Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5994

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 464-474 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Phenological Stages of Wild Species and Cultivated Species of Guava (*Psidium guajava* L.)

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Received: 14.11.2017 | Revised: 10.12.2017 | Accepted: 12.12.2017

ABSTRACT

Guava (Psidium guajava L., 2n = 22) belongs to the family Myrtaceae, has got adequate genetic variation which will be an essential criteria for any crop improvement programme. The study of phenological stages and growth behavior is crucial to exploit these species in introgressing beneficial genes. Hence, the present study deals with the phenology of wild species of guava viz., Psidium guineense, P. chinensis, P. cattleianum and cultivar Arka Kiran. Phenological stages from time of leaf flushing to duration of fruiting were considered. The results revealed that synchronization was noticed in P. guineense and P. chinensis with Arka Kiran for peak flowering, duration of flowering and anther dehiscence, whereas P. cattleianum showed differential flowering time (June) compared to other species. P. cattleianum recorded lowest values for duration of flower bud initiation to full bloom, duration of flowering, peak flowering, per cent pollen germination, duration of flowering to fruit set and duration of fruiting.

Key words: *Phenological stages, Guava, Wild*

INTRODUCTION

Guava (*Psidium guajava* L., 2n = 22) belongs to the family Myrtaceae, is one of the most important commercial fruit crops of India. Commercial cultivation of guava is common in Brazil, Mexico, Florida, Hawaii, California etc. The genus *Psidium* includes about 150 species among which only twenty produce edible fruits and is widely distributed all over the equatorial regions of tropical and subtropical climate. Guava fruits contain calcium, phosphorus, iron and small quantities of thiamine, riboflavin and niacin. It is also rich in pectin and vitamin C. *Psidium* genus has got adequate genetic variation which is required for any crop improvement programmes. Other *Psidium* species including *P. cattleianum* Sabine, *P. friedrichsthalianum* (O. Berg) Nied., *P. guineense* Sw., *P. montanum* Sw. and *P. sartorianum* (O. Berg) Nied[15] reported to have different utility and are fairly well distributed and thus can be used for crop improvement.

Cite this article: Alfia, M.A., Vasugi, C., Honnabyraiah, M.K., Adiga, J.D., Shivapriya, M. and Vincen, L., Phenological stages of wild species and cultivated species of guava (*Psidium guajava* L.), *Int. J. Pure App. Biosci.* **5(6):** 464-474 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5994

These wild species also have resistance or tolerance towards many biotic and abiotic stresses[4,8,19]. In order to make use of particular genotypes for effective crop improvement programme, it is crucial to know their phenological stages.'Phenology' is defined as the study of the sequence of all periodical events involved in a plant life cycle. Phenological stages are external physiological changes occurring at specific periods of time, which coincide with the natural growth cycle at each specific moment[5].Plant growth rates can be evaluated by establishing the beginning and end of every developmental stage[21]. The interval between two different phases is called 'phenological stage'[23]. The knowledge of flower bud development, time of dehiscence and anthesis, extent of fruit set and degree of cross pollination are a pre-requisite for a planned hybridization programme. The growing cycle depends on plant genotypes as well as on climatic conditions. Even identical genotypes when grown under different conditions may show different developmental stages. Thus phenological studies help to bring out precise information about the flowering behavior, duration of flowering, anthesis and pollen dehiscence, time taken for fruit set, duration of fruiting among the cultivated and wild species. This will help in planning an effective hybridization programme involving the wild species and cultivated varieties. According to Villalpando and Ruız[23] the interval between blooming and fruit set is one of the most important phenological stages.The systematic research related to phenological stages in wild species of guava is limited. Thus the present study on phenology of wild species of guava *viz., Psidium guineense, P. chinensis, P. cattleianum* and cultivar Arka Kiran was executed, which helps in future guava improvement program.

MATERIAL AND METHODS

The study was conducted at ICAR -Indian Institute of Horticultural Research, Hessarghatta Lake Post, Bengaluru located at 13^0 58' North latitude and 78^0 East longitude and at an altitude of 890 m above mean sea level and red sandy loam with a pH of 5.2-6.4. The experiment period was from July 2016 to May 2017 with moderately warm and mild summer. The maximum mean temperature ranged from 25.2 ^{0}C to 31.7^{0}C with a mean of 27.93^{0}C, while the minimum mean temperature ranged from 15.1^{0}C to 21.7^{0}C with a mean of 18.43^{0}C. The mean relative humidity, mean wind speed and total rainfall was 68.38 per cent, 2.53km hr^{-1} and 336.46 mm respectively.The wild species (*P. guineense, P. chinensis, P. cattleianum*) and *P. guajava* L. variety Arka Kiran of 6 to 7 years old maintained in the Field Gene Bank of ICAR-IIHR were used in the study. These accessions were planted at a spacing of 5 X 5 m with three plants per accession representing individual tree as one replication. The cultural practices and diseases pest management were followed as per the standard package of practices.The phenological stages *viz*., time of leaf flushing (days taken from leaf bud emergence to the leaf emergence was counted and expressed in number of days), duration of flower bud initiation to full bloom (days taken from flower bud initiation to full bloom was counted and expressed in number of days), time of flowering (month in which flowering was noticed), duration of flowering (days taken from first flowering to last flowering was counted and expressed in number), peak flowering (days taken from initiation of flowering to 50 per cent flowering was counted and expressed in number of days), anther dehiscence (time at which anther dehiscence was observed and expressed in hours), pollen viability assessment (per cent germination of pollen was calculated by adopting hanging drop method), duration of flowering to fruit set (days taken from anthesis to development of peanut stage fruit was counted and expressed in number of days), duration of fruit set to harvest (days taken from fruit set (pea size) till it reaches horticultural maturity was counted and expressed in number of days), duration of fruiting (days taken from first fruiting to last fruiting was counted and expressed in number of days) were considered during the study. Ten

branches of each tree in each accession were selected to record the observations and the mean value was calculated and expressed.

RESULTS AND DISCUSSION

The mean data on phenological stages of wild species *viz., P. guineense, P. chinensis, P. cattleianum* and *P. guajava* cv. Arka Kiran are presented in Table 1, Fig. 1-7 and Plate 1-4.

Time of leaf flushing

The days taken from bud bursting to leaf emergence ranged from six to nine in various species. Arka Kiran recorded longest (9) duration for leaf flushing followed by *P. cattleianum* (8) and *P. guineense* (7) and shortest in *P.chinensis* (6).

Duration of flower bud initiation to full bloom

The days taken from flower bud initiation (from when the flower bud becomes visible, to full bloom) ranged from 19 to 23 days. *P. guineense* recorded highest (23) number of days taken for full bloom followed by *P. chinensis* (21) and Arka Kiran (20). The lowest (19) number of days was noted in *P. cattleianum* to reach full bloom from flower bud initiation.In a study conducted by Seth[18] on floral morphology and floral biology of *P. guajava, P. guineense, P. chinense, P. molle* and *P. cattleianum* var. *lucidum*, it was reported that maturation of floral buds was most rapid in *P. cattleianum* which was in supplementary with the present study results.Whereas, Subramanyam *et al*.[20] reported that, flower development in *P. quadrangularis, P. molle, P. cattleianum* and *P. friedrichsthalianum* took 36–45 days which was in contradiction to the present study results.

Time of flowering

The time of flowering ranged from February-April and August-September in *P. guineense*, *P. chinensis* and Arka Kiran whereas, it was June in *P. cattleianum.* The results indicated that wild species *viz., P. guineense* and *P. chinensis* was in synchrony with the commercially cultivated species *P. guajava* cv Arka Kiran. Hence, it is a favorable trait for exploitation of the specific character from the wild species, where hybridization can be effected with fresh pollen; thereby increasing the chances of good fruit set and seed recovery. Use of fresh pollen for higher fruit set and seed recovery in mango has been reported[22].Differential flowering time (June) noticed in the wild *P. cattleianum* could be due to the inherent genetic makeup of the species, where the possibility of pollen storage could be attempted for introgression with the commercial varieties. Ray[17] has also recorded similar results, where, in India, the duration of flowering during two peak flowering seasons was noticed in 35 to 45 days respectively in *P.guajava* varieties.In contradiction to the present result, a study conducted by Normand and Habib[12] on strawberry guava (*Psidium cattleianum* Sabine) at 100, 480 and 720m over 2 years in Reunion Island, France revealed that the flowering was observed from November to January. Bud burst, shoot and flower bud development are completely temperature dependent which causes a difference in flowering period according to elevation.

Duration of flowering

The days taken from occurrence of first flowering to last flowering ranged from 30 to 65 days.The duration was highest (65) for Arka Kiran followed by *P. guineense* (60) and *P. chinensis* (58). It was observed that the lowest duration (30) was recorded for *P.cattleianum*.These results might be due to the inherent species behavior. According to Seth[18] maturation of floral buds and fruits was most rapid in *P. cattleianum* which is in agreement with the present results. Knowledge about duration of flowering in cultivars, which gives extended fruiting, will help to avoid glut in market that will result in premier price in market.

Peak flowering

Days taken to 50 per cent flowering from the initial flowering were in the range between 15 to 30 days. Arka Kirantook longest time (30) to reach 50% flowering followed by *P. guineense* (28) and *P. chinensis* (22). Whereas, *P. cattleianum* took 15 days to reach peak

flowering which was the lowest among all the other varieties/ species.

Anther dehiscence

The anther dehiscence, which was recorded and expressed in hours, observed in different species was in the range of 7.00 to 10.00 a.m. The *P. guineense* showed the earliest time (7.00 to 8.00 a.m) of anther dehiscence followed by *P. cattleianum* (7.30 to 8.30 a.m) and Arka Kiran (7.00 to 9.00 a.m). The anther dehiscence was delayed in *P. chinensis* (8.00 to 10.00 a.m.) comparedto other varieties/ species. The synchrony of anther dehiscence of the wild species with the commercially cultivated species is a welcoming trait as it helps in the transfer of fresh viable pollen grains which in turn helps in good fruit and seed set. The results are in agreement with the findings of Ray[17] where he found that anthesis starts at 4.00 a.m. and continues till 10.00 a.m., the peak opening occurring between 5.00 and 7.00 a.m.

Pollen viability assessment

The per cent germination of pollen in the freshly opened flowers was in the range of 40.23 to 80.34. Arka Kiran showed the highest(80.34) pollen germination percent followed by *P. chinensis*(65.46) and *P. guineense* (62.30). The lowest(40.23) percent pollen germination was found to be in *P. cattleianum*.The encouraging results obtained by wild species indicate its potential for crossing success. The low germination (40.23%) exhibited by *P.cattleianum* could be due to different behavior of the species. Seth[18] reported that *P. cattleianum* pollen had the lowest viability which is in accordance with the present study. Hirano and Nakasone[7] reported that the pollen of *P. cattleianum* showed 32% germination, whereas, pollen of *P. cattleianum* var. *lucidum* could not be germinated which was in supplementary with present study. They also reported that pollen of *P. guajava* (cultivars used had n = 22 and n = 33) generally had high germination rates, which were higher than those for species with higher chromosome numbers. Ray[17] reported that viability of the freshly collected pollens varies from 42 to 95% depending upon the varieties which was in supplementary with the present study results.

Duration of flowering to fruit set

The days taken from anthesis to development of peanut stage fruit was in the range of 12 to 18 days. *P. guineense* took more (18) days from flowering to fruit set followed by *P.chinensis* (15) and Arka Kiran (15). *P. cattleianum* took less number of days (12) to attain fruit set when compared to other varieties/ species.

Duration of fruit set to harvest

The days taken from fruit set (pea size) to horticultural maturity was in the range of 103 to 120 among the species and the variety Arka Kiran. The longest time (120) was recorded in Arka Kiran and *P. chinensis* followed by *P. guineense* (103) while the shortest period (100) was recorded in *P. cattleianum*.The short time period between fruit set to harvest is of importance in getting an early crop by reducing the time taken for the fruit development to attain early harvestable maturity. These results were supplementary with the findings of Garce´s[6], Barcelo´ *et al.*[1]and Coombe[2]. According to Mercado-Silva *et. al.*[9] the guava cultivar, 'Media china' also showed similar results, where the spring–summer crop took lesser days (130 days) to develop while autumn–winter crop required more (190) days to reach the ripe stage. A study conducted by Padilla-Ramirez *et al.*[14] with an aim to study the phenological development of guava trees and their relationships with ambient temperature at three locations of Mexico having different climatic conditions reported that at a location with annual mean temperature fluctuates from 25 to 18°C, duration from flowering to beginning of harvest (F-BH) varies from 100 to 180 days which was in accordance with the present study.

Duration of fruiting:

The days taken from first fruiting to last fruiting were in the range of 60 to 120. Arka Kiran showed the longest duration (120) of fruiting followed by *P. guineense* (80) and *P. chinensis* (70), whereas, *P. cattleianum* showed the shortest duration (65) of

fruiting.The longest duration of fruiting is of very much importance in the production of extended crop availability which in turn will help to avoid glut in market and to get premium market price. As per the findings of Normand *et. al.*[13] the fruiting lasted upto 1.5 to 2 months in *P. cattleianum* which is in accordance with the present study. In a study conducted in Brazil to evaluate the phenological characteristics, yield and fruit quality of the 'Paluma' guava tree at different pruning times, the plants pruned on all three pruning times *viz.*, August, September and October took an average of 120 days from early fruiting to early maturation stage[3].

Table 1: Phenological stages of guava varieties and wild species

Varieties/ species	Time of leaf flushing (days)	Duration of flower bud initiation to full bloom (days)	Time of flowering (month)	Duration of flowering (days)	Peak flowering (days)	Anther dehiscence (time)	Pollen viability assessment (%)	Duration of flowering to fruit set (days)	Duration of fruit set to harvest (days)	Duration of fruiting (days)
P. guineense	7.00	23.00	Feb.- Apr. and Aug.-Sept.	60.00	28.00	7.00-8.00 a.m	62.30	18.00	103.0	80.00
P.chinensis	6.00	21.00	Feb-Apr and Aug.-Sept.	58.00	22.00	8.00-10.00 a.m	65.46	15.00	120.0	70.00
P.cattleianum	8.00	19.00	June	30.00	15.00	7.30-8.30 a.m	40.23	12.00	100.0	65.00
P.guajava var. ArkaKiran	9.00	20.00	Feb.-Apr. and Aug.-Sept.	65.00	30.00	7.00-9.00 a.m	80.34	15.00	120.0	120.0
Mean	**7.50**	**20.75**		**49.50**	**23.75**		**62.08**	**15.00**	**110.75**	**78.75**
SEm±	**0.65**	**0.85**		**7.38**	**3.38**		**8.28**	**1.22**	**5.38**	**13.90**
CV (%)	**17.21**	**8.23**		**29.63**	**28.43**		**26.67**	**16.33**	**9.71**	**29.80**

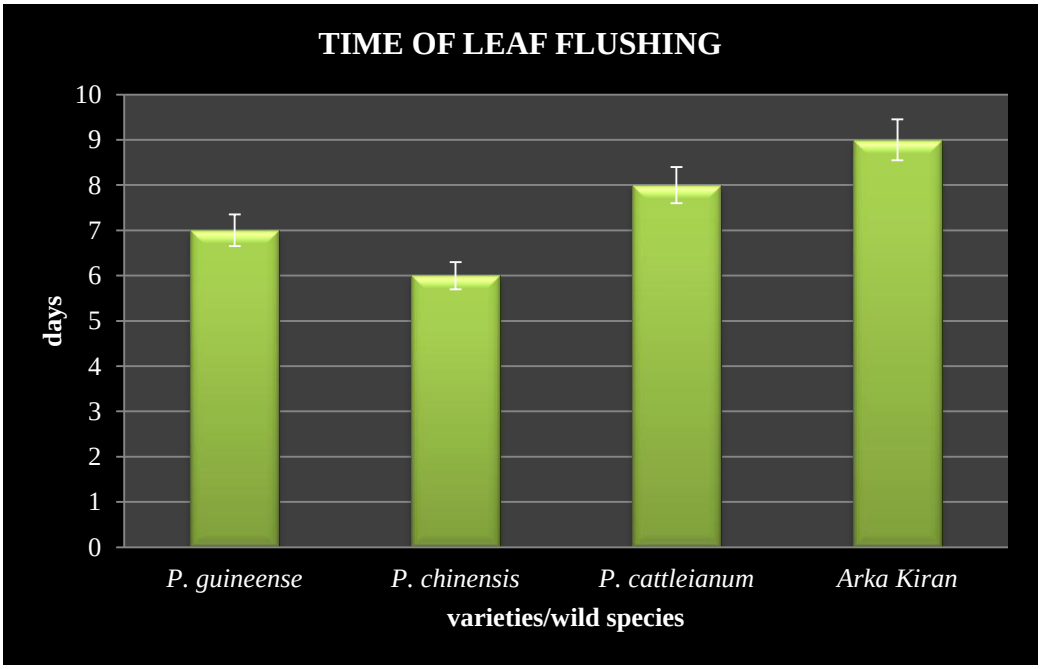


Fig. 1: Time of leaf flushing in guava varieties and wild species

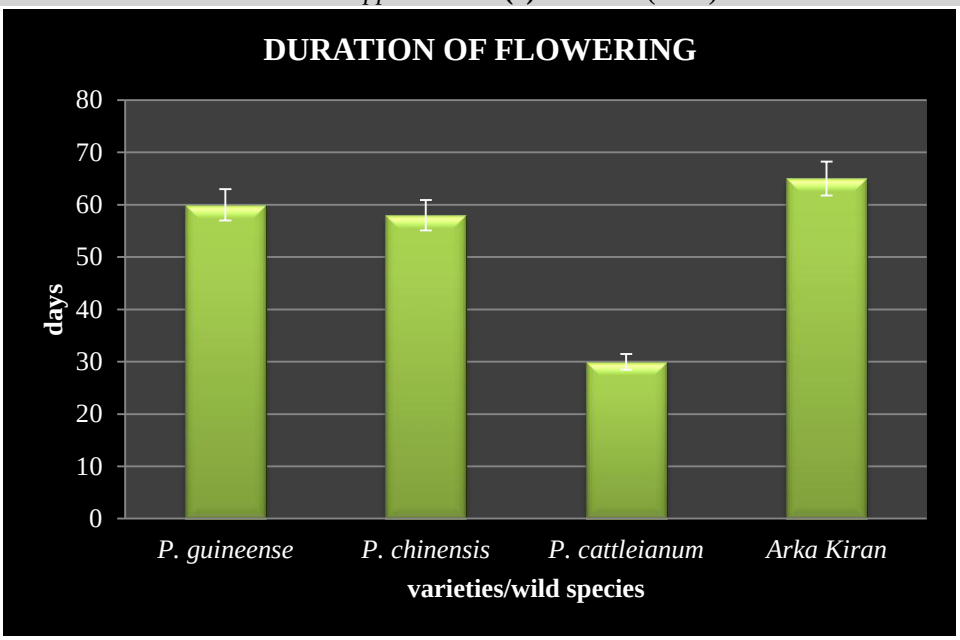


Fig. 2: Duration of flowering in guava varieties and wild species

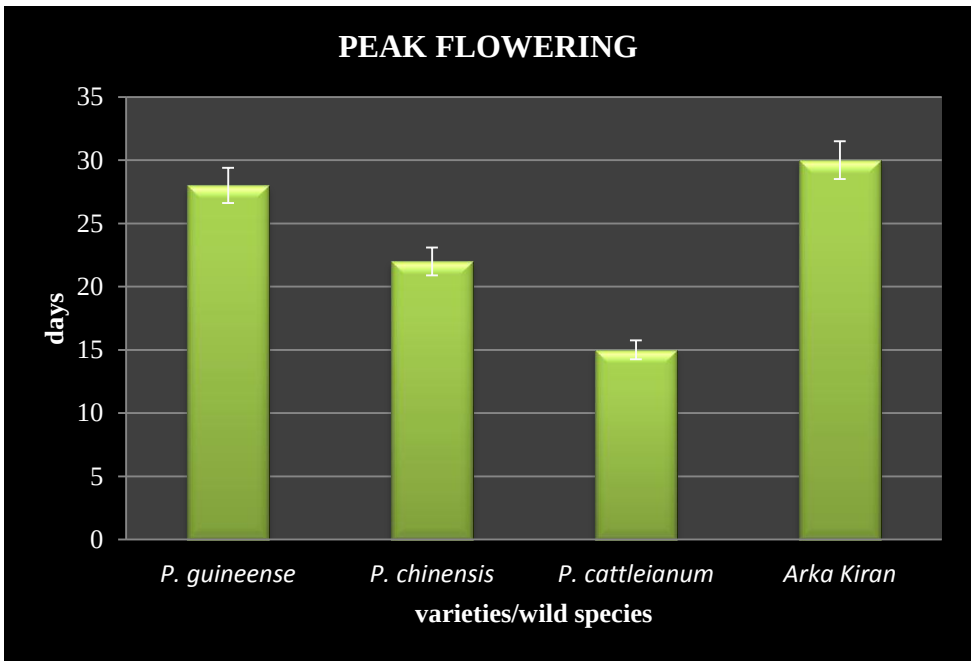


Fig. 3: Peak flowering in guava varieties and wild species

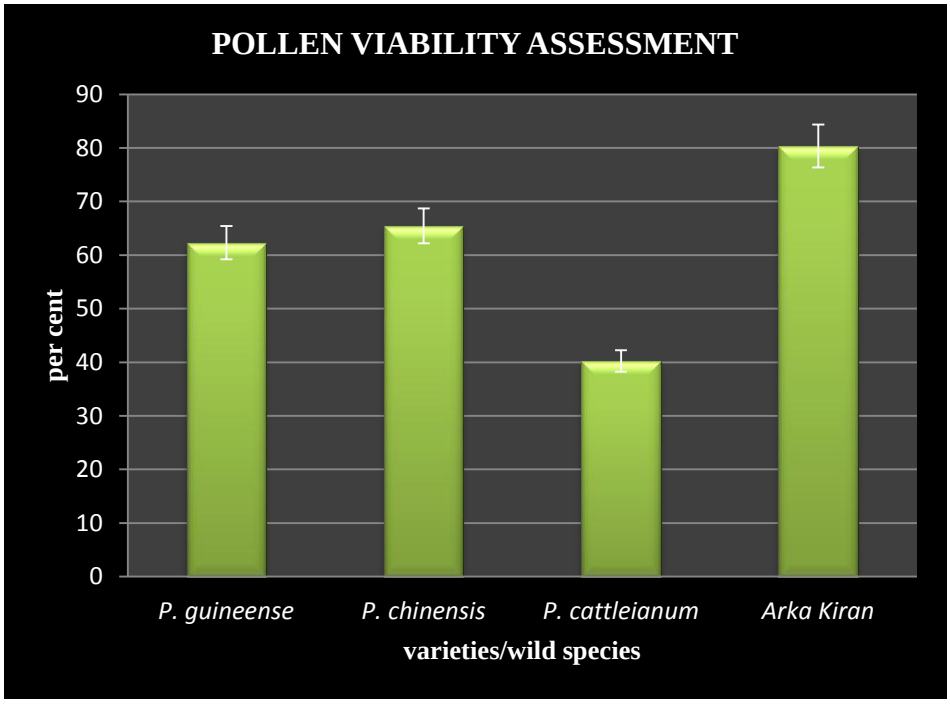


Fig. 4: Pollen viability assessment in guava varieties and wild species

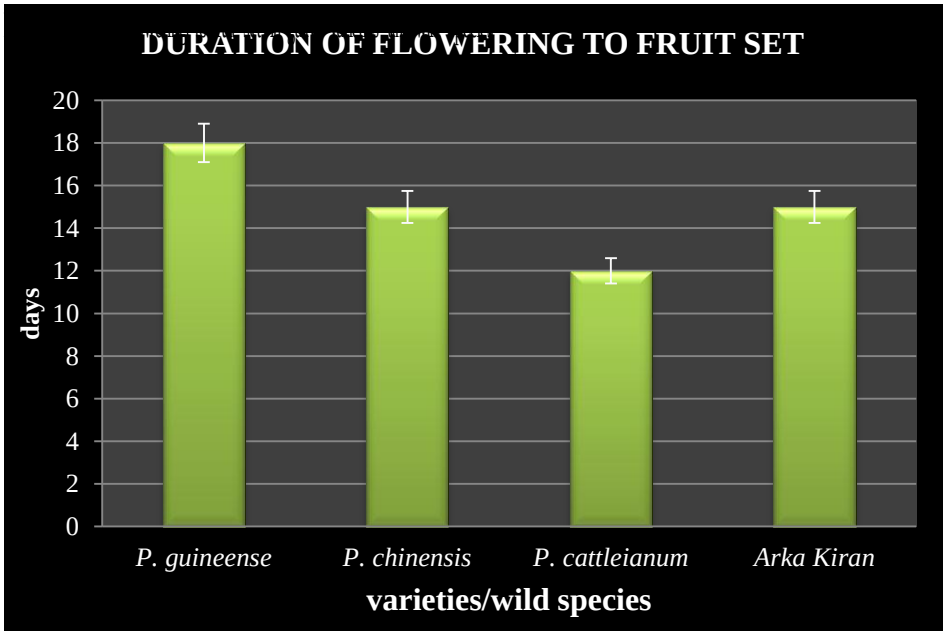


Fig.5: Duration of flowering to fruit set in guava varieties and wild species

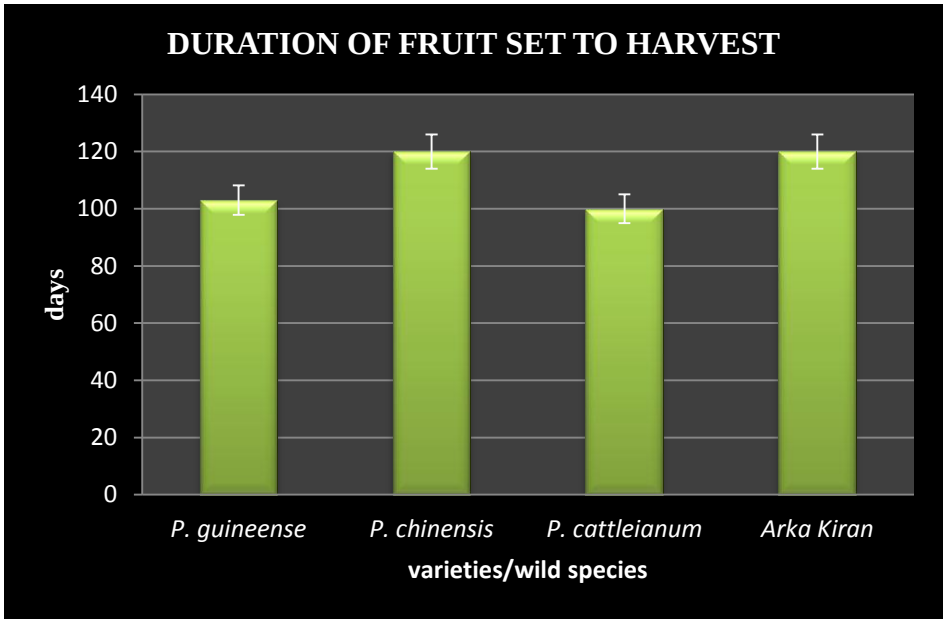


Fig. 6: Duration of fruit set to harvest in guava varieties and wild species

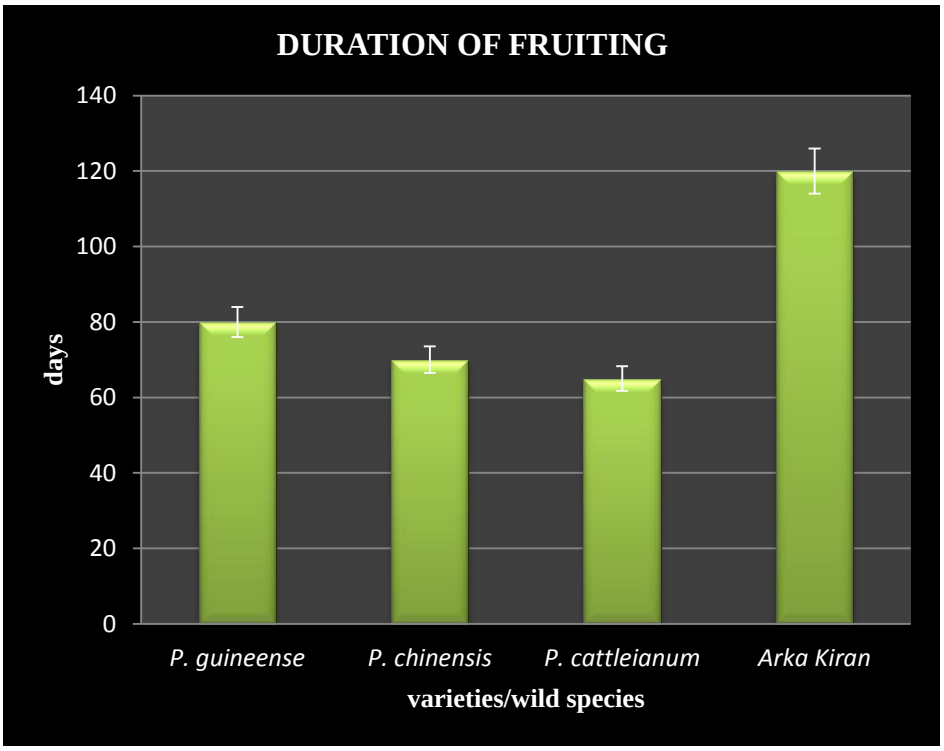


Fig.7: Duration of fruiting in guava varieties and wild species

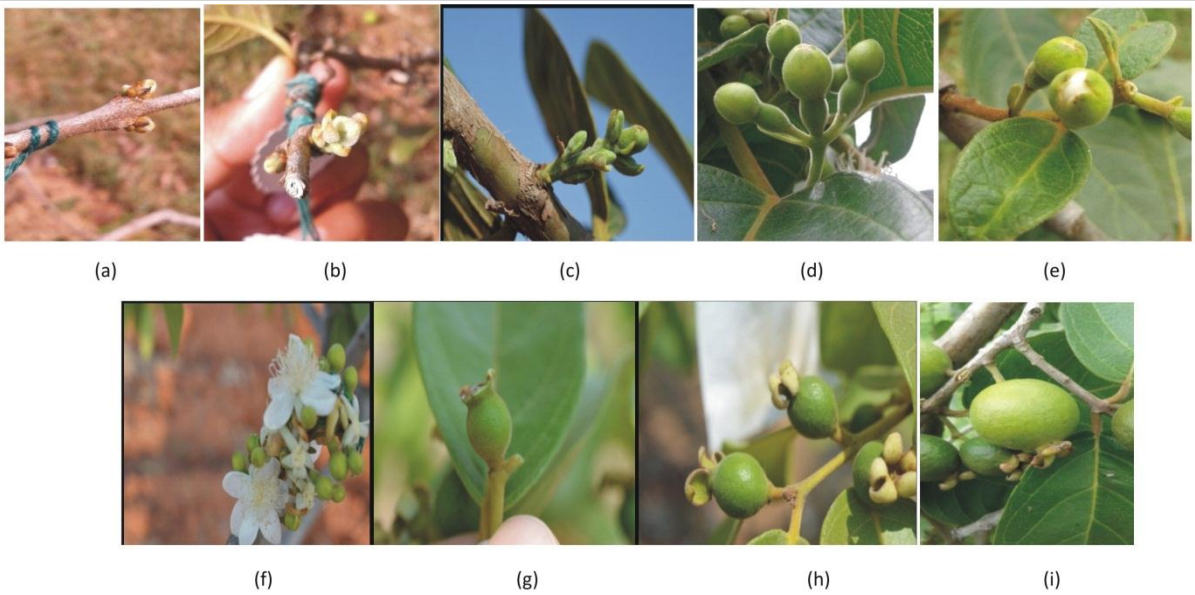


Plate 1. Phenological stages in *Psidium guineense*

(a) Bud differentiation, (b) Leaf emergence, (c) Flower bud initiation, (d) Flower bud development, (e) Flower bud ready to open, (f) Anthesis, (h) Fruit set, (i) Fruit development, (j) Ripening

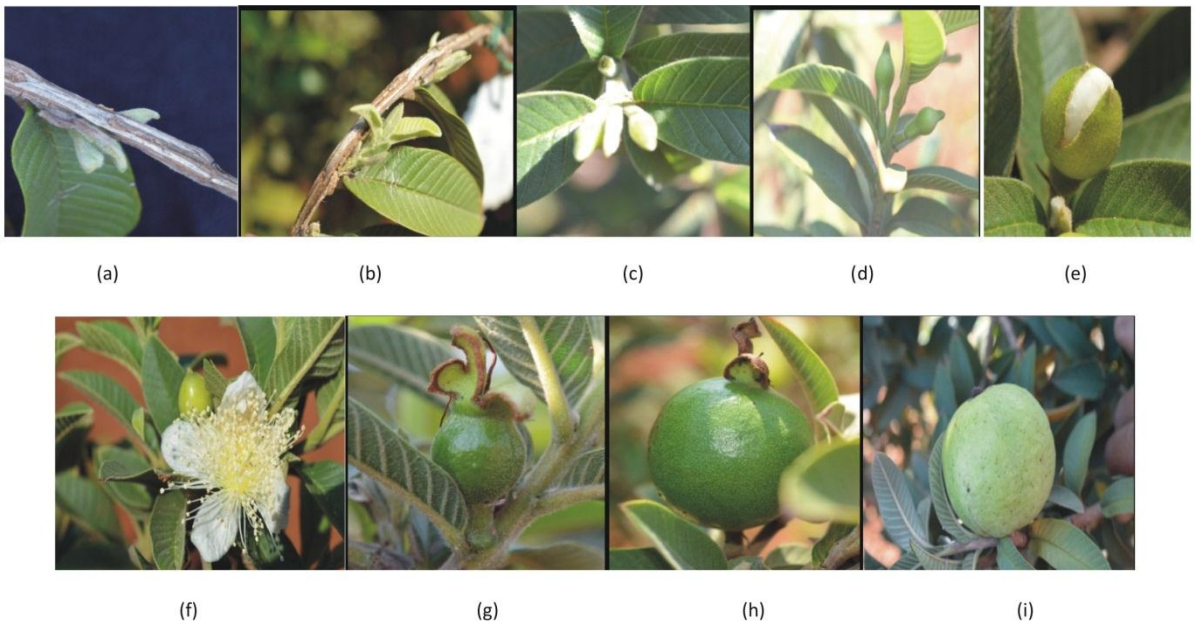


Plate 2. Phenological stages in *Psidium chinensis*

(a) Bud differentiation, (b) Leaf emergence, (c) Flower bud initiation, (d) Flower bud development, (e) Flower bud ready to open, (f) Anthesis, (h) Fruit set, (i) Fruit development, (j) Ripening

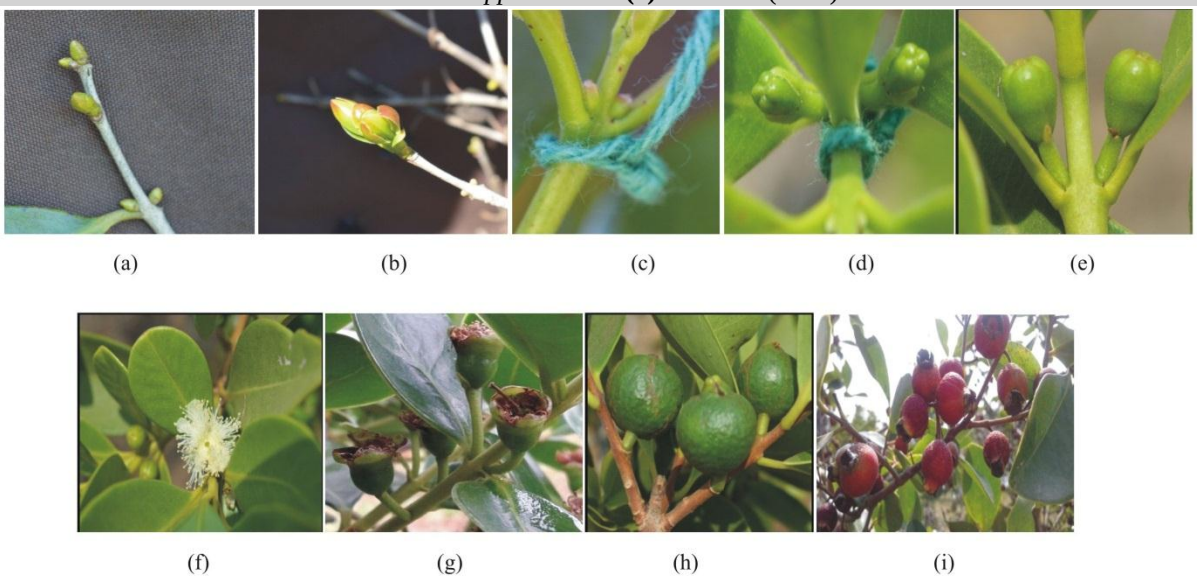
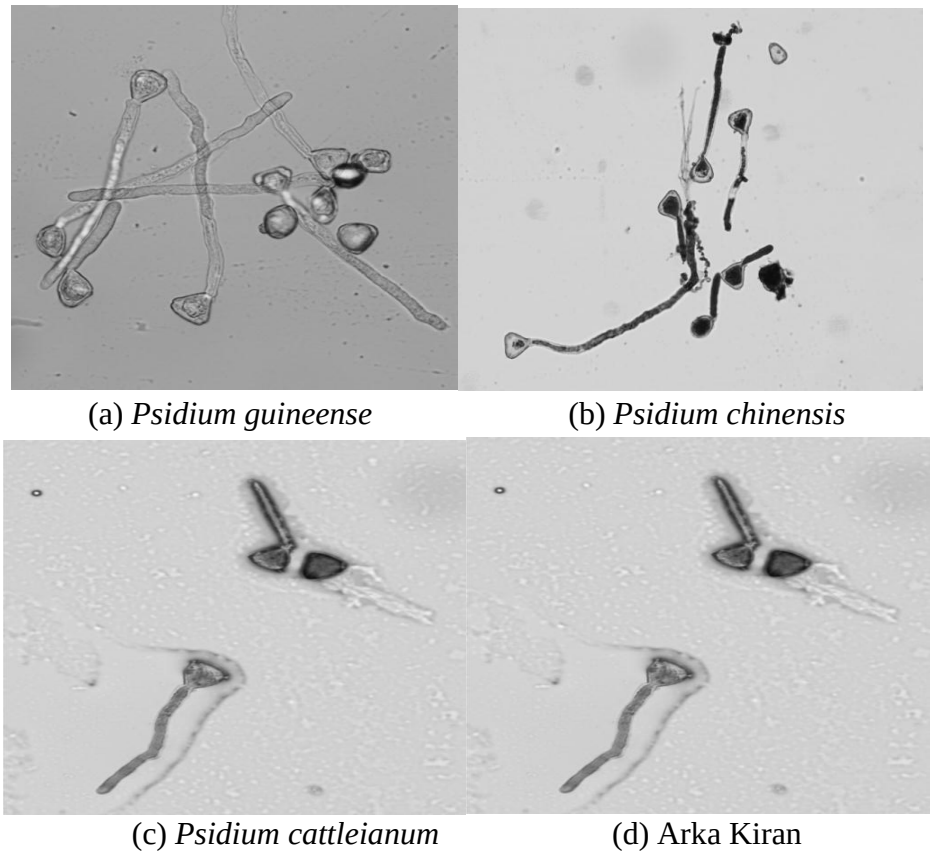


Plate 3. Phenological stages in *Psidium cattleianum*

(a) Bud differentiation, (b) Leaf emergence, (c) Flower bud initiation, (d) Flower bud development, (e) Flower bud ready to open, (f) Anthesis, (h) Fruit set, (i) Fruit development, (j) Ripening



(a) *Psidium guineense* (b) *Psidium chinensis*

(c) *Psidium cattleianum* (d) Arka Kiran

Plate 4. Pollen germination in guava varieties

CONCLUSION

A synchronization of peak flowering, duration of flowering as well as anther dehiscence was recorded between Arka Kiran and wild species like *P. guineense* and *P. chinensis*. Hence this study will help to plan and carry out effective hybridization work. Ultimately this study helps to tackle the major problem in guava

cultivation and transfer the biotic and abiotic tolerance/ resistance traits from the wild species (when used as male parent) to cultivated species, as the wild species are reported to have biotic and abiotic resistance/ tolerance

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