

**Effect of pre-sowing treatments, growing media
and conditions on seed germination and seedling
growth of guava (*Psidium guajava* L.)**

By

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HORTICULTURE – FRUIT SCIENCE



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CERTIFICATE- I

This is to certify that this dissertation entitled “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava**” submitted in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in the subject of **Horticulture-Fruit Science** to the Maharana Pratap Horticultural University, Karnal is a record of bonafide research work carried out by **Manish Kumar**, Admission No. **MHU2019H02M**, under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of this investigation has been fully acknowledged.

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CERTIFICATE- II

This is to certify that this thesis entitled “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava**” submitted by **Manish Kumar**, Admission No. **MHU2019H02M** to the Maharana Pratap Horticultural University, Karnal in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in the subject of **Horticulture-Fruit Science** has been approved by the student's advisory committee after an oral examination on the same in collaboration with an External Examiner.

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ABBREVIATIONS

%	per cent
@	at the rate of
C	carbon
CD	critical difference
cm	centimeter
cm²	centimeter square
cv.	cultivar
DAS	day after sowing
DAT	day after transplanting
et al.	et alii (and other)
Fig.	figure
FYM	farm yard manure
GA₃	gibberellic acid
gm	gram
H₂SO₄	sulphuric acid
HCl	hydrochloric acid
hrs.	hours
i.e.	id est (that is)
IBA	indole butyric acid
KOH	potassium hydroxide
mm	millimeter
N	nitrogen
No.	number
NS	non-significant
ppm	parts per million
VC	vermicompost
viz.	namely
wt.	weight

Guava (*Psidium guajava* L.) popularly known as “Apple of the tropics” or “Poor man’s fruit” is an important commercial fruit crop of India. It is taxonomically belonging to the family Myrtaceae which contains nearly 150 species (Boricha *et al.*, 2020) and has gain recognition of being the most widely cultivated species of this family. The other important trees of this family include Eucalyptus, Jamun and Nutmeg. Common guava is diploid ($2n=22$) in nature while the seedless guava is triploid in nature and a shy bearer. It is a valuable fruit crop of tropical and subtropical climatic regions of India. Guava is native to tropical America extending from Mexico to Peru. It is well adapted to Indian environmental conditions so it appears to be an Indian fruit. It was introduced to India by the Portuguese during the 17th century and has been cultivated since then.

In India, guava ranks fifth in position in terms of area and production after mango, banana, citrus and papaya. Its share in the total fruit production of India is approximately 4 per cent. In India, Guava occupies an area of 2.65 lakh hectares with an annual production of 40.54 lakh metric tonnes and productivity of 15.30 metric tonnes per hectare (Anonymous, 2018a). The leading guava growing states in India are Uttar Pradesh, Madhya Pradesh, Bihar, Chhattisgarh, West Bengal, Orissa, Gujarat and Haryana. Uttar Pradesh leads both in terms of area (49.53 thousand hectares) and production (928.44 thousand MT) but maximum productivity was recorded in Andhra Pradesh (24.12 MT/Ha). In Haryana guava is cultivated in an area of 0.12 lakh hectares with an annual production of 1.37 lakh metric tonnes and productivity of 11.33 MT/Ha (Anonymous, 2018b). It is mostly grown in districts of Sonipat, Karnal, Hisar, Jind, Ambala, Yamunanagar, Panipat, Jhajjar and Fatehabad. In the recent past in Haryana, data showed that the area (360 hectares) of guava has increased substantially (Anonymous, 2018b) which showed that farmers have shown interest towards guava cultivation. Its performance is better than other fruits in terms of productivity, hardiness and adaptability. The wide adaptability nature of the guava tree helped it to sustain a wide range of environmental conditions, soils, pH (4.5 to 8.2), drought and salinity. It is susceptible to frost. It is quite a hardy, prolific bearer and considered to be one of the most delicate nutritionally valuable and remunerative crops of the tropics (Sharma *et al.*, 2020; Singh *et al.*, 2000).

Guava is one of the excellent sources of vitamin `C`, pectin and minerals like calcium, iron and phosphorous. The Vitamin “C” content in guava ranges from 100 to 300 mg/100gm pulp of fresh fruit which is 2 to 5 times more than that of citrus fruits (Bose and

Mitra, 2001). The Pectin content of guava varies from 0.5 to 1.8 per cent (Adsule and Kadam, 1995). Guava has high pectin content that is why it is extensively used in the processing industry for the preparation of many delicious products such as jam, jelly, cream, cheese, puree, powder and nectar. Best jelly prepared from common sour wild guava. Unripe fruits are used for making chutney and pickles. The leaves of guava have been used for curing diarrhea, and also for dyeing and tanning (Manthri *et al.*, 2014). Even rotten guava is also utilized for ethanol formation. Owing to its hardy nature, it comes up well even in harsh conditions. The area under guava cultivation increases day by day and farmers also adopted new techniques like high-density planting and meadow orcharding which leads to an increase in demand for budded and grafted plants but this demand is not fulfilled because of deficiency of superior seedling rootstock which might be due to poor seed germination and seedling growth. These factors adversely affect the production and productivity levels in guava cultivation.

In recent years various asexual propagation methods such as wedge grafting, inarching, veneer grafting, forket, patch and shield budding are employed to obtain quality saplings. However, to fulfill the increasing demand for quality rootstock, seedlings need to be raised from seeds and guava seeds take a long time to germinate because seeds suffer from physical dormancy due to hard seed coat and impermeability to water and gases. Hard seed coat and low germination are major hindrances for the nurseryman in raising a large quantity of rootstock with graftable size in a shorter time for the growers. Different methods like water soaking, mechanical scarification and chemical treatments using GA₃ are used for breaking dormancy in seeds to improve germination and seedling growth. It has been reported that chemical and mechanical scarification can hasten the imbibition of water by making hard seeds permeable (Sourabh *et al.*, 2020). Seed imbibition is a crucial phase for successful germination as ample water is necessary to rehydrate enzymes and their substrates in preparation for seed germination. The seed scarification process involves breaking, scratching and softening of the seed coat so that water enters to stimulate the process of seed germination.

Growing media also play crucial role in quality seedling production. The function of growing media is to provide nutrients, water and air to the roots of the plant. It provides support or anchorage to the plant and also helps the plant to stand in an upright position against gravity. It allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside the root substrate. Different growing media such as peat moss: sand: saw dust (1:1:1), silt, top soil and bagasse: silt (1:1) and different cutting heights can be evaluated by using a single concentration of IBA (400 mg/kg). Therefore, the use of good rooting media along with rooting hormone increases germination percentage and root

induction (Leonardi *et al.*, 2001). Growing media is considered an essential part of the propagation system because rooting competency depends on the type of medium used. Rooting medium directly effects on quality and percentage of rooting (Chadha, 2007). The suitability of the medium depends on the type of species, cuttings, growing conditions, season and the cost effectiveness of the medium components (Hartmann *et al.*, 2002). Growing media acts as a growing place and source of nutrients for seedling growth, its composition influences the quality of seedlings (Wilson *et al.*, 2001). Sand is used to making the media more porous and organic matter (FYM and vermicompost) is added to enrich an adequate amount of nutrients in the media for the seedling growth. Cocopeat is a by-product obtained after the extraction of fiber from the coconut husk. It is considered as a good growing media with appropriate pH, electrical conductivity with other chemical attributes and components. Cocopeat media has excellent physical properties, high total pore space, high water content, low shrinkage, low bulk density and slow biodegradation.

Vermiculite is a hydrated aluminum-iron-magnesium silicate material that consists of an accordion-like structure. It has very low bulk density and extremely high-water holding capacity, approximately five times its weight. It has neutral pH, high cation exchange capacity and a small amount of potassium and magnesium. Perlite is a siliceous material of volcanic origin; its particle has a unique closed-cell structure so that water adheres only to their surface; they do not absorb water as in the case of peat moss and vermiculite. Therefore, growing media containing perlite are well-drained and light weight. It has good porosity, minimal CEC, neutral pH, and promotes aeration. On a commercial basis, it is recommended that not more than 10-30% perlite should be used in the media mix. Sowing seed in a nursery with soil media results in unhealthy root growth and poor seedling growth. If a medium containing soil is used, it should contain 10 to 30 per cent soil, amended with organic ingredients to promote aeration and drainage for maintaining good water holding capacity. Therefore, it is recommended that for this type of condition, soil-based media can be replaced with an organic-based or artificial growing media consisting of compost, peat and coconut coir.

Commonly for germinating seeds or establishing germinants, the seed propagation media used must be sterile and consist of fine texture to maintain high moisture around the germinating seeds whereas, for rooting cutting media, cuttings are rooted with frequent misting so the growing medium must be very porous to prevent waterlogging and allow good aeration for root formation. The common practice used by nurserymen for nursery raising is the use of polythene bags with the potting media consisting of FYM: Soil: Sand (1:2:1). An effective growing media for guava should be physically very stable, not interfere with plant nutrition, light in weight for easy transport and reduces soil borne diseases. Guava is sexually

propagated for rootstock raising, so too hot and cold temperature can affect germination. So, to maintain productivity, changes in present horticultural practices and adoption of greenhouse technology are some of the solutions to minimize the effect of climate change. Seedlings raised in polyhouse conditions are also less susceptible to insect-pest attack as compared to open field conditions.

Besides the recent advances in the use of pre-sowing treatments and growing media, as far limited studies were known about their effect on guava seed germination and seedling growth. So, it necessitates the study of pre-sowing treatment and media effect on guava. Therefore, by considering all the above facts this study has been framed entitled “Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)” is undertaken with the following objectives.

1. To study the effect of pre-sowing treatments for improved seed germination and seedling growth
2. To study the effect of different growing media and conditions on seed germination and seedling growth

The relevant literature pertaining to “Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)” has been reassessed in this chapter with congruous heads as under:

2.1 Effect of pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.)

Muhammad and Amusa (2003) reported that seeds of tamarind when treated with 50 per cent sulphuric acid concentration for 60 minutes recorded the highest germination. Agbogidi *et al.* (2007) studied the effect of acid scarification on germination and seedling growth of African pear and concluded that seeds soaked in 5% H₂SO₄ for 20 min helps in breaking dormancy and enhance germination in *D. edulis* seeds.

Olmez *et al.* (2007) concluded that *Punica granatum* seeds soaked in H₂SO₄ for 15 minutes with cold stratification for 60 days resulted in better germination rate and maximum germination percentage. Saied *et al.* (2008) examined the impact of different scarification methods on germination of *Ziziphus spina-christi* seeds and found that seeds soaked for one hour in concentrated sulphuric acid was a suitable method for encouraging emergence with easy application.

Rostami and Shasavar (2009) carried out an experiment to study the impact of seed scarification on seed germination and early growth of olive seedlings and reported that scarification treatments increased germination and early growth. Sulphuric acid treatment was better over mechanical scarification in removing the hard endocarp surrounding the olive seeds. Mabundza *et al.* (2010) found that passion fruit seeds treated with H₂SO₄ prior to sowing improved germination, number of leaves and height of seedlings.

Ito *et al.* (2011) found that in seed propagation type of F1 hybrid strawberry the seed germination performance enhanced by scarification with concentrated sulphuric acid and matric priming. These treatments improved strawberry seed germination performance even under unfavourable temperature conditions. Owino and Ouma (2011) investigated the effect of potassium priming on papaya and reported that potassium solutions improve germination of papaya seeds and also their subsequent growth. Potassium salts such as KOH, K₂O and K₂SO₄ appear superior in this promotion.

Caliskan *et al.* (2012) investigated the effect of different pre-sowing treatments on the seed germination and emergence of fig seeds (*Ficus carica* L.) and concluded that seed

treated with GA₃ significantly increased the germination and emergence of fig seeds. Gokturk *et al.* (2012) reported that in both the greenhouse and laboratory, cold stratification with submersion in H₂SO₄ pre-treatment gave higher germination percentage than H₂SO₄ alone as pre-treatment.

Stephen *et al.* (2012) concluded that acid (H₂SO₄) scarification of seeds for 10 min results in maximum germination percentage both in diffused light and dark conditions in *Syzygium cumini*. Azad *et al.* (2013) found that pre-sowing treatments of cold water (40 °C for 24 h) and scarification with sand paper performed better than other treatments in seed germination, germination percentage and other seedling growth attributes of *Tamarindus*.

Jamwal *et al.* (2013) investigated the effect of various pre-sowing treatments on seed germination and quality of rootstock in Indian Ber and revealed that seed soaked in water for 48 hours followed by 6 days storage in moist gunny bags enhanced germination and seedling growth parameters. Shah *et al.* (2013) found that for better germination and maximum seedling growth, the seeds of plum, peach and apricot should be soaked in water followed by GA₃ treatment.

Soliman and Abbas (2013) found that in *Cassia fistula* the best pre-sowing treatment which breaks dormancy, enhanced germination percentage and seedling growth was seed scarification with acid for 2 minutes and then dip in hot water for 6 minutes at 100°C. Adekunle (2014) found that seed soaking in cold water enhanced better seed germination percentage, time of germination and seedling vigour in soursop than other treatments.

Brijwal and Kumar (2014) found that from the different pre-sowing treatments, scraping of seed coat with sand paper + seeds soaked in GA₃ 50 ppm for 24 hours (T₄) was the most beneficial treatment for enhancing seedling height, stem girth, number of leaves per seedling, fresh and dry weight of stems, leaves and roots of guava rootstock. Seeds sowed without pre-sowing treatment showed poor results for all parameters. Manthri *et al.* (2014) carried out an experiment on guava to study the effect of various pre-sowing seed treatments like water soaking, gibberellic acid, thiourea, hot water and acid treatments on germination percentage and he observed that the highest germination 83.79 and 80.30 per cent was obtained with GA₃ (1000 ppm) and (500 ppm) respectively which were superior over other treatments.

Mawalagedera *et al.* (2014) found that in *Phyllanthus emblica* the seed dormancy was broken by the pre-treatment where the seed coat was scarified and treated with 1% gibberellin. Vasantha *et al.* (2014) found that tamarind seeds subjected to mechanical scarification result in an increase in germination percentage, rate of germination and decrease

in the number of days taken to initiation of germination while the seedling parameters are better enhanced by GA₃ 200 ppm treatment.

Dorji *et al.* (2015) found that the best pre-sowing treatment for overcoming seed dormancy and seedling emergence of the rare *Ziziphus budhensis* was complete removal of hard seed stone by cracking or scarification of stone with sand paper (sanding). Joshi *et al.* (2015) studied the effect of various plant growth promoting substances on seedling growth of acid lime and found that for inducing germination and better seedling performance the best seed treatment was GA₃ 200 ppm.

Lal *et al.* (2015) studied the effect of different scarification treatments on seed germination of olive and concluded that among the different treatments, seed treatment with GA₃ 500 ppm for 12 h recorded minimum germination time (115 days) and maximum seed germination percentage (90%). Masilamani *et al.* (2015) studied the influence of various pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.) and reported that seeds treated with H₂SO₄ 200 ml/kg for 10 or 15 minutes was adjudged as the most promising method for germination and seedling growth of guava.

Pratibha *et al.* (2015) conducted an experiment to study the effect of chemical treatments on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Pusa Nanha and concluded that among the various chemical treatments, seeds treated with 300 ppm GA₃ for 24 hours was reported best in early seed germination, maximum germination percentage while, maximum root length and root dry weight were recorded in GA₃ 200 ppm for 24 hours. Samir *et al.* (2015) carried out an experiment on khirni to study the influence of pre-sowing treatments on seed germination and revealed that seed treated with 100 ppm GA₃ showed best results for germination percentage, germination index, and germination value. Results for earliest seedling emergence was noticed in 2% KNO₃ seed treatment. Parameters like mean daily germination, seed vigour and germination energy were observed maximum when seeds treated with 200 ppm GA₃.

Acar *et al.* (2017) reported that sulphuric acid scarification has the highest germination rate in both *Pistacia khinjuk* treatments and the best seedling growth obtained from scarification along with GA₃ application. Bhavya *et al.* (2017) conducted a trial to study the effect of different chemical treatments along with water soaking treatment and concluded that germination and morphological characters of karonda seedlings improved with water soaking treatments for 8 hours.

Chiranjeevi *et al.* (2017) studied the impact of growth regulators and biofertilizers on seed germination behaviour and seedling growth of aonla (*Emblica officinalis* Gaertn) and concluded that aonla seeds soaked in GA₃ 200 ppm solution for 12 hours followed by 12

hours shade drying enhanced the germination characters and seedling attributes. Dilip *et al.* (2017) studied the effect of different concentrations of gibberellic acid (GA₃) at different time intervals on seed germination and seedling growth of Rangpur lime and reported that seed treated with GA₃ 80 ppm for 12 hours are the most beneficial treatment for improving seed germination, plant height, number of leaves per plant, fresh and dry shoot weight, taproot length, number of secondary and fibrous roots, fresh and dry root weight and survival percentage.

Ghosh *et al.* (2017) found that pre-germination treatment with H₂SO₄ for 4 minutes improved germination and seedling growth of yellow passion fruit. Joshi *et al.* (2017) conducted an investigation to study the effect of various pre-sowing seed treatments on chironji and observed that among the different treatments, seeds dipped in water for 24 hours followed by soaking in GA₃ at 200 ppm for 24 hours results in early germination, maximum germination percentage with excellent seedling growth and maximum survival percentage.

Khopkar *et al.* (2017) studied the influence of GA₃ solution on rate of seed germination and seedling growth of pummelo and found that among various pre-sowing treatments the best results for seed germination and growth parameters were shown by GA₃ 50 ppm solution for 24 hours. Palepad *et al.* (2017) examined the effect of seed treatments on seed germination and seedling vigour of custard apple and found that GA₃ 1000 ppm solution improve the germination percentage (83.33%) and minimized the days (10.27) taken for germination over other treatments. Growth parameters which are seedlings height (23.33, 37.54 and 48.31 cm), girth of plant (0.46, 0.62 and 0.93 cm), number of leaves (17.37, 28.60 and 32.64), leaf area (76.42 cm²), fresh and dry weight of the plant and survival percentage (72.81%) also show similar trends.

Parab *et al.* (2017) studied the effect of pre-soaking chemicals on germination and subsequent seedling growth of papaya (*Carica papaya* L.) cv. Solo and revealed that the maximum girth of seedling at 60 DAS (5.77 mm), leaf area at 60 DAS (56.00 cm²) and total fresh weight (17.02 g) were observed in when seeds treated with GA₃ 200 ppm. Patel *et al.* (2017) conducted an experiment to study the influence of pre-sowing treatments on survival percentage and growth of mango rootstock and reported that mango stones treated with 100 ppm GA₃ for 24 hours had better growth and survival percentage. The resultant seedlings also have higher shoot and root length.

Patil *et al.* (2017) investigated the role of different seed treatment and foliar spray of chemical substances on seedling growth of *Syzygium cuminii* L. seeds and showed that the maximum seedling height (82.60 cm), number of leaves (42.63), stem diameter (7.90 mm), number of shoots/seedling (2.95), leaf area (86.30 cm²), root: shoot ratio (3.21), primary root

length (43.04 cm) was recorded when seeds treated with GA₃ @ 200 mg/l for 10 min. Rab *et al.* (2017) found that peach stones soaked in tap water for 36 hours stimulate early germination, maximum germination percentage, seedling height and seedling diameter as compared to other soaking periods.

Singh and Maheswari (2017) carried out an experiment to standardize the seed treatment practices on soursop seedlings and found that pre-sowing seed treatment with GA₃ 500 ppm for 24 hours was the most promising treatment for seed germination and seedling growth. Choudhary *et al.* (2018) studied the effect of different concentration of GA₃ on papaya and found that when seeds treated with GA₃ 200 ppm results in higher root growth, shoot growth and survival percentage.

Gaikwad and Borkar (2018) concluded that seed soaked in 10% KOH and 10% NaOH for 10 min was the excellent pre-sowing treatment that promotes maximum seed germination in *Syzygium cumini*. Hejazi *et al.* (2018) investigated the impact of various concentrations of GA₃, H₂O₂ and bleach solutions on guava seed germination and observed that the guava seeds treated with 300 ppm GA₃ for 24 hours stimulate quick emergence and assured highest germination percentage.

Lata *et al.* (2018) found that seed scarified with H₂SO₄ 36 N recorded the highest in vitro strawberry seed germination and it was statistically at par with H₂SO₄ 30N. Panda *et al.* (2018) conducted an investigation to know the impact of gibberellic acid (GA₃) on germination, growth and survival of kagzi lime and found that 100 ppm gibberellic acid gave better results.

Patil and Halesh (2018) found that overnight water-soaked seeds result in early and complete germination while GA₃ treated seeds result in maximum germination percentage, survivability percentage and seedling growth in Surinam cherry. Barathkumar (2019) found that aonla seed treated with 2 per cent KNO₃ for 24 hours significantly increased the seed germination percentage, root length and maximum dry matter content. Other parameters such as shoot length, days taken for graftable thickness and vigour index were observed maximum in 500 ppm GA₃ for 24 hours.

Chaudhary *et al.* (2019) investigated the effect of gibberellic acid on germination and vigour of Kagzi lime Seedlings and concluded that freshly extracted kagzi lime seeds soaked in an aqueous solution of 500 ppm GA₃ for 12 hours induced early germination, higher seedling vigour index and survival percentage. Dinesh *et al.* (2019) carried out a study on different physical and chemical methods of seed treatment on germination and seedling growth attributes of guava (*Psidium guajava* L.) and revealed that seeds treated with GA₃

1000 ppm for 24 hours (T5) germinate prior to other treatments and seedling growth parameters were also found superior as compared to other treatments.

Jadhav *et al.* (2019) examined the effect of different growth regulators, chemical and organic wastes on rangpur lime seedlings and found that GA₃ 100 ppm showed the maximum height of seedlings (60.90 cm), percent seedlings attain buddable diameter (82.57%) and length of roots that is primary and secondary (45.20 and 16.43 cm, respectively). Momin *et al.* (2018) found that mechanically scarified seeds took minimum number of days to initiate germination while other growth parameters such as height of seedlings, number of leaves, collar girth, root length, number of roots, seedling biomass were highest in GA₃ 150 ppm treatment and minimum in control.

Reshma and Simi (2019) studied the effect of pre-sowing treatments, sowing positions and age of stones after extraction on germination of mango and found that the freshly extracted mango stones when treated with 200 ppm GA₃ solution and sown in stalk-end up position results in minimum number of days for initiation of germination, and 50% germination, highest rate of germination, seedling length and dry weight whereas the stones soaked in 100 ppm GA₃ solution recorded the highest germination, seedling vigour index-I and seedling vigour index-II. Sau *et al.* (2019) found GA₃ (100 ppm) as the best seed priming treatment for wood apple, as it increased germination percentage by 96.01 per cent over control besides improved vegetative growth (85.21 per cent longer seedlings than control), leaf chlorophyll content and leaf mineral composition, to procure seedlings with vigorous growth.

Boricha *et al.* (2020) revealed that guava seeds soaked in GA₃ @150 mg/l for 24 hours improved germination percentage (80.77%) and took minimum number of days for germination (16.73). The same trend was witnessed for vegetative growth parameters such as number of leaves (7.80, 14.33, 17.93), the height of seedling (7.28, 15.07, 28.18 cm), stem diameter (0.87, 2.22, 2.75 mm), fresh weight of shoot (14.21 g), dry weight of shoot (5.97 g), fresh weight of root (1.94 g), dry weight of root (1.12 g), shoot: root ratio (7.32) and survival percentage (75.00%). Dadhaniya *et al.* (2020) conducted an experiment in which six different chemical treatments were applied on custard apple seeds to study the effect on seedling growth. Results revealed that maximum height of seedling, stem girth, number of leaves, shoot length, root length, number of roots and fresh weight of shoot was observed in seeds treated with GA₃ 200 ppm.

Kumar *et al.* (2020) carried out an experiment to study the effect of pre-sowing seed treatments on root growth and survival of Ber (*Zizyphus mauritiana* L.) and found that GA₃ @ 400 ppm significantly reduce plant mortality and also enhance diameter of tap root

(0.68mm) and survival percentage (72.33%) of seedling at 120 days. Lal *et al.* (2020) studied the effect of soaking and placement of seed on germination and seedling emergence in litchi and found that seed germination improved when seeds were soaked in water as compared to without soaking.

Lalitha *et al.* (2020) conducted an experiment to know the impact of chemicals on aonla seed germination and seedling growth and found that GA₃ @ 500 mg/l for 24 hours minimized days required for initiation of germination as well as ameliorate germination percentage, growth of seedling and maximum survival percentage at 180 DAS. Lanjhiyana *et al.* (2020) studied the role of different pre-sowing seed treatments on seed germination behavior and seedling vigour of papaya (*Carica papaya* L.) and concluded that seed soaked with 150 ppm GA₃ + 12 hours + azotobacter induced early germination, rate of emergence, germination percentage as well as seed vigour index-I and vigour index-II.

Mistry and Sitapara (2020) concluded that karonda seeds soaked with GA₃ 100mg/l for 24 hours took minimum number of days (21.00) for germination. Rajput and Sharma (2020) carried out an experiment in which seeds of *Annona squamosa* L. were treated with 13 different organic and inorganic sources. The result revealed that the maximum plant height (12.91 cm), number of leaves (13.75), Stem girth (4.01 mm), length of seedling (24.27 cm), root length (11.56 cm), maximum chlorophyll content index (19.49) and maximum mean survival percentage of seedlings (85.00%) were recorded when seeds soaked in 200 ppm GA₃.

Sanaullah *et al.* (2020) studied the influence of plant growth regulators and chemicals on seedling growth of rough lemon (*Citrus jambhiri* L.) under hydroponic condition and concluded that the best results for most of the growth parameters was shown by GA₃150 ppm solution for 12 hours and this treatment was at par with KNO₃ at 1.5%. Sikhondze *et al.* (2020) investigated the effects of pre-germination treatments on seed germination and growth of wild guavas and stated that seed treated with sulphuric acid showed the highest germination percentage.

Sodimu *et al.* (2020) concluded that among the different seed priming methods, mechanical scarification was the best dormancy breaking method in *Z. mauritiana* with a germination percentage of 95.20. Sourabh *et al.* (2020) investigated the effect of scarification treatments on seed germination of guava (*Psidium guajava*) and concluded that maximum germination performance and comparatively higher seed viability resulted from scarification of guava seeds with 30% concentrated sulphuric acid for 5 seconds. Hot water soaking at 80°C for 1-minute leads to maximum seedling length (6.03 cm). Untreated seeds and seeds treated with higher concentrations of sulphuric acid or soaked in hot water results in poor seed germination and seedling growth.

Thounaojam and Dhaduk (2020) studied the enhancement of seed germination in chironji through chemical and physical treatments and reported that higher germination percentage was observed when treated with alternate wetting (24 hours) and drying (24 hours) followed by 3 days dipping in tap water, scarification with H₂SO₄ 5% for 5 minutes and with sand paper. Zoubi (2020) examined the effect of mechanical and chemical scarification of date palm seeds and found that scarification treatments enhance the germination rate and early growth of seedlings. Sulphuric acid more efficiently removes the hard endocarp of seeds than mechanical scarification.

Sharma *et al.* (2021) scrutinized the effect of different treatments on breaking seed dormancy in aonla (*Phyllanthus emblica* L.) and found that aonla seed scarified with acid for 30 sec significantly improved seed germination and also helps in breaking seed dormancy but the parameters like seedling length and root length was found higher in seeds treated with GA₃ 500 ppm for 24 hours.

2.2 Effect of growing media on seed germination and seedling growth of guava (*Psidium guajava* L.)

Abirami *et al.* (2010) studied the effect of different propagation media on seed germination, seedling growth and vigour of nutmeg and found that in growing media containing soil: coir: sand: vermicompost (1:1:1:1), the germination parameters as well seedling growth parameters were recorded maximum as compared to other media. Yadav *et al.* (2012) investigated the effect of media on the growth and development of acid lime seedlings with and without azotobacter and reported that among different combinations the medium combination of soil + sand + vermicompost + vermiculite + cocopeat (1: 1: 1: 1: 1) with azotobacter gave significantly superior results. This media combination showed best results for height of seedling, number of leaves per seedling, stem diameter longest tap root, root/shoot ratio, chlorophyll content in leaf and leaf area of seedlings as compared to other media combinations.

Anjanawe *et al.* (2013) found that media consist of FYM: Soil: Sand (1:1:1) recorded the highest germination, shoot growth and root growth parameters in papaya. Bhardwaj (2014) carried out an experiment on papaya and concluded that the media mixture of Vermicompost + Sand + Pond soil (1:1:1) with 2 cm cocopeat in top of the polybags gave the maximum speed of emergence, maximum germination percentage, highest seed vigour, maximum germination index, and minimum germination period during both years of experimentation. This media was also found superior for the growth of papaya seedlings as it gave the maximum height of seedling, leaf area, number of leaves per seedling, stem girth and root length.

Mandal *et al.* (2015) examined the influence of media on seed germination of papaya and concluded that among the different media used, the media M4 (Soil + FYM + Cocopeat @ 2:1:1) gave best results for germination parameters. Surakshitha and Kumar (2015) studied the effect of different media and bio-inoculants on jamun seed germination and seedling growth and reported that the minimum days taken for germination and other seedling growth parameters such as plant height, number of leaves, stem diameter, fresh and dry weight, vigour index-I and II and root length were found superior in medium M1- red earth (2 parts): sand(1part): vermicompost(1 part) and in the bio-inoculant *Glomus fasciculatum* as compared to other media.

Abeyrathna *et al.* (2016) reported that the superior growth performances in nursery plants of avocado were recorded in growing media of sand: compost: burnt paddy husk (1:1:1) and top soil: sand: compost (1:2:3). Both treatments also took minimum number of days for seed germination. Dharmveer *et al.* (2016) found that soil media mixed with cocopeat, vermicompost and sand under shade net house improved the seed germination and seedling growth parameters of *Angelica glauca*.

Nagar *et al.* (2016) concluded that for raising papaya seedlings, growing media that contains cocopeat as an ingredient was considered most suitable for improved germination, vigour and survival of seedlings in the field. Samir *et al.* (2016) found that growing media significantly influenced seed germination and seedling growth parameters of khirni. He found the mixture of soil + sand + FYM superior in seed germination, seedling length, number of leaves, root length, root dry weight, seedling dry weight, seedling vigour-I and II and the parameters like shoot length, stem diameter and dry weight of shoots were found superior in media consist of soil + sand + vermicompost.

Dayeswari *et al.* (2017) found that among the different potting media the best results for highest seed germination percentage, seedling height, seedling girth, leaf nutrient content, chlorophyll content and leaf soluble protein content was obtained in Cocopeat + Vermicompost + Azospirillum + Phosphobacteria + *Pseudomonas fluorescens* in TNAU papaya Co-8. Desai *et al.* (2017) studied the effect of different growing media on seed germination and seedling growth of papaya and observed that growing media consists of soil + cocopeat (1:1) took minimum number of days for germination and also increase the germination percentage over other treatments. Growth parameters such as seedling height, length of root, stem diameter, leaf area, fresh weight of root and shoot were also found best in the same media.

Kaur (2017) studied the effect of media mixtures on seed germination and seedling growth of different mango cultivars under sub-mountainous conditions of Punjab and found

that dusehri mango stones sown in growing media consist of soil + sand + vermicompost (1:1:2) reported minimum days to initiation of germination with highest germination percentage, survival percentage, the height of seedling, number of leaves, girth of seedling, number of roots, tap root length, root girth, fresh weight of seedling, dry weight of seedling, root fresh weight and root dry weight. Meena *et al.* (2017) found that growing media of soil + vermicompost + vermiculite (1:1:1) with 2 cm cocopeat at top of polybags was significantly superior medium for seedling growth as it results in highest growth parameters in terms of stem girth (4.49 mm and 5.90 mm at 30 and 45 DAS, respectively), number of roots (16.06), root length (9.07 cm), fresh weight of shoot and root (4.66 gm and 1.04 gm) and least root: shoot ratio (0.22).

Mishra *et al.* (2017) concluded that 100 ppm GA₃ in growing media of sand: garden soil: FYM (1:1:2) had a significant effect on the growth and seedling establishment of papaya. Prajapati *et al.* (2017) concluded that in acid lime better germination obtained by sowing seeds immediately after extraction in soil + cocopeat (1:1). Seedling growth parameters viz. seedling height, number of leaves, root length, shoot length, dry weight of root, dry weight of shoot was found higher in growing media of soil + vermicompost (1:1).

Rajkumar *et al.* (2017) investigated the effect of different growing media on the rooting of pomegranate cv. Phule arakta cuttings and reported that perlite + vermiculite (1:1) and vermiculite + Cocopeat may be suitable alternatives to the conventionally used garden soil for better rooting and establishment of pomegranate cuttings. Chiranjeevi *et al.* (2018) concluded that in aonla the combination of the regular potting mixture (Red earth, FYM, Sand in 2:1:1 proportion) along with cocopeat and VAM (20 gm per polybag) results in high seed germination percent (86.11%), seedling vigour-I (3484.01 cm), seedling vigour- II (264.35 g) seedling height (24.13 cm), root length (16.33 cm), seedling girth (0.63 cm) and number of leaves (18.86).

Kumar *et al.* (2018) found that for the production of quality seedlings of *Albizia lebbek* with maximum shoot length, root length, collar diameter, dry weight of shoot and root and seedling quality index, the seeds should be sown in media mixture of soil + sand + vermicompost (1:1:1). Nainwad *et al.* (2018) concluded that among the different growing media, the medium M1 that is soil: sand: vermicompost (2:1:1) took minimum number of days for seed germination (12 days) with maximum germination percentage (82.50%) and also took minimum number of days (13.25) to reach 50 per cent germination in Rangpur lime.

Sajana *et al.* (2018) examined the influence of various growing media mixtures on seed germination and seedling growth attributes of marking nut and found that medium of vermicompost + soil + sand (1:1:1) with 2 cm cocopeat recorded higher germination and seedling growth parameters as compared to other media. Dash (2019) concluded that media

mixture consists of 10% Pond soil + 30% vermicompost +30% vermiculite + 30% perlite found best for raising papaya seedlings as it gives early germination, maximum germination percentage, height of seedlings, girth of seedling, root length, shoot length and survival percentage of seedlings.

Gawankar *et al.* (2019) concluded that media mixture consists of soil + vermicompost + rice husk + cocopeat (1: 1: 1: 1) reported higher germination index (33.72), higher germination value (18.58), maximum seedling vigour index (4.60), more percentage of graftable seedlings (91.13%) and highest seed vigour (97.08) in jackfruit. Mahmoud *et al.* (2019) concluded that for maximum germination and seedling growth, the pistachio seeds were planted on march,10 in a growing media mixture of soil: sandy: soil: vermiculite (2:1:1).

Rakibuzzaman *et al.* (2019) evaluated different growing media for seedling initiation and seedling growth of red lady papaya and found that growing media consist of soil + vermicompost + sand + Trichoderma (2:2:1:1) and coco pellet media were found significantly better over other treatments in all the growth parameters of papaya seedlings. Chaudhary *et al.* (2020) found that growing media mixture of soil + FYM + vermicompost (1:1:1) recorded higher germination percentage, germination period, seed vigour (%) and germination index in papaya.

Netam *et al.* (2020) reported that growing media consists of sand + cocopeat recorded significantly higher survival percentage, higher root growth (number of roots per cuttings, length of roots per cuttings, diameter of roots per cuttings, fresh weight of roots per cuttings and dry weight of roots per cuttings) in pomegranate cv. Super Bhagwa hardwood stem cuttings as compared to other growing media. Rawat and Kumar (2020) investigated the effect of different rooting media on seedling growth of two important aromatic crops of Garhwal Himalaya and observed that among the rooting media mixtures, soil and cocopeat combination in rosemary and coco peat and vermicompost combination in geranium results in highest survival percentage (86.7%), number of roots, root length and shoot length.

Sharma *et al.* (2020) analyzed the impact of protective conditions and media on the growth of guava seedlings in north western Haryana and revealed that superior guava seedlings with maximum height, number of leaves and stem girth were found under greenhouse in cocopeat sowed at the first fortnight of September. Vandana *et al.* (2020) investigated the effect of different organic mixtures on stone germination and seedling growth of mango cv. Totapuri under net house and polyhouse conditions and concluded that all growth parameters were found better in media consist of soil: sand: FYM: vermicompost: cocopeat: PGPR (2: 1: 1: 1: 1: 1) as compared to other media combinations in polyhouse conditions.

The present experiment entitled “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)**” was carried out at Precision Farming Development Centre (PFDC), Department of Horticulture, CCS HAU, Hisar in the year 2020-2021.

3.1 Experimental site

The experiments were carried out under both poly house and in open field conditions at Precision Farming Development Centre, Department of Horticulture, CCS Haryana Agricultural University, Hisar, which is located at 215.2 m above the mean sea level with coordinates of 29 10` North latitude and 75 46` East longitudes.

3.2 Weather and Climate

Climate of Hisar is typically semi-arid with very hot and dry summers and bitterly cold winters. Hisar climate is characterized by dryness, high temperature and scanty rainfall. The temperature reaches around 45 °C accompanied by hot and dry winds in May and June, however, the temperature drops to freezing point followed by frost in December and January. Hisar receives 80-85 per cent of total rainfall (about 450 mm) during July to September and 10-15 per cent during winter month *i.e.*, December to February which is due to western disturbances. Relative humidity increases with the onset of monsoon which falls with the withdrawal of monsoon. Monthly mean wind speed varies from 4 to 10 kms per hour.

3.3 Source of Material

Fresh guava seeds were collected from ripe fruits harvested from guava orchard of Department of Horticulture, CCS HAU, Hisar. The seeds were extracted in April, 2020. After extraction, the seeds were properly cleaned, dried under shade and then stored at room temperature.

3.4 Experiment 1: Effect of different pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.)

3.4.1 Experimental details

The field experiment was laid out in Randomized Block Design. Different pre-sowing seed treatments of varying concentration and time were given to guava seeds extracted in the month of April, 2020, along with control; with 3 replications, comprising 39 treatment

combinations. Treated and untreated seeds were sown simultaneously in raised nursery beds, in the month of August, 2020. Details of treatments are given below-

3.4.2 Treatments:

Sr. No.	Treatment Details
T ₁	Scraping of seed coat with sand paper
T ₂	Seed soaked in GA ₃ 100 ppm for 24 hours
T ₃	Seed soaked in GA ₃ 200 ppm for 24 hours
T ₄	Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours
T ₅	Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours
T ₆	0.1 % solution Potassium hydroxide soaking for 2 minutes
T ₇	0.2% solution Potassium hydroxide soaking for 2 minutes
T ₈	30% sulfuric acid soaking at different time intervals
	(i) Quick dip
	(ii) 1 minute
	(iii) 3 minutes
T ₉	5% Hydrochloric acid soaking for 2 minutes
T ₁₀	10% Hydrochloric acid soaking for 2 minutes
T ₁₁	Hot water soaking at 80 ⁰ C at different time intervals
	(i) Quick dip
	(ii) 1 minute
	(iii) 3 minutes
T ₁₂	Water soaking for 48 hours
T ₁₃	Control

Total no. of treatments = 13

Replications = 3

Date of seed sowing = 1st August, 2020

Number of seeds/replications = 50

Environmental Conditions = Open Field conditions

Experimental Design = FRBD

3.5 Experiment No. 2: Effect of different media on seed germination and seedling growth under different growing conditions

3.5.1 Experimental details

The experiment was carried out at the Precision Farming Development Centre (PFDC) of the Department of Horticulture, CCS Haryana Agricultural University, Hisar. The blocks were filled with different growing media combinations on raised nursery beds. Before sowing of seeds, light irrigation was given. In each block, fifty seeds were sown during the 2nd week of August, 2020. The nursery bed was irrigated with the help of water cane soon after seed sowing and thereafter, moisture was maintained regularly. In polyhouse conditions, experiment was laid out in completely randomized design while factorial randomized block design in open field conditions with three replications, comprising 10 media combinations under each condition.

3.5.2 Treatments:

Sr. NO.	Growing Media Combinations
T ₁	Garden Soil + FYM (1:1)
T ₂	Garden Soil + Vermicompost (1:1)
T ₃	Garden Soil + Cocopeat (1:1)
T ₄	Cocopeat + Perlite + Vermiculite (3:1:1)
T ₅	Cocopeat + Perlite + Vermicompost (3:1:1)
T ₆	Cocopeat + Vermiculite + Vermicompost (3:1:1)
T ₇	Sand + Garden Soil + Vermicompost (1:2:1)
T ₈	Sand + Soil (1:1)
T ₉	Garden Soil + Farm Yard Manure + Vermicompost + Cocopeat (3:1:1:1)
T ₁₀	Garden Soil (Control)

3.5.3 Growing Conditions: The nursery beds of all the growing media combinations were raised under the following conditions: -

- i. Open Conditions: In open field conditions, the natural environment prevailed.
- ii. Polyhouse: The polyhouse used under experiment was low-cost polyhouse.

Total number of treatments: $2 \times 10 = 20$

Date of seed sowing: 14th August 2020

Replications: 3

Experimental Design: CRBD and FRBD

3.6 Observations recorded for both experiments:

A. Seed germination parameters:

- 1) Seed viability (%) (Only for first experiment)
- 2) Days to initiation of germination
- 3) Days to 50% of germination
- 4) Germination percentage
- 5) Survival percentage

B. Seedling Growth Parameters

- 1) Height of seedling (cm)
- 2) Root length (cm)
- 3) Shoot length (cm)
- 4) No. of leaves per seedling
- 5) Girth of seedling (mm)
- 6) Leaf area of seedling (cm²)
- 7) Root: Shoot Ratio
- 8) Total chlorophyll content (SPAD units)

3.7 Collection of data

For the collection of data five representative plants were selected randomly and tagged in each replication. Data were collected from these plants for germination and seedling growth.

3.8 Germination parameters:

3.8.1 Seed Viability

Twenty-five seeds of each treatment replicated thrice were soaked in 50 ml water for 16 hours at 25^o C to activate dehydrogenase enzymes. The seeds were stained in 0.01% tetrazolium solution (2,3,5- triphenyl tetrazolium chloride) for 5 hours at 38^o C in Petri plates after longitudinal sectioning of seeds with a sharp blade. After that solution was poured off and

seeds were washed in tap water and examined under a magnifying glass. The completely red-stained seeds were considered as normal viable seeds and expressed in percentage.

3.8.2 Days to initiation of germination

Days to initiation of germination were recorded from the date of sowing to plumule comes out above the soil surface. The average time required for germination in each replication was calculated.

3.8.3 Days to 50 % of germination

Number of days required to reach 50% of the final germination was computed from the germination percentage calculated for each observation during the course of experiments.

3.8.4 Germination percentage

The germination percentage was calculated as the percent of germinating seeds starting from the first seed germination to the cessation of germination. It was calculated by the number of germinated seeds divided by the total number of seeds sown and multiplied by 100.

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

3.8.5 Survival percentage

Survival percentage was calculated by total survived seedlings divided by total germinated seeds and multiplied by 100. The formula is:

$$\text{Survival percentage} = \frac{\text{Total survived seedlings}}{\text{Total germinated seedlings}} \times 100$$

3.9 Seedling growth parameters:

3.9.1 Height of seedling (cm)

Height of seedling was measured from the root tip to the tip of the primary leaf. Randomly five normal seedlings were selected in each replication and measured in centimeters.

3.9.2 Shoot length (cm)

Shoot length of five randomly selected seedlings was recorded 90 days after sowing. The seedling height was measured from collar region to tip of shoot and mean shoot length was expressed in centimeters.

3.9.3 Girth of seedling (mm)

Randomly selected five seedlings that were adopted for measuring seedling height were also used to measure the girth of seedlings. Stem girth was measured at 90 days after sowing with digital vernier caliper and girth expressed in millimeters.

3.9.4 Number of leaves per seedling

Seedlings selected for measurement of plant height were also used to count the number of leaves per seedling at 90 days after sowing. Average data was calculated for each replication.

3.9.5 Leaf area of seedling (cm²)

Five randomly selected leaves of different size were separated from seedlings and their actual leaf area was recorded by a digital leaf area meter (CI-202 Portable laser leaf area meter). Leaf area was measured in square centimeters.

3.9.6 Root length (cm)

Root length was measured by the destructive method of uprooting the plants and measurement was recorded by using a centimeter scale. Root length was measured from the collar region to the tip of the longest root. Average data was calculated for each replication at 90 days after sowing.

3.9.7 Root: shoot ratio

The ratio was calculated by dividing average root length by average shoot length. For each replication average data was calculated.

3.9.8 Total chlorophyll content

Total chlorophyll content of five randomly selected leaves were recorded by using MC-100 chlorophyll concentration meter at 90 days after sowing. The meter directly measures and displays chlorophyll concentration from intact leaf samples without damaging the plant.

3.9 Statistical Analysis

Data recorded during the study was statistically analyzed by applying the Factorial Randomized Block Design for the first experiment and Factorial Randomized Block Design and Completely Randomized block design for the second experiment for analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1995). The mean value of different parameters is represented in this thesis. OPSTAT statistical software was used for all the statistical analysis.



Plate 1. Seed treatment of guava by different chemicals



Plate 2. Measuring girth of seedling using vernier caliper



Plate 3. Measuring total chlorophyll content using MC-100 Chlorophyll concentration meter



Plate 4. General view of experimental site

This chapter embodies the results of present investigation on “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)**” carried out at Precision Farming Development Centre (PFDC), Department of Horticulture, CCS HAU, Hisar during the year 2020-2021. The results along with statistical inferences are presented in this chapter.

4.1 Effect of different pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.)

In this experiment, guava seeds were subjected to different pre-sowing seed treatments and their response were studied.

4.1.1 Seed Viability

It is perusal from the data presented in Table 1 and depicted in Figure 1 indicated that under different pre-sowing treatments, seed viability of guava was significantly influenced and varied from 56.00 to 84.00 per cent. Maximum seed viability was recorded in control (84.00%) that was statistically at par with water soaking for 48 hours (80.00%). Except control and Water soaking for 48 hours, seed viability decreased significantly in all the treatments. Minimum seed viability (56.00%) was observed when seeds were soaked in 30% H₂SO₄ solution for 3 minutes.

4.1.2 Days to initiation of germination

Data regarding days to initiation of germination is presented in Table 1 and Figure 1. Different pre-sowing treatments had a significant effect on days to initiation of germination. Among the pre-sowing treatments seeds soaked with 5% HCl for 2 minutes required minimum number of days to initiate germination (17.67) and followed by 10% HCl for 2 minutes and quick dip in 30% H₂SO₄ i.e., 18.33 and 19.00, respectively. Maximum number of days (25.33) taken to initiate germination was recorded in the control.

4.1.3 Days to 50 per cent germination

Different pre-sowing treatments had a significant effect on days to 50 per cent germination (Table 1 & Fig.1.). Seeds treated with 5% HCl for 2 minutes requires minimum number of days for 50 per cent germination (27.33) that was followed by 10% HCl soaking for 2 minutes, quick dip soaking in 30% H₂SO₄, scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours, scraping of seed coat with sand paper + seeds soaked in

GA₃ 100 ppm for 24 hours and 0.1% Potassium hydroxide solution soaking for 2 minutes i.e., 28.33, 28.67, 29, 29.33 and 30.00 days, respectively. Maximum number of days (37.33) taken for 50 per cent germination was recorded in control.

Table 1: Effect of different pre-sowing treatments on seed viability, days to initiation of germination and days to 50% germination

Treatment	Seed viability (%)	Days to initiation of germination	Days to 50% germination
T ₁ (Scraping of seed coat with sand paper)	69.33	23.33	35.33
T ₂ (Seed soaked in GA ₃ 100 ppm for 24 hours)	73.33	21.00	31.00
T ₃ (Seed soaked in GA ₃ 200 ppm for 24 hours)	72.00	20.33	30.67
T ₄ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours)	68.00	19.33	29.33
T ₅ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours)	66.67	18.67	29.00
T ₆ (0.1% solution Potassium hydroxide soaking for 2 minutes)	65.33	19.67	30.00
T ₇ (0.2% solution Potassium hydroxide soaking for 2 minutes)	64.00	20.67	32.33
T ₈ (30% Sulfuric acid soaking) i. Quick dip	65.33	19.00	28.67
ii. 1 minute	62.67	20.67	32.00
iii. 3 minutes	56.00	21.67	34.67
T ₉ (5% Hydrochloric acid soaking for 2 minutes)	62.67	17.67	27.33
T ₁₀ (10% Hydrochloric acid soaking for 2 minutes)	60.00	18.33	28.33
T ₁₁ (Hot water soaking at 80° C) i. quick dip	70.67	22	35.67
ii. 1 minute	65.33	21.33	31.67
iii. 3 minutes	61.33	20.66	34.33
T ₁₂ (Water soaking for 48 hours)	80.00	24.67	36.00
T ₁₃ (Control)	84.00	25.33	37.33
C.D. at 5%	5.58	1.36	2.94

4.1.4 Germination percentage

Germination percentage was increased significantly with different pre-sowing treatments as compared to control (Table 2 and Fig. 2). The germination per cent ranged from 31.33 per

cent to 60.00 per cent. Maximum germination percentage in guava was recorded with the scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours (60.00%) which was significantly higher as compared to the other treatments, followed by scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours (56.00%) whereas, minimum germination (31.33%) was observed in control.

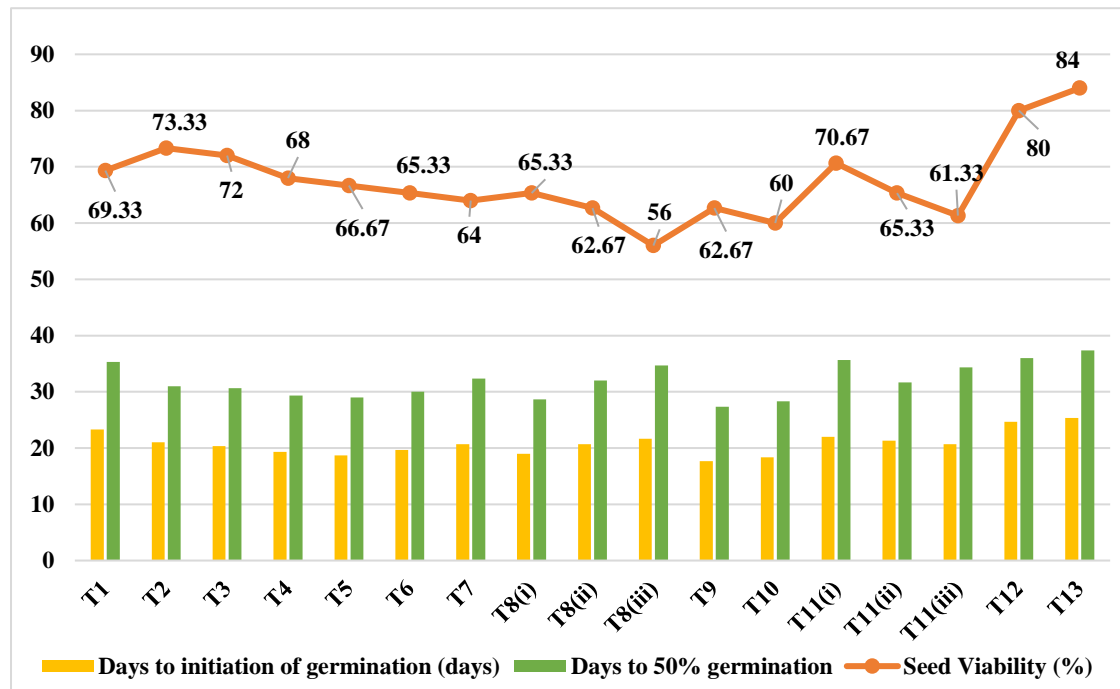


Figure 1: Effect of different pre-sowing treatments on seed viability, days to initiation of germination and days to 50% germination

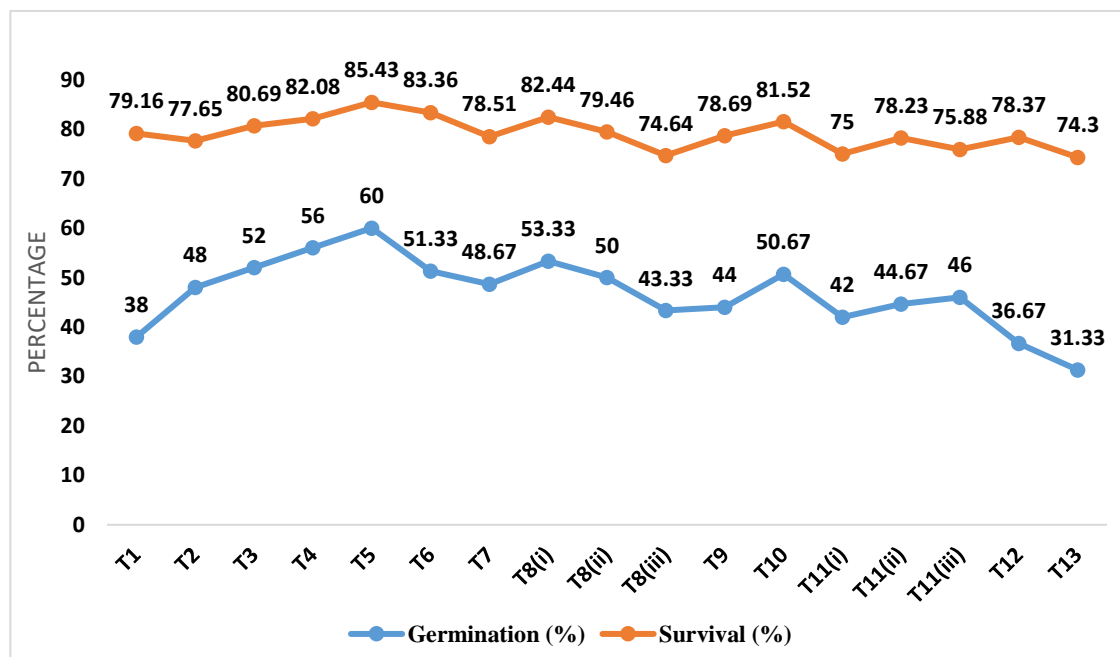


Figure 2: Effect of different pre-sowing treatments on germination percentage and survival percentage of guava seedlings

4.1.5 Survival percentage (%)

It is apparent from the data presented in Table 2 and depicted in Figure 2 that survival percentage was significantly affected by the different pre-sowing treatments. Survival percentage under different pre-sowing treatments ranged from 74.30 per cent to 85.43 per cent. Maximum survival percentage was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours (85.43 %) that was followed by seed soaked in 0.1% KOH for 2 minutes, quick dip soaking in 30% H₂SO₄ solution and scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours i.e., 83.36, 82.44 and 82.08%, respectively. Minimum survival percentage (74.30%) was observed in control.

Table 2: Effect of different pre-sowing treatments on germination percentage, survival percentage and height of seedlings (cm)

Treatment	Germination percentage	Survival percentage	Height of seedling(cm)
T ₁ (Scraping of seed coat with sand paper)	38.00	79.16	2.99
T ₂ (Seed soaked in GA ₃ 100 ppm for 24 hours)	48.00	77.65	3.98
T ₃ (Seed soaked in GA ₃ 200 ppm for 24 hours)	52.00	80.69	4.06
T ₄ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours)	56.00	82.08	4.40
T ₅ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours)	60.00	85.43	4.59
T ₆ (0.1% solution Potassium hydroxide soaking for 2 minutes)	51.33	83.36	4.28
T ₇ (0.2% solution Potassium hydroxide soaking for 2 minutes)	48.67	78.51	4.12
T ₈ (30% Sulfuric acid soaking) i. Quick dip	53.33	82.44	4.46
ii. 1 minute	50.00	79.46	4.30
iii. 3 minutes	43.33	74.64	4.15
T ₉ (5% Hydrochloric acid soaking for 2 minutes)	44.00	78.69	3.59
T ₁₀ (10% Hydrochloric acid soaking for 2 minutes)	50.67	81.52	4.16
T ₁₁ (Hot water soaking at 80° C) i. quick dip	42.00	75.00	3.44
ii. 1 minute	44.67	78.23	3.90
iii. 3 minutes	46.00	75.88	3.75
T ₁₂ (Water soaking for 48 hours)	36.67	78.37	3.13
T ₁₃ (Control)	31.33	74.30	2.75
C.D. at 5%	3.36	3.82	0.19

4.1.6 Height of seedling (cm)

Under different pre-sowing treatments height of seedlings varied from 2.75 cm to 4.59 cm (Table 2). Maximum height of seedlings (4.59 cm) was recorded with the treatment of scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours that was statistically at par with quick dip soaking in 30% H₂SO₄ solution and scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours (4.46 cm and 4.40 cm, respectively). Results showed that minimum height of seedling (2.75 cm) was observed in control.

4.1.7 Shoot length (cm)

It is apparent from the data that different pre-sowing treatments had a significant effect on shoot length (Table 3). Shoot length under different pre-sowing treatments ranged from 4.12 cm to 6.75 cm. Maximum shoot length (6.75 cm) was recorded when seeds were treated with scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours that was statistically at par with quick dip soaking in 30% H₂SO₄ solution (6.53 cm). Minimum shoot length (4.12 cm) was found in control.

4.1.8 Root length (cm)

It is perusal from the data presented in Table 3 that under different pre-sowing treatments root length ranged from 3.15 cm to 5.85 cm. Maximum root length (5.85 cm) was observed when seeds were subjected to scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours that was statistically at par with quick dip soaking in 30 per cent sulphuric acid solution (5.58 cm). In control treatment the minimum root length (3.15 cm) was recorded.

4.1.9 Root: Shoot ratio

Results given in Table 3 elucidated that root: shoot ratio was significantly affected by different pre-sowing treatments. Highest root: shoot ratio (0.87) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours and followed by quick dip soaking in 30 per cent sulphuric acid solution and scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours i.e., 0.86 and 0.85, respectively. Whereas, lowest root: shoot ratio (0.76) was observed in the control.

4.1.10 Girth of seedling (mm)

It is evident from the data that different pre-sowing treatments had a significant effect on girth of seedlings (Table 4). Seedling girth varied from 1.01 mm to 1.34 mm. Girth of seedling (1.34 mm) was found maximum in quick dip seed soaking in 30 per cent sulphuric acid solution that was statistically at par with scraping of seed coat with sand paper + seeds soaked

in GA₃ 200 ppm for 24 hours (1.31 mm). Whereas, minimum girth of seedling (1.01 mm) was recorded in control.

Table 3: Effect of different pre-sowing treatments on shoot length (cm), root length (cm) and root: shoot ratio

Treatment	Shoot length (cm)	Root length (cm)	Root: Shoot ratio
T ₁ (Scraping of seed coat with sand paper)	4.50	3.50	0.78
T ₂ (Seed soaked in GA ₃ 100 ppm for 24 hours)	5.45	4.45	0.82
T ₃ (Seed soaked in GA ₃ 200 ppm for 24 hours)	5.63	4.64	0.83
T ₄ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours)	6.30	5.35	0.85
T ₅ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours)	6.75	5.85	0.87
T ₆ (0.1% solution Potassium hydroxide soaking for 2 minutes)	5.85	4.85	0.83
T ₇ (0.2% solution Potassium hydroxide soaking for 2 minutes)	5.48	4.35	0.80
T ₈ (30% Sulfuric acid soaking) i. Quick dip	6.53	5.58	0.86
ii. 1 minute	5.09	4.07	0.80
iii. 3 minutes	4.68	3.85	0.83
T ₉ (5% Hydrochloric acid soaking for 2 minutes)	4.97	4.03	0.81
T ₁₀ (10% Hydrochloric acid soaking for 2 minutes)	6.07	5.10	0.84
T ₁₁ (Hot water soaking at 80° C) i. quick dip	4.65	3.60	0.77
ii. 1 minute	5.27	4.26	0.81
iii. 3 minutes	4.99	4.01	0.81
T ₁₂ (Water soaking for 48 hours)	4.25	3.30	0.77
T ₁₃ (Control)	4.12	3.15	0.76
C.D. at 5%	0.41	0.29	0.03

4.1.11 Number of Leaves per seedling

Number of leaves per seedling under different pre-sowing treatments ranged from 9.20 to 12.40 (Table 4). Maximum number of leaves per seedling (12.40) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours that was statistically at par with quick dip soaking in 30 per cent sulphuric acid solution and scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours (12.13 and 11.87, respectively). Results showed that minimum number of leaves per seedling (9.20) was observed in control.

Table 4: Effect of different pre-sowing treatments on girth of seedlings (mm), number of leaves per seedling and leaf area of seedlings (cm²)

Treatment	Girth of seedling (mm)	No. of leaves per seedling	Leaf area of seedling (cm ²)
T ₁ (Scraping of seed coat with sand paper)	1.06	10.00	2.35
T ₂ (Seed soaked in GA ₃ 100 ppm for 24 hours)	1.20	11.20	3.30
T ₃ (Seed soaked in GA ₃ 200 ppm for 24 hours)	1.22	11.33	3.37
T ₄ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours)	1.28	11.87	3.69
T ₅ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours)	1.31	12.40	3.83
T ₆ (0.1% solution Potassium hydroxide soaking for 2 minutes)	1.24	11.60	3.52
T ₇ (0.2% solution Potassium hydroxide soaking for 2 minutes)	1.12	11.07	3.27
T ₈ (30% Sulfuric acid soaking) i. Quick dip	1.34	12.13	3.43
ii. 1 minute	1.16	10.80	3.02
iii. 3 minutes	1.11	10.27	2.79
T ₉ (5% Hydrochloric acid soaking for 2 minutes)	1.14	10.67	2.92
T ₁₀ (10% Hydrochloric acid soaking for 2 minutes)	1.26	11.47	3.18
T ₁₁ (Hot water soaking at 80° C) i. Quick dip	1.10	10.40	2.79
ii. 1 minute	1.18	10.93	3.14
iii. 3 minutes	1.15	10.53	2.96
T ₁₂ (Water soaking for 48 hours)	1.03	9.33	2.08
T ₁₃ (Control)	1.01	9.20	1.95
C.D. at 5%	0.05	0.64	0.25

4.1.12 Leaf area of seedling (cm²)

Results obtained from the study (Table 4) revealed that different pre-sowing treatments had a significant effect on leaf area of seedling. Data showed that leaf area of seedling varied from 1.95 cm² to 3.83 cm². Maximum leaf area of seedling (3.83 cm²) was found in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours that was statistically at par with scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm (3.69 cm²) while the minimum leaf area of seedling (1.95 cm²) was found in control.

4.1.13 Total Chlorophyll Content

Total chlorophyll content was significantly influenced by different pre-sowing treatments (Table 5).

Table 5: Effect of different pre-sowing treatments on total chlorophyll content (SPAD units)

Treatment	Total chlorophyll content (SPAD unit)
T ₁ (Scraping of seed coat with sand paper)	20.52
T ₂ (Seed soaked in GA ₃ 100 ppm for 24 hours)	25.73
T ₃ (Seed soaked in GA ₃ 200 ppm for 24 hours)	26.83
T ₄ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 100 ppm for 24 hours)	28.22
T ₅ (Scraping of seed coat with sand paper + Seeds soaked in GA ₃ 200 ppm for 24 hours)	29.85
T ₆ (0.1% solution Potassium hydroxide soaking for 2 minutes)	24.66
T ₇ (0.2% solution Potassium hydroxide soaking for 2 minutes)	21.97
T ₈ (30% Sulfuric acid soaking) i. Quick dip	27.84
ii. 1 minute	22.50
iii. 3 minutes	20.16
T ₉ (5% Hydrochloric acid soaking for 2 minutes)	22.21
T ₁₀ (10% Hydrochloric acid soaking for 2 minutes)	26.60
T ₁₁ (Hot water soaking at 80° C) i. quick dip	21.03
ii. 1 minute	23.25
iii. 3 minutes	22.27
T ₁₂ (Water soaking for 48 hours)	18.71
T ₁₃ (Control)	17.87
C.D. at 5%	2.51

Results showed that maximum chlorophyll content (29.85 SPAD unit) was recorded in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours followed by scraping of seed coat with sand paper + seeds soaked in GA₃ 100 ppm for 24 hours and quick dip soaking in 30 per cent sulphuric acid solution i.e., 28.22 and 27.84 SPAD unit, respectively. Whereas, minimum total chlorophyll content was recorded in control (17.87 SPAD unit).

4.2 Effect of growing media on seed germination and seedling growth under different growing conditions

In this experiment, guava seeds were sown in different growing media under different growing conditions i.e., in the open field and poly house, and their responses were recorded.

4.2.1 Days to initiation of germination

It is evident from Table 6 and Figure 3 that all growing media significantly reduced the days to initiation of germination of guava seedlings as compared to garden soil (control) in both the growing conditions i.e., open field and polyhouse conditions. The data depicted that in open field condition, minimum days to initiation of germination (24.33) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with sand + soil + vermicompost and cocopeat + perlite + vermicompost (3:1:1) (25.00 and 25.33, respectively). Maximum days to initiation of germination (28.33) were observed in garden soil (control).

Table 6: Effect of different growing media on days to initiation of germination under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	27.00	23.33
T ₂ Garden soil + vermicompost (1:1)	27.67	24.00
T ₃ Garden soil + cocopeat (1:1)	26.67	23.67
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	26.33	22.67
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	25.33	22.00
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	24.33	21.33
T ₇ Sand + garden soil + vermicompost (1:2:1)	25.00	21.67
T ₈ Sand + garden soil (1:1)	26.00	22.33
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	27.33	24.67
T ₁₀ Garden soil (Control)	28.33	25.33
C.D. at 5 %	1.28	1.04

Whereas, in poly house conditions, minimum number of days to initiation of germination (21.33) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was followed by growing media combination of sand + garden soil + vermicompost (1:2:1), Cocopeat + Perlite + Vermicompost (3:1:1) and Sand + Soil (1:1) i.e., 21.67, 22.00 and 22.33 days, respectively. Maximum number of days to initiation of germination (25.33) were recorded in garden soil (control).

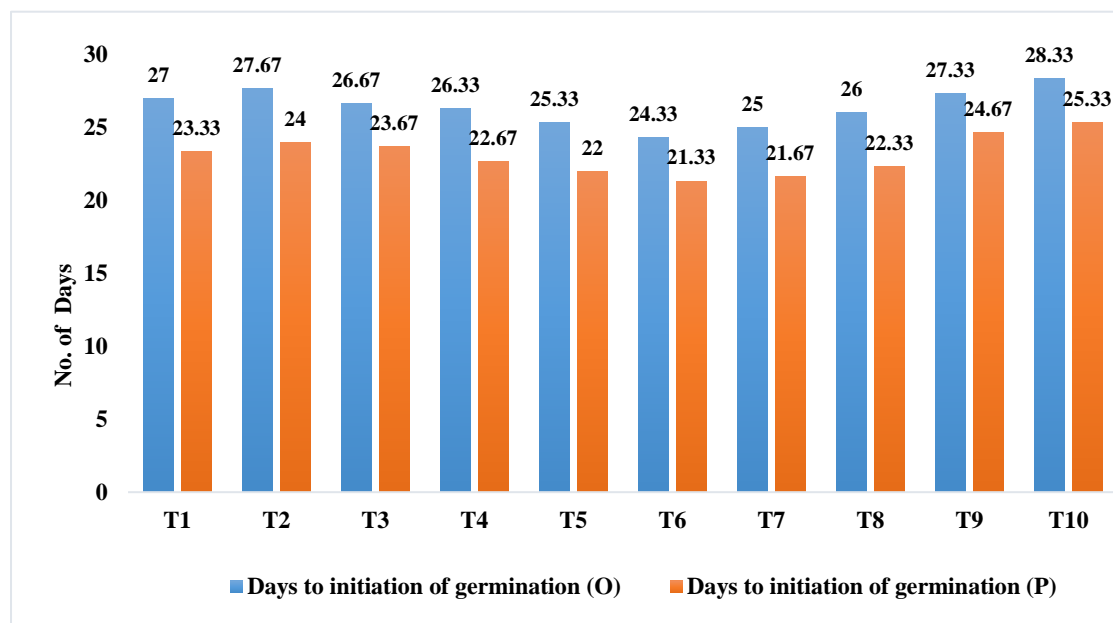


Figure 3: Effect of different growing media on days to initiation of germination under different growing conditions

4.2.2 Days to 50 per cent germination

It is apparent from the data that growing media had a significant effect on days to 50 per cent germination in both the growing conditions i.e., open field and polyhouse (Table 7). Data indicated that in open field condition, seeds sown in cocopeat + vermiculite + vermicompost (3:1:1) required minimum number of days to 50 per cent germination (32.33) followed by cocopeat + perlite + vermiculite (3:1:1) i.e., 33.67 days. Maximum number of days required for 50 per cent germination (37.00) was observed in garden soil (control).

Whereas, in poly house condition, seeds sown in cocopeat + vermiculite + vermicompost (3:1:1) required minimum number of days for 50 per cent germination (26.00) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and garden soil + sand (1:1) (26.67 and 27.33 days, respectively). In garden soil (control) seeds required maximum number of days (32.67) for 50 per cent germination.

Table 7: Effect of different growing media on days to 50% germination under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	35.67	29.33
T ₂ Garden soil + vermicompost (1:1)	36.00	30.00
T ₃ Garden soil + cocopeat (1:1)	35.00	29.67
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	33.67	28.00
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	34.67	26.67
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	32.33	26.00
T ₇ Sand + garden soil + vermicompost (1:2:1)	34.00	28.67
T ₈ Sand + garden soil (1:1)	36.33	27.33
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	35.33	31.67
T ₁₀ Garden soil (Control)	37.00	32.67
C.D. at 5 %	1.51	1.57

4.2.3 Germination percentage

Data elucidated that different growing media significantly influenced the germination percentage in both the growing conditions i.e., open field and polyhouse (Table 8 and Fig.4). In open field condition, germination percentage ranged from 27.33 to 54.67 per cent. Maximum germination percentage (54.67%) was recorded in cocopeat + perlite + vermicompost (3:1:1) that was statistically at par with cocopeat + vermiculite + vermicompost (3:1:1) (51.33%) while in garden soil (control) minimum germination percentage (27.33) was observed.

Whereas, in poly house conditions the germination percentage ranged from 30.00 to 59.33 per cent. Maximum germination percentage (59.33%) was observed in cocopeat + perlite + vermicompost (3:1:1) that was observed statistically at par with cocopeat + vermiculite + vermicompost (3:1:1) (54.00%). Minimum germination percentage (30.00%) was observed in garden soil.

Table 8: Effect of different growing media on germination percentage under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	37.33	40.67
T ₂ Garden soil + vermicompost (1:1)	40.67	43.33
T ₃ Garden soil + cocopeat (1:1)	32.00	34.67
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	47.33	48.67
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	54.67	59.33
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	51.33	54.00
T ₇ Sand + garden soil + vermicompost (1:2:1)	44.00	46.67
T ₈ Sand + garden soil (1:1)	34.67	38.00
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	44.67	50.67
T ₁₀ Garden soil (Control)	27.33	30.00
C.D. at 5 %	5.02	5.42

4.2.4 Survival percentage

Data presented in Table 9 and graphically illustrated in Figure 4 that survival percentage was significantly influenced by growing media under both the growing conditions i.e., open field and polyhouse. In open field conditions, it was observed that the survival percentage of seedlings ranged from 73.25 to 85.33 per cent. Maximum survival percentage (85.33%) was observed in cocopeat + perlite + vermicompost (3:1:1) which was found statistically at par with garden soil + FYM (1:1) (83.67%). Results shown that minimum survival percentage (73.25%) was noticed in garden soil (control)

Whereas, in poly house conditions the survival percentage varied from 75.63 to 88.85 per cent. Maximum survival percentage (88.85%) was observed in cocopeat + perlite + vermicompost (3:1:1) that was followed by garden soil + FYM + vermicompost + cocopeat (3:1:1:1) and garden soil + FYM (1:1) i.e., 86.94 and 86.10 per cent, respectively. Minimum survival percentage (75.63%) was observed in growing media of garden soil (control).

Table 9: Effect of different growing media on survival percentage under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	83.67	86.10
T ₂ Garden soil + vermicompost (1:1)	80.76	82.50
T ₃ Garden soil + cocopeat (1:1)	74.93	76.80
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	77.95	80.27
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	85.33	88.85
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	78.69	84.96
T ₇ Sand + garden soil + vermicompost (1:2:1)	82.03	85.56
T ₈ Sand + garden soil (1:1)	82.19	81.20
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	79.94	86.94
T ₁₀ Garden soil (Control)	73.25	75.63
C.D. at 5 %	2.94	3.08

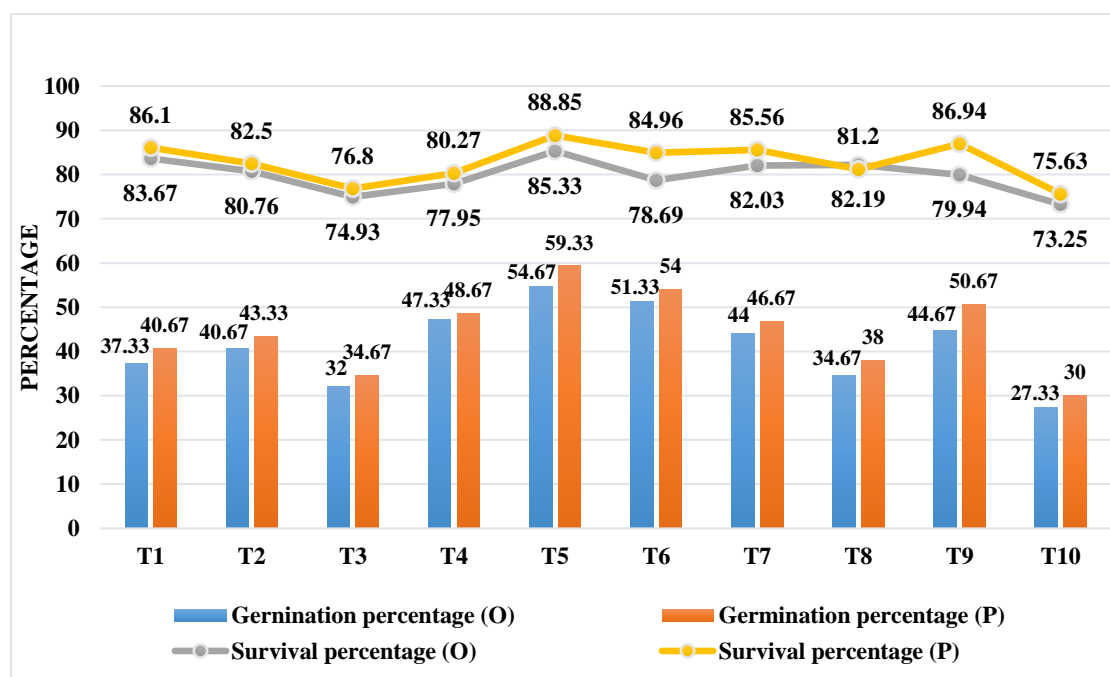


Figure 4: Effect of different growing media on germination percentage and survival percentage of seedlings under different growing conditions

4.2.5 Height of seedling (cm)

It is apparent from the data presented in Table 10 that growing media combinations significantly influenced the height of seedlings as compared to garden soil (control) in both the growing conditions i.e., open field and polyhouse. Results shown that in open field conditions, height of seedlings ranged from 3.00 cm to 4.38 cm. Maximum height of seedlings (4.38 cm) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) followed by cocopeat + perlite + vermiculite (3:1:1) (4.24 cm) while minimum height of seedling (3.00 cm) was observed in garden soil.

Whereas, in poly house conditions, the data ranged from 3.06 cm to 4.53 cm. Maximum height of seedlings (4.53 cm) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermiculite (3:1:1) (4.36 cm) and minimum height of seedling (3.06 cm) was recorded in garden soil (control).

Table 10: Effect of different growing media on the height of seedlings (cm) under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	3.46	3.55
T ₂ Garden soil + vermicompost (1:1)	3.62	3.70
T ₃ Garden soil + cocopeat (1:1)	3.30	3.40
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	4.24	4.36
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	4.08	4.20
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	4.38	4.53
T ₇ Sand + garden soil + vermicompost (1:2:1)	3.80	3.86
T ₈ Sand + garden soil (1:1)	3.14	3.22
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	3.94	4.02
T ₁₀ Garden soil (Control)	3.00	3.06
C.D. at 5 %	0.17	0.21

4.2.6 Shoot length (cm)

It is perusal from the data that shoot length differed significantly with respect to different growing media in both the growing conditions i.e., open field and polyhouse (Table 11). In open field conditions, the data showed that shoot length ranged from 4.34 cm to 6.14 cm. Growing media of cocopeat + vermiculite + vermicompost (3:1:1) recorded maximum shoot

length (6.14 cm) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and cocopeat + perlite + vermiculite (3:1:1) (5.95 cm and 5.73 cm, respectively). Minimum shoot length (4.34 cm) was observed in control.

Whereas, in polyhouse conditions, data on shoot length varied from 4.52 cm to 6.34 cm. Maximum shoot length (6.34 cm) was found in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) (6.09 cm) whereas, minimum shoot length (4.52 cm) was observed in garden soil (control).

Table 11: Effect of different growing media on shoot length (cm) under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	4.97	5.09
T ₂ Garden soil + vermicompost (1:1)	5.15	5.28
T ₃ Garden soil + cocopeat (1:1)	4.79	4.91
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	5.73	5.91
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	5.95	6.09
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	6.14	6.34
T ₇ Sand + garden soil + vermicompost (1:2:1)	5.34	5.51
T ₈ Sand + garden soil (1:1)	4.56	4.70
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	5.57	5.72
T ₁₀ Garden soil (Control)	4.34	4.52
C.D. at 5 %	0.41	0.33

4.2.7 Root length (cm)

The results pertaining to the effect of different growing media on root length revealed that root length was significantly affected by different growing media in both the growing conditions i.e., open field and polyhouse (Table 12). In open field conditions, root length of seedlings ranged from 3.48 cm to 5.35 cm. Data indicated that maximum root length of seedlings (5.35 cm) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) (5.14 cm) while the minimum root length (3.48 cm) was observed in garden soil (control).

Whereas, in polyhouse conditions, root length of seedlings varied from 3.63 cm to 5.51 cm. Maximum root length of seedlings (5.51 cm) was found in cocopeat + vermiculite + vermicompost (3:1:1) followed by cocopeat + perlite + vermicompost (3:1:1) (5.14 cm). Root length of seedlings was found minimum (3.63 cm) in garden soil (control).

Table 12: Effect of different growing media on root length of seedlings (cm) under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	4.08	4.24
T ₂ Garden soil + vermicompost (1:1)	4.30	4.42
T ₃ Garden soil + cocopeat (1:1)	3.90	4.05
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	4.95	5.03
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	5.14	5.26
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	5.35	5.51
T ₇ Sand + garden soil + vermicompost (1:2:1)	4.47	4.60
T ₈ Sand + garden soil (1:1)	3.72	3.86
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	4.71	4.83
T ₁₀ Garden soil (Control)	3.48	3.63
C.D. at 5 %	0.32	0.29

4.2.8 Root: Shoot ratio

Data on root: shoot ratio in different growing media under open field as well as polyhouse conditions is presented in Table 13. In the case of open field conditions, maximum root: shoot ratio (0.87) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and cocopeat + perlite + vermiculite (3:1:1) (0.86 and 0.86, respectively) and minimum root: shoot ratio (0.80) was observed in garden soil (control).

Whereas, in poly house conditions, maximum root: shoot ratio (0.87) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and cocopeat + perlite + vermiculite (3:1:1) (0.86 and 0.86, respectively). Minimum root: shoot ratio (0.80) was reported in garden soil (control).

Table 13: Effect of different growing media on root: shoot ratio under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	0.82	0.83
T ₂ Garden soil + vermicompost (1:1)	0.83	0.83
T ₃ Garden soil + cocopeat (1:1)	0.82	0.82
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	0.86	0.86
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	0.86	0.86
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	0.87	0.87
T ₇ Sand + garden soil + vermicompost (1:2:1)	0.84	0.83
T ₈ Sand + garden soil (1:1)	0.82	0.82
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	0.85	0.85
T ₁₀ Garden soil (Control)	0.80	0.80
C.D. at 5 %	0.03	0.02

4.2.9 Girth of seedling (mm)

Growing media had a significant affect on girth of seedlings under open field as well as polyhouse conditions (Table 14). In open field conditions, girth of seedlings ranged from 1.02 mm to 1.29 mm.

Table 14: Effect of different growing media on the girth of seedlings (cm) under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	1.13	1.15
T ₂ Garden soil + vermicompost (1:1)	1.16	1.18
T ₃ Garden soil + cocopeat (1:1)	1.08	1.12
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	1.23	1.27
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	1.27	1.30
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	1.29	1.33
T ₇ Sand + garden soil + vermicompost (1:2:1)	1.19	1.22
T ₈ Sand + garden soil (1:1)	1.05	1.09
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	1.22	1.24
T ₁₀ Garden soil (Control)	1.02	1.06
C.D. at 5 %	0.04	0.03

Among different growing media combinations seedlings raised in cocopeat + vermiculite + vermicompost (3:1:1) showed maximum girth of seedlings (1.29 mm) that was statistically at par with growing media of cocopeat + perlite + vermicompost (3:1:1) (1.27 mm). Minimum girth of seedlings (1.02 mm) was recorded in garden soil (control).

Whereas, under polyhouse conditions, among the various growing media, maximum girth of seedlings (1.33 mm) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) (1.30 mm). Girth of seedlings was found minimum (1.06 mm) in garden soil (control).

4.2.10 Number of leaves

Results obtained from study (Table 15) revealed that different growing media had a significant effect on number of leaves per seedling under both growing conditions (open field and polyhouse). Number of leaves per seedling varied from 9.60 to 11.73 mm in open field condition. Maximum number of leaves (11.73) was observed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and cocopeat + perlite + vermiculite (3:1:1) (11.60 and 11.33, respectively) while minimum number of leaves (9.60) was noticed in garden soil (control).

Whereas, in polyhouse conditions, data on number of leaves per seedling lies between 10.00 to 12.00. Growing media consists of cocopeat + vermiculite + vermicompost (3:1:1) observed maximum number of leaves per seedling (12.00) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) and cocopeat + perlite + vermiculite (3:1:1) (11.87 and 11.60, respectively). In garden soil, minimum number of leaves (10.00) was observed.

Table 15: Effect of different growing media on number of leaves per seedling under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	10.53	10.80
T ₂ Garden soil + vermicompost (1:1)	10.93	11.07
T ₃ Garden soil + cocopeat (1:1)	10.40	10.53
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	11.33	11.60
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	11.60	11.87
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	11.73	12.00
T ₇ Sand + garden soil + vermicompost (1:2:1)	11.07	11.33
T ₈ Sand + garden soil (1:1)	10.00	10.27
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	11.20	11.47
T ₁₀ Garden soil (Control)	9.60	10.00
C.D. at 5 %	0.50	0.49

4.2.11 Leaf area of seedling (cm²)

It is delineated from data presented in Table 16 that leaf area of seedlings was significantly affected by different growing media under both growing conditions i.e., open field and polyhouse. In open field conditions, leaf area of seedlings ranged from 2.56 cm² to 3.58 cm². Maximum leaf area of seedlings (3.58 cm²) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) (3.43 cm²). Minimum leaf area of seedlings (2.56 cm²) was recorded in garden soil (control).

Whereas, in polyhouse conditions, leaf area of seedlings ranged from 2.77 cm² to 3.72 cm². Maximum leaf area of seedlings (3.72 cm²) was noticed in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermiculite (3:1:1) and cocopeat + perlite + vermicompost (3:1:1) (3.58 cm² and 3.49 cm², respectively). Minimum leaf area of seedlings (2.77 cm²) was recorded in garden soil (control).

Table 16: Effect of different growing media on leaf area of seedlings (cm²) under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	3.15	3.17
T ₂ Garden soil + vermicompost (1:1)	3.02	3.23
T ₃ Garden soil + cocopeat (1:1)	2.88	3.01
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	3.34	3.58
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	3.43	3.49
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	3.58	3.72
T ₇ Sand + garden soil + vermicompost (1:2:1)	3.29	3.31
T ₈ Sand + garden soil (1:1)	2.72	2.87
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	3.20	3.38
T ₁₀ Garden soil (Control)	2.56	2.77
C.D. at 5 %	0.20	0.23

4.2.12 Total chlorophyll content (SPAD unit)

Total chlorophyll content was influenced by different growing media under both the growing conditions (open field and polyhouse) are presented in Table 17. In open field conditions, total chlorophyll content varied from 15.82 SPAD units to 25.40 SPAD unit. Total

chlorophyll content (25.40 SPAD unit) was recorded maximum in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with cocopeat + perlite + vermicompost (3:1:1) (23.94 SPAD unit). While, minimum was recorded (15.82 SPAD unit) in garden soil (control).

Whereas, in polyhouse conditions, total chlorophyll content ranged from 18.56 SPAD unit to 26.22 SPAD unit. Among different growing media, total chlorophyll content (26.22 SPAD unit) was recorded maximum in cocopeat + vermiculite + vermicompost (3:1:1) that was statistically at par with growing media of cocopeat + perlite + vermiculite (3:1:1) (24.97 SPAD unit). Results shown that total chlorophyll content was recorded minimum (18.56 SPAD unit) in garden soil (control).

Table 17: Effect of different growing media on total chlorophyll content (SPAD units) of seedlings under different growing conditions

Treatment	Open Field conditions	Polyhouse conditions
T ₁ Garden soil + FYM (1:1)	18.22	20.16
T ₂ Garden soil + vermicompost (1:1)	18.63	21.40
T ₃ Garden soil + cocopeat (1:1)	17.45	19.93
T ₄ Cocopeat + perlite + vermiculite (3:1:1)	21.22	24.97
T ₅ Cocopeat + perlite + vermicompost (3:1:1)	23.94	23.38
T ₆ Cocopeat + vermiculite + vermicompost (3:1:1)	25.40	26.22
T ₇ Sand + garden soil + vermicompost (1:2:1)	19.17	22.62
T ₈ Sand + garden soil (1:1)	16.41	18.94
T ₉ Garden soil + FYM + vermicompost + cocopeat (3:1:1:1)	19.78	22.40
T ₁₀ Garden soil (Control)	15.82	18.56
C.D. at 5 %	2.04	2.25

The present study entitled “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)**” was conducted to assess the effectiveness of different pre-sowing treatments and growing media for improving seed germination and seedling growth of guava. The experimental findings consolidate in the preceding chapter are discussed in this part with the help of observations recorded in the present study and findings of other researchers.

5.1 Effect of different pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.)

5.1.1 Seed Viability

Maximum seed viability (84.00%) was observed in control. Whereas, minimum seed viability (56.00%) was recorded in seed soaked with 30 per cent sulphuric acid for 3 minutes. Seed viability decreased by various pre-sowing treatments may be due to over-exposure of seed to scarification treatments. Sulphuric acid has a detrimental effect on seeds because acid penetrates the seed via its exposed micropyle and end up damaging the seeds (Ells, 1963). Results are in accordance with the findings of Musara *et al.* (2015) in okra. Seed viability also reduced when soaked in hot water for a longer duration.

5.1.2 Days to initiation of germination

Pre-soaking seed treatments significantly decreased number of days required for seed germination in guava as compared to control. Seeds soaked with 5 per cent hydrochloric acid solution required minimum number of days (17.67) to initiate germination. Maximum number of days (25.33) for initiation of germination was observed in control. Time required for seed germination was reduced after pre-soaking of seeds in acid because seed coat became soften and more permeable to water and gases (Chattopadhyay and Dey, 1992). Similar results were observed by Brijwal and Kumar (2014) in guava. They reported that pre-soaking of seeds with hydrochloric acid significantly reduced days to initiation of germination as compared to control. Results were also in accordance with the findings of Sharma (2016) in chironji.

5.1.3 Days to 50 per cent germination

It has been observed from the present investigation that minimum number of days (27.33) required for 50 per cent germination was recorded in five per cent hydrochloric acid soaking for two minutes and maximum number of days (37.33) required for 50 per cent germination was observed in control. Concentrated acid accelerates the water absorption capacity and

improves the gaseous exchange for seed germination by softening the hard seed coat (Nayak and Sen, 1999). Similarly, Brijwal and Kumar (2014) reported in their study that maximum days to 50 per cent germination of seeds was recorded in control. Whereas, minimum days to 50 per cent germination was recorded in seeds treated with 10 per cent hydrochloric acid for 2 minutes.

5.1.4 Germination percentage

It is amply clear from the results that scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours had a significant effect on seed germination percentage. Maximum germination percentage (60%) was noticed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200ppm for 24 hours and minimum germination percentage (31.33%) was observed in control. GA₃ acts as growth regulator for breaking seed dormancy, plays an important role in germination of seed by leaching out retardants and activates the cytological enzymes which stimulate α -amylase enzyme that converts insoluble sugar into soluble sugar (Babu *et al.*, 2010, Hartmann and Kester, 197). These findings are in consent with Joshi *et al.* (2015) reported that germination of acid lime seeds was significantly influenced by GA₃. Results are in accordance with the findings of Joshi *et al.* (2017) and Sharma (2016) in chironji.

5.1.5 Survival percentage

Highest survival percentage (85.43 %) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours and the lowest (74.30 %) were observed in the control. Higher survival percentage might be due to the early germination of guava seeds which helps in successful acclimatization and establishment of seedlings. The observation analogues to these findings were observed by Joshi *et al.* (2017) in chironji. They concluded that seeds treated with GA₃ (200 ppm) for 24 hours results in maximum survival percentage (64.13 %). Results are also in correspondence with the findings of Manekar *et al.* (2011) in aonla.

5.1.6 Height of seedling

Maximum height of seedling (4.59 cm) was recorded in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours as compared to control (2.75 cm). GA₃ effect on elongation of internodes because it promotes cell elongation by improving osmotic uptake of nutrients results into increasing plant height (Feucht and Watson, 1958, Krishnamoorthy and Sandooja, 1981). Gibberellic acid regulates stem elongation by loosening cell walls, increasing cell wall extensibility, accelerating wall synthesis, narrowing the rigidity of cell wall and boosting cell division, all of which contribute to increased growth. These chemicals have a direct impact on stem elongation by increasing the synthesis of IAA (Leopold and

Kriedeman,1983). These results are in conformity with the findings of Vasantha *et al.* (2014) in tamarind, Reshma and Simi (2019) in mango and Chiranjeevi *et al.* (2017) in aonla. They reported that maximum height of seedlings was observed in GA₃ 200 ppm.

5.1.7 Shoot length

Results of the investigation revealed that maximum shoot length (6.75 cm) was observed in scraping of seed coat with sand paper + seed soaked in GA₃ 200 ppm for 24 hours as compared to control (4.12 cm). GA₃ have a stimulating impact on the cell wall which causes it to release and transmit its calcium into the cytoplasm and also provides a favourable environment for water absorption through increased cell size and growth. GA₃ also stimulates amylase which converts the available carbohydrates into simple sugars, providing additional energy and nutrients for seedling growth (Vishwakarma, 2013). These findings were supported by Dadhaniya *et al.* (2020), that seed soaked in GA₃ 200 ppm results in maximum shoot length in custard apple. Joshi *et al.* (2017) also found similar results in chironji.

5.1.8 Root length

The maximum root length (5.85 cm) was found in scraping of seed coat with sand paper + seed soaking in GA₃ 200 ppm for 24 hours, whereas minimum root length was recorded in control (3.15 cm). GA₃ promotes shoot growth which leads to higher production of photosynthates that moves through the phloem to the root zone and enhanced osmotic uptake of nutrients, resulting in elongation of the cells in the sub-apical region of roots (Salisbury and Ross, 1988). Rajput and Sharma (2020) reported that application of GA₃ 200 ppm in custard apple results in higher root length (11.56 cm). The results are also in accordance with the findings of Vasantha *et al.* (2014) in tamarind and Pratibha *et al.* (2015) in papaya.

5.1.9 Root: Shoot ratio

Maximum root: shoot ratio (0.87) was observed in scraping of seed coat with sand paper + seed soaked in GA₃ for 24 hours as compared to control (0.76). High root: shoot ratio might be due to appropriate level of gibberellic acid which maintain high water content in the cell, enhanced cell division, elongation and multiplication which had promoted the overall growth of seedlings. Choudhary *et al.* (2018) reported that papaya seed treated with GA₃ 200 ppm results in maximum root: shoot ratio.

5.1.10 Girth of seedling

Maximum girth of seedling (1.34 mm) was observed in quick dip soaking in 30 per cent sulphuric acid solution and minimum in control (1.01 mm). The possible reason may be due to corresponding number of days to emergence of seedling and mean germination time with corresponding treatments. Results are in conformity with findings of Sourabh *et al.* (2016) in

guava. They reported that seed soaked with sulphuric acid results in maximum girth of seedlings.

5.1.11 Number of leaves per seedling

Maximum number of leaves per seedling (12.40) was observed in pre-sowing treatment of scraping of seed coat with sand paper + seed soaked in GA₃ for 24 hours, whereas minimum number of leaves per seedlings (9.20) was found in control. It might be due to action of GA₃ at the apical meristem leading to more synthesis of nucleoprotein and growth of seedlings that resulted in higher leaf initiation (Sen and Ghunti, 1976). Salisbury and Ross (1988) reported that GA₃ migrates into shoot apex, resulting in increased cell division and cell growth which apparently contributed to the development of young leaves. Results are in confirmation with the findings of Joshi *et al.* (2017) in chironji. They reported that maximum number of leaves (14.63) was observed in seed treated with GA₃ 200 ppm. Muralidhara *et al.* (2015) also observed greater number of leaves (22.5) when mango stones were treated with GA₃ 200 ppm. Similar findings were reported by Dadhaniya *et al.* (2020) in custard apple and Patil *et al.* (2017) in jamun.

5.1.12 Leaf area of seedlings

Maximum leaf area of seedling (3.83 cm²) was observed in scraping of seed coat with sand paper + seed soaked in GA₃ for 24 hours and minimum leaf area of seedlings (1.95 cm²) was recorded in control. Use of GA₃ might have boosted the leaf growth by enhancing cell division, multiplication and elongation, resulting in increased leaf area (Taiz and Zeiger, 2002). Results are in accordance with the findings of Choudhary *et al.* (2018) in papaya. They observed that maximum leaf area was recorded in GA₃ 200 ppm.

5.1.13 Total chlorophyll content

Total chlorophyll content was recorded maximum (29.85 SPAD unit) in scraping of seed coat with sand paper + seed soaked in GA₃ for 24 hours and minimum (17.87 SPAD unit) was recorded in control. Results are in accordance with the findings of Parab *et al.* (2017) in papaya. They reported that maximum chlorophyll content was recorded when seeds were treated with GA₃ 200 ppm.

5.2 Effect of growing media on seed germination and seedling growth under different growing conditions

5.2.1 Days to initiation of germination and days to 50% germination

Minimum number of days required to initiate germination (24.33 and 21.33) and for 50% germination (32.22 and 26.00) were recorded in cocopeat + vermiculite + vermicompost (3:1:1) whereas, maximum number of days required to initiate germination (28.33 and 25.33)

and for 50 % germination (37.00 and 32.67) were observed in garden soil (control) in both growing conditions i.e., open field and polyhouse, respectively. Cocopeat + vermiculite + vermicompost (3:1:1) have appropriate physical properties, good water retention capacity, high organic matter content which preserves humidity, improves nutrient content and media structure that resulted in early germination. Further, this combination also increases water holding capacity, maintains cell turgidity, cell elongation as well as increases respiration that leads to early seed germination (Joiner and Nell, 1982). Garcia and Deverede (1994) reported that cocopeat along with vermicompost & vermiculite, possess excellent properties and also successful as a growing media. These results are in agreement with the findings of Meena *et al.* (2017) and Bhardwaj (2014) in papaya.

5.2.2 Germination percentage and survival percentage

Maximum germination (54.67 % and 59.33 %) and survival percentage (85.33 % and 88.85 %) were recorded in cocopeat + perlite + vermicompost (3:1:1) whereas minimum germination (27.33 % and 30.00 %) and survival percentage (73.25 % and 75.63 %) were observed in garden soil (control) in open field as well as polyhouse conditions. This might be due to the fact that cocopeat + perlite + vermicompost (3:1:1) have excellent water holding capacity, adequate porosity and ample moisture supply which enables sufficient moisture and gaseous exchange between media and seeds. Vermicompost as an organic manure contains organic acids which preserves soil humidity, increases nutrient content and respiration rate at optimum level which is favourable for seed germination. Perlite as a substrate have excellent properties in soilless cultivation, has high water absorption capacity which enhances water efficiency (Inden and Torres, 2004). Better survival percentage might be due to media combination having proper aeration, porosity, drainage and adequate moisture availability in the root zone helped to reduce the soil-borne diseases in seedlings. Good physical and biological conditions in perlite, cocopeat and vermicompost had a synergistic effect on the root and shoot growth which also helps for better survival percentage. The results were close to the findings of Meena *et al.* (2017) in papaya, they reported that maximum survival percentage and germination percentage were observed in growing media of soil + vermicompost + perlite along with cocopeat layer on top. Similar results were obtained by Dash (2019) in papaya.

5.2.3 Shoot length, height of seedling, girth of seedling, number of leaves, leaf area of seedling, root length, root: shoot ratio and total chlorophyll content

Results of present investigation revealed that maximum height of seedling (4.38 cm and 4.53 cm), shoot length (6.14 cm and 6.34 cm) and girth of seedling (1.29 mm and 1.33 mm), number of leaves (11.73 and 12.00), leaf area of seedling (3.58 cm² and 3.72 cm²), root length

(5.35 cm and 5.51 cm), root: shoot ratio (0.87 and 0.87) and total chlorophyll content (25.40 SPAD unit and 26.22 SPAD unit) was observed in cocopeat + vermiculite + vermicompost (3:1:1) in both growing conditions i.e., open field and polyhouse conditions, respectively.

Application of cocopeat + vermiculite + vermicompost has a significant effect on above seedling growth parameters and total chlorophyll content probably due to improved water bearing capacity, porosity, aeration, structure, maintained temperature and improved nutrient status of media. Vermicompost is microbiologically active, nutrient rich organic manure that provide macronutrient especially nitrogen to plant for good root and shoot growth. Vermicompost promotes growth and development of seedlings and also stabilize the composition of nutrients in media (Zaller, 2007). Vermiculite is water insoluble, has excellent buffering properties, cation exchange capacity and contains enough potassium and magnesium for luxurious plant growth. It improves water holding capacity, permeability and airflow in the media. Cocopeat has high water holding capacity, rooting hormones and antifungal properties which enhances root and shoot growth. Girth of seedlings and number of leaves increased due to corresponding increase in plant height. High leaf area and chlorophyll content might be due to presence of nitrogen and micronutrients in vermicompost and vermiculite. Better root and shoot growth in cocopeat + vermiculite + vermicompost (3:1:1) results in better root: shoot ratio. The combination of cocopeat, vermiculite and vermicompost provide optimum amount of nutrients that improves biological and physical properties of media which enhances the shoot growth parameters (Soegiman, 1982). Abirami *et al.* (2010) reported that cocopeat had a positive effect on the root system of nutmeg seedlings. Results are in agreement with the findings Meena *et al.* (2017) who reported that application of growing media containing soil + vermicompost + vermiculite (1:1:1) with cocopeat layer at top increases the physiological growth parameters of papaya seedlings viz. shoot length, stem girth, number of roots, root length, root to shoot ratio. Similarly, results are in conformity with the findings of Bhardwaj (2014) in papaya; Yadav *et al.* (2012) in acid lime; Dayeswari *et al.* (2017) in papaya and Vandana *et al.* (2020) in mango.

The current investigation entitled “**Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava**” was undertaken to find out suitable pre-sowing treatment and growing media for seed germination and seedling growth of guava. The salient findings of the present study are summarized and concluded below:

6.1 Effect of different pre-sowing treatments on seed germination and seedling growth of guava (*Psidium guajava* L.)

- Seed viability decreased significantly by different pre-sowing treatments. Extent of loss of viability depends on the degree and duration of pre-sowing treatment adopted. Maximum seed viability (84.00%) was recorded in control.
- Minimum number of days required for germination (17.67) and for 50% germination (27.33) were observed in seed subjected to 5 per cent hydrochloric acid solution for 2 minutes.
- Maximum germination percentage (60%) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Survival percentage was recorded maximum (85.43%) in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours
- Height of seedling was recorded maximum (4.59 cm) when seed treated with scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Maximum shoot length (6.75 cm) was noticed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Maximum root length (5.85 cm) was recorded in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Root: shoot ratio (0.87) was noticed maximum in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Girth of seedling was found maximum (1.34 mm) in quick dip soaking in 30 per cent sulphuric acid solution.
- Maximum number of leaves (12.40) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.

- Maximum leaf area of seedling (3.83 cm²) was observed in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.
- Total chlorophyll content was found maximum (29.85 SPAD unit) in scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours.

6.2 Effect of growing media on seed germination and seedling growth under different growing conditions

- Minimum number of days required for initiation of germination (24.33 and 21.33) were recorded in cocopeat + vermiculite + vermicompost (3:1:1) in open field as well as polyhouse conditions.
- Minimum number of days to 50 per cent germination (32.33 and 26.00) were recorded in cocopeat + vermiculite + vermicompost (3:1:1) in open field as well as polyhouse conditions.
- Germination percentage was found maximum (54.67% and 59.33%) in cocopeat + perlite + vermicompost (3:1:1) in open field and polyhouse conditions, respectively.
- Maximum survival percentage was observed maximum (85.33% and 88.85%) in cocopeat + perlite + vermicompost (3:1:1) in both growing conditions i.e., open field and polyhouse, respectively.
- Height of seedling was recorded maximum (4.38 and 4.53 cm) in growing media of cocopeat + vermiculite + vermicompost (3:1:1) in open field and polyhouse conditions.
- Maximum shoot length (6.14 and 6.34 cm) was observed in cocopeat + vermiculite + vermicompost (3:1:1) in open field as well as polyhouse conditions.
- Root length was noticed maximum (5.35 and 5.51 cm) in cocopeat + vermiculite + vermicompost (3:1:1) in both growing conditions i.e., open field and polyhouse, respectively.
- Maximum root: shoot ratio (0.87 and 0.87) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) in both growing conditions i.e., open field and polyhouse, respectively.
- Girth of seedlings was recorded maximum (1.29 and 1.33 mm) in cocopeat + vermiculite + vermicompost (3:1:1) in open field as well as polyhouse conditions.
- Maximum number of leaves (11.73 and 12.00) was observed in cocopeat + vermiculite + vermicompost (3:1:1) in both growing conditions i.e., open field and polyhouse, respectively.

- Leaf area of seedling was recorded maximum (3.58 cm² and 3.72 cm²) in growing media of cocopeat + vermiculite + vermicompost (3:1:1) in open field as well as polyhouse conditions.
- Maximum total chlorophyll content (25.40 and 26.22 SPAD value) was recorded in cocopeat + vermiculite + vermicompost (3:1:1) in open field and polyhouse conditions.

Conclusion

On the basis of experimental findings, it can be concluded that different pre-sowing treatments and growing media had a significant effect on seed germination and seedling growth of guava. Among the different pre-sowing treatments, highest germination percentage, survival percentage, maximum height of seedlings, shoot length, root length, number of leaves, leaf area of seedling, root: shoot ratio and total chlorophyll content were recorded in T₅ (Scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours). Maximum girth of seedlings was observed in T_{8(i)} (Quick dip soaking in 30 per cent sulphuric acid solution). Minimum days to initiation of germination and days to 50% germination was observed in T₉ (5 per cent hydrochloric acid solution for 2 minutes).

Among the different growing media, T₆ (Cocopeat + Vermiculite + Vermicompost) required less number of days for germination, 50% germination, growth parameters i.e., maximum height of seedlings, shoot length, root length, number of leaves, leaf area of seedling, root: shoot ratio and total chlorophyll content whereas, maximum germination percentage and survival percentage was recorded in T₅ (Cocopeat + Perlite + Vermicompost) in both growing conditions i.e., open field and polyhouse, respectively.

It can also be inferred that the performance of growth media cocopeat + vermiculite + vermicompost (3:1:1) and cocopeat + perlite + vermicompost (3:1:1) was found better under polyhouse conditions as compared to open field conditions.

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ABSTRACT

Title of Thesis : **Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)**

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The present investigation was carried out to study the effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.) in the Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2020-21. The first experiment comprised of 13 different pre-sowing treatments with three replications and second experiment comprised of 10 different growing media with three replications laid out in two different conditions i.e., open field and polyhouse was carried out to study the effect on seed germination and seedling growth of guava.

Pre-sowing treatments and growing media significantly influenced seed germination and seedling growth of guava. Among different pre-sowing treatments, T₉ (Seed soaked in 5 per cent hydrochloric acid solution for 2 minutes) performed best in terms of days to initiation of germination (17.67) and days to 50 % germination (27.33). Whereas, T₅ (Scraping of seed coat with sand paper + seeds soaked in GA₃ 200 ppm for 24 hours) performed best in terms of germination percentage (60%), survival percentage (85.43%), height of seedling (4.59 cm), shoot length (6.75 cm), root length (5.85 cm), root: shoot ratio (0.87), number of leaves per seedling (12.40), leaf area of seedling (3.83 cm²) and total chlorophyll content (29.85 SPAD unit). Girth of seedling was found maximum (1.34 mm) in T_{8(i)} (Quick dip soaking in 30 per cent sulphuric acid).

Among different growing media, height of seedling (4.38 and 4.53 cm), shoot length (6.14 and 6.34 cm), root length (5.35 and 5.51 cm), root: shoot ratio (0.87 and 0.87), girth of seedling (1.29 and 1.33 mm), number of leaves per seedling (11.73 and 12.00), leaf area of seedling (3.58 and 3.72 cm²) and total chlorophyll content (25.40 and 26.22 SPAD unit) were found significantly higher in T₆ (Cocopeat + Vermiculite + Vermicompost) whereas, maximum germination (54.67% and 59.33%) and survival percentage (85.33% and 88.85%) was found in T₅ (Cocopeat + Perlite + Vermicompost) in both the growing conditions i.e., open field and polyhouse, respectively.

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I, **Manish Kumar**, Admn. No. **MHU2019H02M**, undertake that I give copy right of my thesis entitled, “Effect of pre-sowing treatments, growing media and conditions on seed germination and seedling growth of guava (*Psidium guajava* L.)” to the Maharana Pratap Horticultural University, Karnal. I also undertake the patent, if any, arising out of the research work conducted during the programme shall be filed by me only with due permission of the competent authority of Maharana Pratap Horticultural University, Karnal.

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