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Effect of sowing time on papaya seedlings

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Abstract
Papaya (*Carica papaya* L.) belongs to Caricaceae family and is native of tropical America and it was introduced in India in 16th century from Malacca. It is an interesting plant producing fruits of many uses and grown under tropical and subtropical conditions. It is popularly known as paw paw or papaw (British), mamao (Brazil) and lechosa (Venezuela). Papaya is a fast growing, short lived herbaceous plant and unbranched which bears fruits within a year. The plant is 2-10 m in height with a straight, cylindrical, soft and hollow trunk surrounded by the apex portion and forming a crown. The fruits are borne on the growing axils of the plant. Being a quick and heavy yielding crop, it is grown widely all over India; both commercially as well as in home gardens. The growers are increasing area under papaya cultivation due to great demand as table fruits as well as vegetable when unripe. Papaya is a nutritive fruit and a chief source of carbohydrate, vitamins and minerals in the daily diet of the people. Propagation of papaya is done only through seeds as a viable option. With the commercialization of papaya cultivation, the demand for quality seeds of well-established varieties has increased therefore proper seed germination and seedling growth are most important considerations in successful seedling production under nursery technique of papaya cultivation. The slow and synchronous germination of papaya seeds is attributed to the time of sowing. Climatic parameters plays an important role in seed germination and seedling growth. Erratic change in climatic parameters shows to impose the effect on seed germination and growth of seedlings. Hence, the time of sowing is very important and plays an important role among lot other factors due to variation in climatic parameters which is a major limiting and promoting factor for the growth and development of seedlings of papaya.

Keywords: Sowing time, papaya, *Carica papaya* L.

Introduction
Carica papaya L. a member of Caricaceae family and 2n chromosome number is 18. It is native of tropical America and it was introduced in India in 16th century from Malacca. It is an interesting plant producing fruits of many uses and grown under tropical and subtropical conditions. It is popularly known as paw paw or papaw (British), mamao (Brazil) and lechosa (Venezuela). Papaya is a fast growing, short lived herbaceous plant and unbranched which bears fruits within a year. The plant is 2-10 m in height with a straight, cylindrical, soft and hollow trunk surrounded by the apex portion and forming a crown. The fruits are borne on the growing axils of the plant. Being a quick and heavy yielding crop, it is grown widely all over India; both commercially as well as in home gardens.

The growers are increasing area under papaya cultivation due to great demand as table fruits as well as vegetable when unripe. Papaya is a nutritive fruit and a chief source of carbohydrate, vitamins and minerals in the daily diet of the people. Propagation of papaya is done only through seeds as a viable option. With the commercialization of papaya cultivation, the demand for quality seeds of well-established varieties has increased therefore proper seed germination and seedling growth are most important considerations in successful seedling production under nursery technique of papaya cultivation. The slow and synchronous germination of papaya seeds is attributed to the time of sowing. Climatic parameters plays an important role in seed germination and seedling growth. Erratic change in climatic parameters shows to impose the effect on seed germination and growth of seedlings. Looking to the importance of papaya as a remunerative short term crop the quality is very important. The seeds of the papaya are very costly and directly affected by various climatic parameters for germination, growth and development of the seedlings.

Review
Ali (1959) [2] noted that the percentage of germination was the highest from seeds sowing in

Late March and early April and again in first three weeks of October in *Citrus limon*, *Citrus karna*, sour orange, *Citrus aurtinum* and *Citrus aurantifolia*. Vats and Bakhashi (1969) [42] reported that spring sowing mandarin seed germinated better when sown on 15th February than on 1st March. Further they reported that a lower germination was obtained with sowing during the monsoon. Singh and Dahiya, (1982) [39] studied that in north India, where occurrence of frost is common; seeds are generally sown from February to April. Muthoo *et al.* (1991) [29] conducted research to examine the seed germination studies of cherry cultivars. Cherry cultivars Waterloo and Bigarreau Noir Grossa were sown in soil and sand in a 1:3 soil: sand mixture on 25th May, 25th June or 25th July during the year 1985 and1986. They found that highest germination percentage was in seeds sown on 25th May in soil: sand mixture, value being 61.24 and 61.66 per cent for cv. Waterloo in 1985 and 1986 respectively, and 51.66 and 49.58% for cv. Bigarreau Noir Grossa. In both cultivars the lowest germination was recorded for the seeds sown on 25th July of both years in soil only. Islam and Khan (1998) [21] studied the effect of sowing time of seeds on germination and growth of seedlings in papaya (pawpaw) from 1992 and 1993. In the first year, freshly extracted seeds from ripe fruits were sown on the 15th of each month, starting from January 1992. While for 1993 planting, stored seeds (of 1992) were sown on the 15th of each month, starting from January 1993. The germination of freshly extracted seeds was below 80% during the months of July-August and November-February and above 80% in other months. In July, December and January it took 22 to 25 days for germination, and 12-15 days in other months. Papaya seeds stored for different duration also indicated similar trend in respect of germination and speed of germination. The germination percentage of stored seeds (67%) was lower than that of freshly extracted seeds (75%). Time taken for germination was 16.3 and 23.9 days for freshly extracted seeds and stored seeds, respectively. Subsequently, growth of the seedlings was also affected differently due to different time of sowing. However, freshly extracted seeds are recommended for sowing during March-June and September-October. Singh and Singh (1999) [37] sown the seeds of Papaya cultivars *viz*. Pusa Delicious, Pusa Majesty, Pusa Dwarf, CO 5 and CO 6, in the middle of each month from January to December except April. The wide variations were observed in the rate of germination and days to 50% seedling emergence among different cultivars. Survival percentages were greater in Pusa Delicious (86.70%) than in CO 6, CO 5, Pusa Dwarf and Pusa Majesty (76.0, 68.0 and 64.0%, respectively). Joshi (2003) performed a research on effect of media, structure and date of sowing on seed germination and seedling growth of aonla (*Emblica officinalis* L.) cv. Gujarat aonla-1. He observed that seeds of aonla sown on 15th February in the mixture of FYM: soil (1:3) under greenhouse structure gave maximum germination, plant height, number of branches per seedling, number of primary roots per seedling, length of tap root of seedling, number of secondary roots per seedling, fresh weight as compared to open conditions. Bandhiya *et al.* (2022) [5] studied on Khirni and found that the Khirni seeds sowed in Soil + FYM after soaking in GA_3 300 ppm for 24 hours found better for early germination, highest germination percentage, maximum shoot length, number of leaves, stem diameter, fresh and dry weight of seedling as well as highest leaf area and survival percentage of Khirni seedling. Farheen *et al.* (2017) [14] concluded that the germination of seeds of certain fruit crops is frequently reported to be slow, erratic and incomplete. Gibberellins act in the mobilization of seed reserves during the germination process. Therefore they are considered important germination promoters and contribute to increased seed germination speed and uniformity thus improving the performance seeds germination. Seeds of papaya, bael, custard apple, citrus spp. including kagzilime, when soaked in a solution of GA_3 gave the better germination at various concentrations. Though, the time of soaking also varies according to the fruit crops and a variety too. It has later on positive effect on the seedling height, numbers of leaves, number of internodes, root growth and number of roots, a period to attain transplanting height and a dry matter.

Gohil (2009) [17] conducted an experiment to show the influence of GA_3 and sowing dates on raising of papaya seedlings under different conditions. He recorded that the seeds treated with GA_3 200 ppm and sown on 1st August under the net house condition gave highest germination percentage (89.17%), high seedling growth (57.25 cm) with higher survival percentage (90.78%) and become more economical. Firoz *et al.* (2009) [15] suggested that sowing time showed significant effect on seed germination and other parameters in lettuce. The highest germination percentage (75.9%) was found when sowing done at 10th November followed by 20th November and the lowest germination percentage found with 20th December. Same results were found with plant height. Days to first flowering were earliest with sowing at 10th November and 20th November and late flowering occur with 20th December. Ahmad (2010) [1] conducted experiment on seeds of two kiwi fruit varieties *viz*., Bruno and Hayward were treated with four concentrations of GA_3 @ 500, 1000, 1500 and 2000 ppm for a period of 20 h and stratified at 4.4 °C for 6, 8, 10 weeks well as and sown directly in open field conditions. The seeds after treatment were sown in during the first week of March whereas the open field sowing was done in first week of February. The germination of seed was higher in cv. Bruno as compared to cv. Hayward. Increase in concentration of gibberellic acid, seed germination was enhanced in both the varieties. However, the effect was much more pronounced in cv. Bruno as compared to cv. Hayward. Maximum seed germination (67.25 and 53.00%) was observed with the application of 2000 ppm GA_3 in cv. Bruno and Hayward respectively. Yucedag and Gultekin (2011) [45] revealed that seeds of almond (*Amygdalus communis* L.) and wild almond (*Amygdalus orientalis* L.) should be sown either after early rainfall in autumn or cold stratification for 75 to 120 days.

Parasana *et al.* (2013) [31] reported that lowest days to germination (30.83), highest germination percentage (70.75%) were recorded at 60 DAS. While, maximum height of seedling (40.15, 43.75 and 46.95 cm), number of leaves per plant (7.17, 10.33 and 13.17), length of shoot (40.15 43.75 and 46.95 cm)and root (18.46, 24.68 and 31.05 cm) root: shoot ratio (0.45, 0.56 and 0.66), stem girth (2.40, 2.70 and 3.18 cm), fresh weight of seedling (8.53, 16.66 and 24.63 g) and dry weight of seedling (6.48, 7.36 and 14.63 g) were recorded at 60, 120 and 180 DAS. In respect of survival percentage (72.17) was recorded at 180 DAS in mango cv. LSM-12 Master royal.

Parmar (2013) [32] studied the different date of sowing of custard apple seeds on March, April and May among them indicted that sowing of custard apple seeds on 15th April is beneficial for getting good seed germination and seedling growth of custard apple cv. Balanagar. Hossain *et al.* (2013)

[19] suggested that early flowering (52.40 days) as well as early fruit harvesting (119.13 days) were occurred in tomato when tomato sowing done at October 1st, whereas sowing on October 30 resulted in delayed flowering (71.73 days) and fruit harvesting (140.67 days), respectively. Number of fruits per plant was also highest (27.40) in October 1st sowing and the lowest (13.73) was in October 30 sowing. Seeds sowing of October 1st was found better in respect of yield (74.75 t/ ha) compared to October 15 (58.55 t/ha) and October 30 (24.60 t/ha) sowing. Singh *et al.* (2014) [38] reported the effect of different dates of sowing on germination of Cape gooseberry (*Physalis peruviana* L.) and found that the maximum seed germination (74.3%) and growth were recorded from 20th September date of sowing than other months of cape gooseberry under Lucknow conditions. Growth parameters like maximum seedling height (5.18 cm), length of tap root (2.50 cm), number of secondary roots (6.80), stem diameter (1.28 mm) at 30 days after germination was also recorded in 20th September.

Kaleri *et al.* (2016) [23] noted that there is significant difference among various sowing dates in lattuce (*Lectuca sativa* L.). The maximum plant height (31.65 cm) was observed at 15th November and 1st December sowing dates while the maximum number of leaves per plant (33.47, 30.80 and 30.04) was observed at 1st November, 15th November and 1st December sowing dates. Crop sown on 15th November and 1st December showed the best performance and produced maximum values for most of the investigated traits. Parmar *et al.* (2016) [33] indicated that custard apple seed sowing on 15th April observed significantly maximum germination percentage (82.81) at 30 DAS. Similarly, 15th April recorded significantly maximum seedling length (7.18, 10.88 and 17.94 cm, respectively), number of leaves per seedling (4.02, 10.60 and 13.67, respectively), number of primary roots per seedling (7.08, 7.93 and 12.05, respectively), length of tap root per seedling (6.50, 12.50 and 17.17, respectively), number of secondary roots per seedling (5.67, 8.73 and 12.02, respectively) and girth of seedlings (0.27, 0.47 and 0.77 cm, respectively) at 30, 60 and 90 DAS. At 90 DAS, maximum fresh and dry weight of seedling (2.55 and 1.33 g, respectively) was obtained with 15th April. Bellad and Hiremanth (2018) [6] studied the effect of sowing date, spacing and fertilizer levels on crop growth and seed yield of hybrid watermelon. They indicated that for production of quality hybrid seeds of watermelon, parental seeds could be sown during January with NPK levels of 150:135:150 kg/ha at 3.00 m × 1.00 m spacing. Kumar *et al.* (2018) [25] suggested that papaya significantly affected by time of sowing and depth of sowing. Minimum days taken to start germination (11.00) were observed in month of July at depth of 0.5 cm whereas maximum in February (32.66) at depth of 2.0 cm. Maximum germination percentage (79.00%) was found at depth of 1.5 cm in month of July and minimum (45.00) at 0.5 cm depth in the month of February. Days taken to complete germination were found minimum (8.00) in month of August at depth 1.0 cm, maximum (18.66) were found in February at depth of 2.0 cm.

Alidu (2019) [3] reported that planting dates have a significant effect on percentage of germination, plant height at flowering, plant height at maturity and at harvest, pods per plant, pod yield and seeds per pod in cowpea. He suggested that for getting the higher yields, cow pea should be planted between the middle of July and early August. Early planting resulted in maturity coinciding with wet period resulting in reduction in quality of seeds. Late planting especially in late August resulted in poor yield. Mahmoud *et al.* (2019) [27] studied the effect of planting dates and different growing media on seed germination and growth of pistachio seedlings and they reported that sowing time and suitable planting media are considered as basic requirements to get the maximum yield and high profit for their direct and significant impact on seedlings quality and productivity of trees later. They concluded that the maximum germination percentage (28%), number of leaves per seedling (28.90), stem diameter (4.71 mm), root length (39.51 cm), leaf fresh weight (18.01 g) and leaf dry weight (7.11 gm) were recorded when the seed was planted on 10th march and seedling growing in the loamy soil: sandy soil: vermiculite (2:1:1).

Pritee *et al.* (2019) [34] studied the effect of GA_3 and date of sowing on growth and development of custard apple seedlings. They concluded that among different sowing dates, 11th November recorded maximum fresh weight of roots (0.87 g), dry weight of roots (0.24 g) and total dry matter (0.370 g), while 2nd November recorded minimum of these attributes. Interaction effect of GA_3 and date of sowing was found significant and maximum fresh weight of root (0.96 g), dry weight of root (0.29 g), total dry matter (0.480 g), plant height (15.83 cm), girth of stem (5.45 mm) and number of leaves per seedling (17.55) at 120 days after germination was recorded with 11th November and 500 ppm GA_3. Aluko (2020) [4] reported that muskmelon planted in May give a higher number of leaves per plant, leaf area and vine length. He suggested that planting muskmelon under rain-fed condition with adequate fertilizer application gave better performance. Dadhaniya *et al.* (2020) and Meera *et al.*, 2018 for papaya) [9, 28] studied the effect of time of sowing and chemical treatments on seedling growth of custard apple (*Annona squamosa* L.) cv. Sindhan and they concluded that height of seedling (50.01 cm), stem girth (4.10 mm), number of leaves (17.51), shoot length (33.31 cm), root length (16.70 cm), number of roots (11.02) and fresh weight of shoot (5.90 g) were observed maximum at 120 days after sowing individually in 15th April sowing as well as in 200 ppm GA_3 treatment. 15th April seed sowing, treated with 200 ppm GA_3 seed soaking for 24 hours found to be the most effective for leaf area, fresh and dry weight of root. To raise custard apple seedling in net house, it should be sown on 15th April with soaking in 200 ppm GA_3 for 24 hours to get the better seedling growth of custard apple cv. Sindhan. Meera *et al.* (2018) [28] reported that the application of treatment G_3C_3 (Papaya seeds are sowed in polybag after soaking in GA_3 300 ppm for 24 hours) was found better for early germination, highest germination percentage, maximum shoot length, number of leaves, stem diameter, fresh and dry weight of seedling as well as highest leaf area and survival percentage of papaya seedling.

Conclusion

Papaya (*Carica papaya* L.) belongs to Caricaceae family and a native of tropical America. It is an interesting plant producing fruits of many uses and grown under tropical and subtropical conditions. It is a fast growing, short lived herbaceous plant and unbranched which bears fruits within a year. The growers are increasing area under papaya cultivation due to great demand as table fruits as well as vegetable when unripe. With the commercialization of papaya cultivation, the demand for quality seeds of well-established varieties has increased therefore proper seed germination and

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