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Effect of growth regulator and growing media on seed germination of papaya: A review

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Abstract
Appropriate choice of plant growth regulators and growing media is very essential for the qualitative and quantitative production of fruit crops. Growing media acts as a reservoir of nutrients and allows the gaseous exchange between plant roots and atmosphere. In some seeds like papaya, the germination is slow due to the presence of some inhibitors such as phenolic compounds. Proper seed germination and seedling growth are the most important aspects of successful bumper production. Seeds treated with plant growth regulators and other chemicals before sowing, accelerates germination rate. Growth regulators and growing media are much more helpful in the germination of papaya seeds. Moreover, application of PGR will improve germination rate as well as reduce the germination period and result in early germination. PGR can also promote the synthesis of hydrolysing enzymes particularly amylase, protease, which hydrolyze food and that could be utilized for the growth of an embryo. The present review reveals the effect of different growth regulators and growing media on seed germination in papaya.

Keywords: Papaya, growth regulator, growing media, germination, growth

Introduction
Papaya (*Carica papaya*) belongs to the family Caricaceae and can be grown under both tropical and subtropical conditions. The papaya production in India, in financial year 2021 is approximately 5.95 million tons (Anonymous, 3rd estimate, 20-21, DAFW). In India, commercial cultivation of papaya is spread across the different states, majorly in Andhra Pradesh, Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Bihar, West Bengal, Tamil Nadu, Kerala, Uttar Pradesh, and Rajasthan. The topography and climate prevailing in these states are ideal for the quality production of papaya. Caricaxanthin imparts the yellow to orange colour of papaya fruits. It is a very refreshing and delicious fruit and is highly valued for its digestive properties. Meena *et al*. (2017) [1] also advocated that juice of papaya also acts as an *in vitro* antiproliferative against liver cancer cells due to presence of the caricaxanthin and lycopene. Regular consumption of papaya can reduce the risk of heart disease, diabetes, cancer. Ripe papayas are used for the extraction of papain which has high medicinal value and is also used as industrial ingredients for the preparation of tanning, cosmetic, optical, and brewery (Dayeswari *et al*., 2017).

Impact of growing media on germination of papaya seeds
The germination percentage of papaya seeds are low and it gets affected by many factors, including type of substrate used, environmental factors such as temperature, oxygen, water and the genotype. Since the seed is a costly input, the proper seedling growth and development are the most important considerations in successful plant production (Rana *et al*., 2020) [3]. The germination percentage and time of papaya seeds are a slow so to promote extent of germination, the right choice of growing medium is very important as it provides the required growing conditions to the growing seedlings.
All soils (used for nursery and cultivation) are not always suitable for the germination of seeds and subsequent growth of seedlings; therefore, choice and use of suitable growing media or substrate is essential for the production of quality plants. Generally, the media for germination of seeds is composed of pond soil, normal soil, sand, and organic matter etc. The quality of resulted seedlings, is affected by the composition of growing media.
When vermicompost is used as growing media it provides sufficient levels of oxygen to roots, adequate storage of water and nutrients for plants (Chaudhary *et al*., 2020) [4]. Various humic substances (present in vermicompost) significantly increase nutrient availability and consequently affect the growth, yield, and quality of plants.

While FYM has good water holding capacity as well as sufficient porosity, thus permitting adequate moisture and exchange of gases between growing media and embryo. Moreover, it contains sufficient nutritional content and creates conducive environment for root and shoot development. Alvarez & Grigera (2005) [5] also concluded that vermicompost had some hormone like activities and promotes rooting process, thus, improves nutritional absorption and ultimately growth and development of the plant. Cocopeat is frequently used as a growing media because of its acceptable properties like good pH, pore space, chemical attributes and physical properties, high moisture content, less shrinkage, low bulk density, and slow biodegradation. Just like a sponge it is able to hold passable amount of water. It also contains good quantity of nutrients (N, P, K, Ca and Mg). But it is not true in case of traditional compost (Sinha *et al*., 2009) [6]. Sphagnum moss is an important growing media. It contains the dehydrated remains of the acid bog plants and has an excellent water-holding capacity. Above all, it also contains a fungistatic substance that is beneficial in inhibition of damping off. Vermiculite is a micaceous mineral that directly affects the development and root system of the seedling. It is used because it gives good aeration and drainage and water holding capacity and can release water whenever needed, and also because it is sterile and free from diseases, having a fairly neutral pH (Dash *et al*., 2019) [7].

The growing media is considered good if it provides plants with good anchorage, nutrients including water and permits gaseous exchange between root and atmosphere outside the root substrate along with diffusion of oxygen to the roots. Bhardwaj (2013) [8] described that growing media is able to supply many nutrients required for plant growth. He considered soil as basic growing media since soil is inexpensive and easily available.

Nagar *et al*. (2016) [9] has also concluded that nursery potting media influence the quality of seedlings produced. Generally, media is available in two types (to be used in containers) *viz*., soil and soilless (organic-based) media. Organic-based media is composed of compost, peat, coconut coir, and other organic materials mixed with inorganic ingredients. Vaughn *et al*. (2011) [10] categorized all type of growing media into organic (tree bark, peat, coconut coir etc. and inorganic materials mineral wool, perlite clay, and vermiculite). Growing media like perlite and vermiculite are frequently used in the horticulture industry because of aeration and drainage properties. Moreover, they are sterilized and free from infection causing germs.

Impact of growth regulators on germination

Growth regulators (PGR) are simply defined as the compounds which may modify the plant growth and development. Treatment with such regulators is a frequent practice to improve germination. Besides this many other organic substances like cow urine, coconut water, and tomato juice etc. while inorganic compounds include KNO3, thiourea, polyethylene glycol, etc. are used for this purpose. Additionally, benzyl adenine, sodium thiosulphate, and thiourea are also used for the same purpose. Regular plant growth regulators such as GA3, NAA, etc., successfully improve the number of seedlings during germination. GA3 (PGR) is reported to be very effective in improving seed germination and subsequent seedling growth in plants especially in fruit crops e.g., grapes, papaya, etc., (Chaudhary *et al*., 2018).

Effect of growth regulators and growing media on seed germination of papaya: Yahiro (1979) [11] established very early the fact that Gibberellic acid (GA3) have the ability to stimulate root and shoot growth, cell division along with rate of seed germination. In case of papaya, aril or sarcotesta the gelatinous enclosure of seeds inhibits the germination process. Research carried out by Okeyo *et al*. (2008) [12], in which freshly extracted seeds of papaya were washed before sowing and it resulted in improved germination which is attributed to low interaction between promoters and inhibitors by washing.

Seeds of papaya when treated with GA3@200ppm for 12hrs resulted in high % of germination and vigour index as GA3 activated cytological enzymes by increasing cell wall plasticity and provided better water absorption, promoted seed germination by producing α-amylase enzyme which converted insoluble starch into soluble sugars and initiated the radical growth by removing some metabolic blocks (Anburani *et al*., 2008). It is a well-recognized fact that gibberellic acid promotes hydrolyzing enzymes like α- amylase and protease, these are responsible for providing food for growth and development by hydrolyzing the starch and thereby lessened the time requirement for germination process (Nagano *et al*., 2010).

GA3 is considered as germination promoter in case of papaya seeds and it was found that So GA3+ FYM: soil: sand combination is used as growing media for maximum seed germination. They explained that it might happened due to participation of gibberellic acid (GA3) in alpha-amylase activity which catalyzed the starch into simple carbohydrates. Ultimately chemical energy is liberated, used in the activation of the embryo of seed (Zanotti & Barros, 2014, Anjamawe *et al*., 2012) [13].

For papaya cv. Red Lady, combination of vermicompost+ pond soil+ sand in ratio of 1:1:1 with cocopeat used as growing media for high germination percentage. Bhardwaj *et al*. (2014) found that the above combination hastened seedling growth by improving physical properties and water holding capacity that supported the germination potential of concerned media.

Malik *et al*. (2019) [16] found that when the seeds of cultivar Taiwan was soaked for 12 hours in GA3 500 ppm, the combined effect of seed treatment and variety gave the maximum germination percentage. For significant growth and relative growth of papaya seedling, an interaction of seed priming with GA3@200 ppm, soil, sand, cocopeat, and vermicompost (1:1:1:1) is used which is mainly due to GA3 that improved the rate of photosynthesis and caused greater accumulation of photosynthesis which led to increased dry matter of plants and improved growth rate (Ramteke *et al*. 2016) [15].

The seeds of papaya cv. Solo when treated with different concentrations of KNO3 (1%) have showed high germination % due to an increase in oxidation of NADPH to NADP by stimulating the pentose pathway in seeds by detection of nitrogen (Maneesha, 2019) [18]. A combination of soil+ vermicompost+ vermiculite (1:1:1) with 2 cm cocopeat layer used as growing media for papaya cv. Pusa delicious showed better germination. The synergistic combinations of these media ameliorate the physical conditions of the media and

nutritional factors which resulted in improved seedling growth (Meena *et al*. 2017) [1]. Maximum germination percentage was recorded when seeds were treated with cocopeat + vermicompost + Azospirillum + Phosphobacteria + Pseudomonas fluorescens because Azospirillum in media helped in fixation of nitrogen and vermicompost maintained steady moisture supply along with cocopeat which improved the overall physical traits of the media (Dayeswari *et al*. 2017).

In the research work of Desai *et al*. (2017) [17], they studied the seed germination and seedling growth of papaya cv. Madhubindu as influenced by media, GA3 and cow urine under net house condition. It was observed when seeds were dipped in cow urine (10%) for 18 hours and soil + cocopeat (1:1), resulted in better growth of seedlings as GA3 removed physiological barriers and acted on the embryo along with the synthesis of hydrolyzing enzymes (alpha-amylase and protease). From the study on influence of growing media and gibberellic acid on seedling growth in papaya cv. Pusa Nanha, a combination of GA3@100ppm, sand: garden soil: FYM (1:1:2) had a significant effect on vegetative growth, seedling size, and quality (Mishra *et al*., 2017). GA3 also plays an important role in leaching out of various inhibitors which in turn helps in removing the seed dormancy. Papaya cv. Madhu Bindu seeds pre-soaked in GA3@300ppm for 24 hours and sowed in polybags was found better for early germination and highest germination percentage due to GA3 involvement in the activation of cytological enzymes which further stimulated α amylase enzymes that converted insoluble starch into soluble sugars. It also initiated radical growth by removing some metabolic blocks (Solanki *et al*., 2018) [20]. NAA result in increased auxin level in roots which causes extra root initiation and nutrient uptake and root cell elongation, thus leading to increased tap root and number of roots in return increased the fresh and dry weight of roots. The experiment conducted by treating seeds of papaya cv. Pusa Nanha with NAA @400ppm which resulted in early germination at 12th day with highest germination percentage (Sharma *et al*., 2018) [21].

Rakibuzzaman *et al*., (2019) [22] evaluated different growing media for seedling emergence and growth of red lady papaya and revealed that when seeds grown in growing media soil + vermicompost + sand + Trichoderma (2:2:1:1) and coco pellet, resulted in significant growth as coco pellet medium supplied adequate water. A combination of (10% Pond soil + 30% Vermicompost + 30% Vermiculite + 30% Perlite) was most suitable for raising the papaya seedlings of cv. Pusa Nanha. It gives better early and maximum seed germination, germination index (seedling height, stem girth, root length, shoot length, fresh weight of shoot and root length), vigor, root: shoot ratio, and survival of seedlings (Dash *et al*., 2019) [7]. Rana *et al*. (2020) [3] studied the effect of pre- treatment on seed germination and seedling growth and concluded that seeds treated with NAA@200ppm was the best. Choudhary *et al*., (2020) [4] carried out the investigation concerning the impact of growing media and GA3 on seed germination of papaya cv. Pusa Nanha. The treatments encompassed combinations of FYM, soil, and vermicompost with variable levels of GA3. They found result that GA3 200 ppm is most effective for improved germination. Soil + FYM + vermicompost (1:1:1) resulted in improved germination, germination period, index and seed vigour (%). Combination of and growing media of soil: FYM: vermicompost (1:1:1) and GA3 200 ppm proved to be best for seed germination for papaya. This might happen due to improved exchange capacity for holding of nutrients and improved water holding capacity including porosity and exchange of gasses between growing media and the embryo. From the studies of, Shipra *et al*. (2020) the effect of different growing media with soil and sand in polybags on seed germination, seedling growth, and survival percentage of papaya cv. Pusa Nanha, the combination of Sand+ Vermicompost + Soil (1:2:1) was best in the terms of germination percentage, shoot length, seedling length, seedling girth. It also served as a reservoir for nutrients and water, allowed oxygen diffusion to the roots. Lanjhiyana *et al*. (2020) [23] revealed that seeds showed early and higher germination percentage, seed vigour index when soaked with (150 ppm GA3 + 12 hours + azotobacter). In this process, gibberellic acid acts on the embryo and caused synthesis of amylase and protease and this hydrolyzed food is utilized for the growth of the embryo and thereby enhanced the germination.

Khadijah *et al*. (2020) [24] concluded that the treatment combination of River sand + Rice hulls and River sand + cow dung facilitates seedling vigor for papaya seeds, which ultimately determined field establishment of crop. Rice husk (hulls) is an important agricultural waste and obtained from milling industry used as a growing medium. Due to high amount of silica it functioned as a sorbent for nutrients (Radha *et al*. 2018) [27]. Paikra *et al*. (2021) [24] studied the impact of growing media and Gibberellic acid on seed germination and growth of papaya at the Horticulture Research Farm, Chhattisgarh. The experiment comprised two factors including four levels of growth regulators and seven levels of unlike growing media. They concluded that soil: sand: vermicompost (1:1:1) and GA3 @100 ppm yielded improved seed germination, root growth parameters and survival percentage while combination of soil: sand: rice husk: vermicompost; in 1:1:1:1 along with GA3 100 ppm was proved to be best for shoot growth parameters. Finally, they recommended these findings for nursery growing of papaya. Shrivastava *et al*. (2021) [26] carried out a research trial on papaya cv. Red Lady under protected conditions and concluded that papaya seeds exhibited effective germination and highest rate of germination % when Soil + FYM + Sand + Vermicompost (1:1:1:1) is used as a growing media and better growth, survival of seedlings when Soil + FYM + Sand + Vermicompost (1:1:1:1) is used as a growing media in a white polybag. Purba *et al*. (2021) [25] proved through an experiment that gibberellin @150 ppm meaningfully affects root and shoot concerning characters.

Conclusion

Growing media and growth regulators are being commonly used now-a-days to get a high germination percentage in a short period. From this paper we can conclude that by using GA3 with a combination of different types of growing media resulted in effective seed germination and good seedling vigor. The resulted high survival % of seedlings in papaya seeds attributed to GA3 which in turn catalyzes the starch conversion into simple carbohydrates by participating in the activity of alpha amylase which liberates chemical energy for the activation of the embryo. On the other hand, growing media helps the germination by providing adequate cation-exchange for holding of nutrients and also having good water holding capacity and sufficiently porous structure that permits

adequate moisture and exchange of gases between the growing media and the embryo which is important for fast and invariant germination of seeds.

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