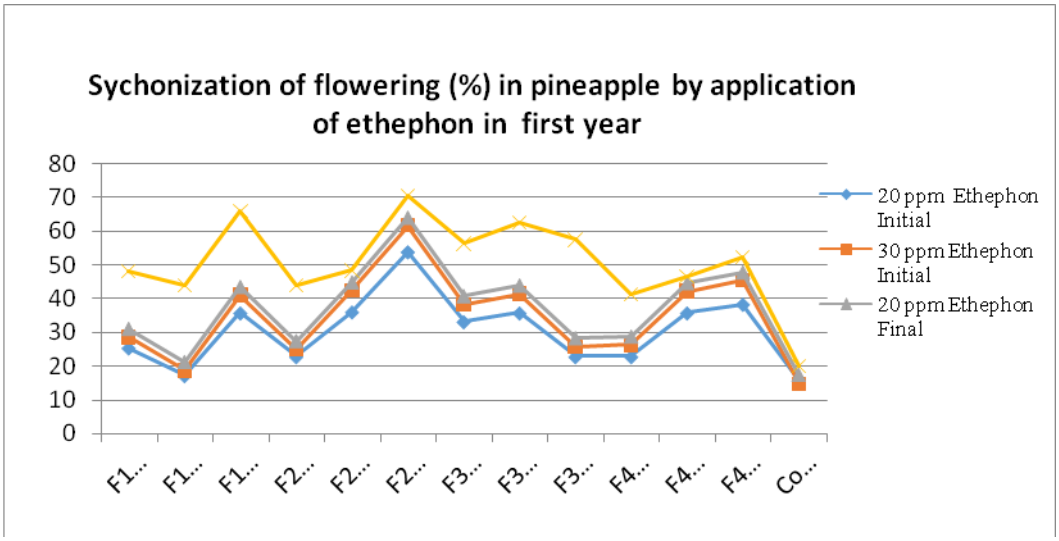
Treatments	Average Flowering (%)	Average Fruit Weight (Kg)	Average Yield (t/ha)	TSS of fruit (^{0}B)
T_1= F1, M1 and 30 ppm Ethephon	51.07	0.93	5.12	11.65
T_2= F1, M2and 30 ppm Ethephon	46.90	1.06	7.00	11.85
T_3= F1, M3 and 30 ppm Ethephon	61.69	0.99	5.30	12.55
T_4= F2, M1 and 30 ppm Ethephon	46.82	1.17	6.79	12.15
T_5= F2, M2 and 30 ppm Ethephon	54.49	1.39	8.16	12.35
T_6= F2, M3 and 30 ppm Ethephon	69.76	1.23	7.33	12.75
T_7= F3, M1 and 30 ppm Ethephon	57.64	1.24	8.16	12.60
T_8= F3, M2 and 30 ppm Ethephon	62.44	1.41	8.90	13.90
T_9= F3, M3 and 30 ppm Ethephon	58.77	1.24	7.95	14.85
T_{10}= F4, M1and 30 ppm Ethephon	43.89	0.99	5.76	11.25
T_{11}= F4, M2 and 30 ppm Ethephon	51.05	1.15	5.01	11.55
T_{12}= F4, M3 and 30 ppm Ethephon	54.27	1.06	5.56	12.53
T_{13}=Control: no fert,muching&Ethephon	24.71	0.89	3.2	11.05

*Treatment means were significant at $p < 0.05\%$

Plate.1 Pineapple as intercrop in guava orchards at ICAR-RCER, Ranchi, Jharkhand

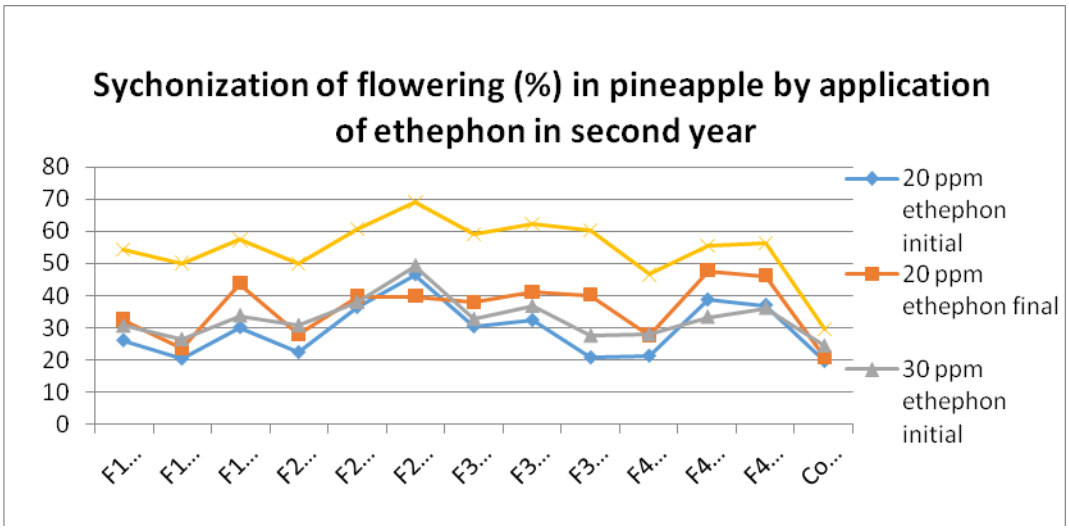
Plate.2 Synchronization of pineapple flowering with 30 ppm ethephon and plastic mulching and 100% standard dose of fertilizer (N: P: K 600:400:400kg/ha). The maximum average flowering was 70. 42%

Fig.1 Synchronization of flowering in pineapple by application ethephon 20 ppm and 30 ppm during first year



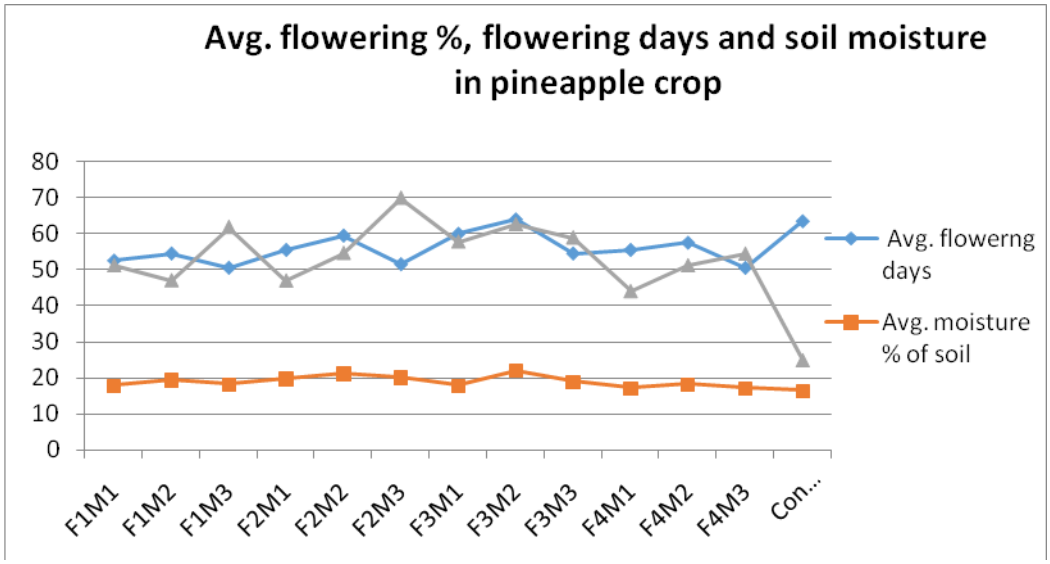
*Treatment means were significant at $p < 0.05\%$

Fig.2 Synchronization of flowering in pineapple by application of ethephon 20 ppm and 30 ppm during second year



*Treatment means were significant at p < 0.05%

Fig.3 Relation between moisture and flowering in pineapple induced by fertilizer, mulching and 30 ppm ethephon (best)



**Treatment means were significant at p < 0.05%*

In above case, it was also found that the maximum average soil moisture of 20.94% during growth period which influenced for bigger fruit size (1.41 kg) by influencing growth and developmental process. This results was also supported by Singleton, 1965, Joy *et al.*, 2010 and Priya Devi *et al.*, 2013; where fruit weight was influenced by sunlight and soil moisture. But in T_6, M3 plastic mulching, fruit weight diminished because of flowering was the maximum which competes for available nutrients from soils in unfavorable weather condition. Fertilizer and moisture stress influence more flowering in

presence of ethephon 30 ppm but nourishment for fruit were interrupted and slow. High temperature during June paved the way for faster ripening of pineapple fruits early. From two consecutive years of study, it was observed that in T_6 plastic mulching of F2 induced early flowering and just took 54 days and 51 days from first January of the respective years. Plastic mulching increased soil temperature which promote osmo-regulation, resulted in increased and early flowering but the fruit size was decreased. In T8, local weed mulching ensured optimum average flowering (62.44 % in F3M2) (Table-1) and gave average maximum production. This might be due to getting additional soil moisture and nutrient from adjacent guava plot/plants. On the contrary, in plastic mulching (F2M3) of T_6, the maximum average flowering was (69.76%) but recorded less yield due to moisture and nutrient stress. Yakushiji *et al.,* (1996) also reported that moisture stress affects many physiological process including sugar accumulation in citrus trees. Mulching also influenced early flowering in cucumber by increasing soil temperature (Shaik and Fouda, 2008). In previous study related to plastic mulching in strawberry also paved the way for early flowering (Das *et al.,* 2007). In our study, in T_8 application of 30 ppm ethephon influenced fruit weight and fruit quality through standard fertilizer dose and local weed mulching. This result was supported by Joy *et al.,* 2010 and Pal *et al.,* 2015 when they applied growth regulators and mulching material for pineapple production.

Conclusion of the study is as follows:

In spite of having medium flowering per cent, the maximum average yield of pineapple 8.9 t/ha was obtained in treatment in T_8, where F3 [100% recommended dose (P) + 50 % (G)] and local weed mulching along with the application of ethephon @ 30 ppm were applied. This was due to bigger fruit size as fruits were supported by sufficient nutrients and soil moisture.

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