



## SEED GERMINATION OF FRUIT CROPS : A REVIEW

**Rajesh Kumar, K.K.Misra, D.S. Misra and Manoj Brijwal**

*Department of Horticulture, G. B. Pant University of Agriculture & Technology, Pantnagar 263145, India*

*E-mail: rkshukla2006@gmail.com*

**ABSTRACT:** Seed germination is the resumption of active growth of embryo that results in the emergence of the young plant. Seeds of many fruit crops remain ungerminated even under favourable conditions. Such kind of dormancy in seeds may be due to presence of hard and impermeable seed coat, germination inhibitors or due to improper development of embryo. Such seeds may require special treatments like scarification, soaking in water, growth regulators etc. for overcoming dormancy. This review summarises the latest developments in seed germination in different fruits crops.

**Keywords:** *Seed, dormancy, seed germination, scarification, growth regulators.*

In recent years asexual methods of propagation such as wedge grafting, inarching, veneer grafting, forkert, patch, shield budding and layering have been found to be quite successful and their use has been advocated. However, even for grafting and budding seedlings have to be raised. Seedling trees bear fruits of variable size and quality but such trees are generally long-lived. For raising rootstocks, seeds are used to obtain seedlings on which the desired variety (scion) can be grafted. Most of the fruit crop seeds germinate poorly and unevenly and require more time for seedling emergence. The dormancy in seeds might be due to hard seed coat, impermeability to water and gases, physiological immaturity of embryo, deficiency of some endogenous growth promoters or excess of endogenous growth inhibitors. Different methods like water soaking, scarification and chemical treatments are used for breaking dormancy in such seeds to improve germination. Soaking of seeds in water promotes germination by softening the hard seed coat, activating the enzymes and diluting the effects of inhibitors. Duration of soaking varies from overnight to 3 or 4 days depending on the nature of seed coat while, scarification is the process of injuring the hard seed coat by any means to accelerate the water absorption and to improve the gaseous exchange for hastening the process of germination. This can be achieved by mechanical scarification or by acid

scarification. In mechanical scarification, the surface of the seed is scratched or injured by rubbing against rough surface or sand paper. The extent of the scarification depends on the species. In acid scarification the seeds are dipped in concentrated acid for varying duration depending on the hardness of the seed coat. Seeds are then washed thoroughly in water to remove the traces of acid. In other instances, seeds can be pre-treated with some chemicals like gibberellic acid, thiourea and potassium nitrate to improve seed germination. Seeds are soaked in the aqueous solution of these chemicals for 12 to 48 hours before sowing. These chemicals are reported to have strong influence on the seedling growth after germination.

### *Effect of Water Soaking*

Water participates in many biochemical reactions and serves as a medium for the life processes. In seeds, water is an essential factor in the external environment for the stimulation of germination. Soaking the seeds in water at room temperature helps in softening the seed coats, removal of inhibitors and reduces the time required for germination and increases germination percentage (Hartman and Kester, 10). Effect of different water and acid soaking periods on seed germination were studied in guava cv. Allahabad Safeda. Seeds soaked in water for 36 hours exhibited an increased percentage germination (90%) and a reduced time for seedling emergence

in comparison to seeds soaked in H<sub>2</sub>SO<sub>4</sub>, HCl and HNO<sub>3</sub> (Pandey and Singh, 23). The percentage germination was highest (90%) and the rate of germination was fastest in seeds soaked in water for 4 days followed by 24 hours in 1000 ppm GA<sub>3</sub>. Ergostim (5% folic acid + 0.1% folic acid) treatment had no effect on seed germination of guava (Rodriguez *et al.*, 30). The germination of guava seed was improved by soaking it in tap water before sowing. Cold water also had a beneficial effect but soaking in hot water was harmful (Haq *et al.*, 11). The extracted seeds of ber soaked for 24 hours in water promoted early germination, good vegetative growth and higher germination percentage compared with sowing whole seeds (control). Cracked seeds exhibited better germination than control seeds but were not good as water soaked seeds (Mankar *et al.*, 18).

Soaking of jackfruit seeds in water for 24 hours has been found to improve the germination (Singh, 33). The effects of soaking seeds in water, ferulic acid (10-3 M), maleic hydrazide (1000 ppm), thiourea (1%), KH<sub>2</sub>PO<sub>4</sub> (1%), or gibberellic acid (100 ppm) for 24 h before sowing on jackfruit seed germination and seedling growth were studied. The highest germination percentage (98.0%) and coefficient of germination velocity (28.00) were obtained with seed soaking in gibberellic acid. The lowest number of days required for maximum germination (10.66 days) and the highest germination value (24.38) and stem diameter (2.36 cm) were obtained with soaking of seeds in water. The tallest plants (25.10 cm) were recorded for the control followed by seed soaking in gibberellic acid (24.90 cm) (Maiti *et al.*, 17). Bael seeds were treated with different chemicals: concentrated H<sub>2</sub>SO<sub>4</sub> for 10 or 20 minutes, H<sub>2</sub>SO<sub>4</sub> for 10 minutes + 1% thiourea, 100 ppm GA<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub> for 10 minutes + 100 ppm GA<sub>3</sub>, 0.5% or 1% thiourea, soaking in water for 24 hours and mechanical scarification by sand paper. Among the various treatments, water soaking resulted in the highest percentage germination (80%) which was closely followed by concentrated H<sub>2</sub>SO<sub>4</sub> treatment for 20 minutes (76%). It was least with

concentrated H<sub>2</sub>SO<sub>4</sub> for 10 minutes + 1% thiourea (20%). Although water soaking resulted in the highest percentage of ultimate germination, initiation and completion of germination took longer than treatment with concentrated H<sub>2</sub>SO<sub>4</sub> (Nayak and Sen, 20). Investigations on the effect of organic and inorganic substances on germination of jamun (*Syzygium cumini*) seeds revealed that such treatments had a significant effect on germination percentage, shoot length and root length. The highest germination percentages were recorded when seeds were treated with water for 48 h, GA<sub>3</sub> at 250 ppm, hot water, cow dung for 24 hours and cow urine for 24 h (96.6%). The lowest percentage germination (56.6%) was recorded in the control. Shoot length was longest in the cow urine. Root length was longest in the GA<sub>3</sub> at 250 ppm treatment (Swamy *et al.*, 40). The effects of soaking mango (var. Local, Neelum and Totapuri) seeds in tap water for 24 h, hot water at 60°C for 5 minutes, gibberellic acid (GA<sub>3</sub>) at 100 or 150 ppm for 24 h, water for 24 h followed by GA<sub>3</sub> (100 or 150 ppm) or treatment with thiourea at 150 ppm for 24 hours on germination was determined. Treatment with thiourea (1500 ppm) and soaking for 24 h in water followed by soaking for 12 or 24 h in 150 ppm GA<sub>3</sub> resulted in the highest germination percentage (Pillewan *et al.*, 26).

#### *Effect of Mechanical Scarification*

After 30 days from extraction, germination was highest (84%) in ber seeds scarified mechanically, however, after 203 days; it was highest (88%) in seed treated with 1% potassium hydroxide (Ghosh and Sen, 9). Seeds of the ber cultivar Umran were (a) scarified with H<sub>2</sub>SO<sub>4</sub> for 6 minutes, (b) cracked manually, (c) the kernels were extracted by breaking the endocarp, and (d) left untreated (control). The treated and control seeds were either sown directly or after soaking in water for 24 h. The shortest time taken to start germination (7 days), the highest final germination percentage (46.66%) and the best seedling growth were obtained when the kernels were extracted by breaking endocarp + water soaking. The

corresponding control figures were 24.5 days and 17.5 % germination (Murthy and Reddy, 19). Breaking of hard shell in Ber helps in early germination (Singh, 34). The maximum germination in jackfruit seeds was obtained when outer thin leathery seed coat was removed and soaked in water for 8 hours. Treatment with of seeds with biotin (10 ppm) and kinetin (50 ppm) resulted in significantly higher seed vigour index. Seedling growth was also better when seeds were soaked in 25 ppm NAA (Prakash, 27).

A field experiment was conducted to find out the effect of cracking and seed coat removal on germination of mango seed. Intact seeds took 23.71 and 55.21 days for the start of germination and to attain 50% of final germination, respectively and the final germination percentage was 45.71. When the seed coat and testa were removed before sowing, the seeds started germinating on the 10th day and reached 50% of final germination in 29.46 days. The final germination was 78.57% (Padma and Reddy, 21). This experiment was conducted to study the effect of seed husking and soaking in GA<sub>3</sub> on germination and vegetative growth parameters of Zebda, Sukkary, Sabre and 13-1 polyembryonic mango rootstocks under nursery conditions. Germination percentage and number of seedlings per seed increased with seed husking and soaking in GA<sub>3</sub> at 100 or 200 ppm concentrations for 48 hours. The highest germination percentage and number of seedlings were recorded by Sabre rootstock meanwhile, the lowest was recorded by Sukkary rootstock. Seedling length, seedling diameter, number of leaves per seedling, leaf area and root length of the studied rootstocks were increased with seed husking and GA<sub>3</sub> treatments. The highest values of seedling length, diameter, leaf area and number of leaves per seedling were observed by Zebda and the lowest was by 13-1. Zebda, Sukkary and Sabre rootstocks recorded higher values of growth parameters than 13-1 rootstock. Husking mango seeds and soaking them in GA<sub>3</sub> prior to sowing improved germination and seedling growth (Shaban, 31). In peach cv. Qiouxiangmi seed dormancy was broken by

mechanical scarification, the germination rate being similar to the seed soaked in GA<sub>3</sub> to overcoming seed dormancy. When the seed coat of peach cv. GF 305 was removed a high emergence percentage was observed even without stratification (Tao and Chen, 41). The highest germination (67%) was obtained with fresh papaya seeds washed in water to remove the sarcotesta followed by drying in the shade for 24 hours. Drying in the sun was detrimental (15% germination compared with 59% for shade drying) as was a 30 minutes dip in hot water (Sippel and Classens, 39).

#### *Effect of Acid Scarification*

Scarification of seeds with concentrated acids, especially sulphuric acid, greatly increased germination of guava seeds, recording 98% germination. The control seeds soaked in cold water gave 20% germination, while pre-treatment with gibberellic acid gave 65% germination. Seeds soaked in hot water did not germinate at all (Essien, 8). The soaking of seeds in concentrated sulphuric acid for 2-3 minutes was very effective for good germination (Pandey and Misra, 24). The acid scarification and boiling in hot water for 5 minutes of seeds shortened the time required for germination without any adverse effect on germination percentage (Hayes, 12). The soaking of seeds of Allahabad Safeda and Red Fleshed in water for 12-72 hour and in sulphuric acid, hydrochloric acid and nitric acids for 3-12 minutes. Soaking in water for 12 hours and in hydrochloric acid for 3 minutes improved the germination percentage to over 90%, compared with 58% for untreated control (Singh and Soni, 35). Seeds (from ripe fruits) placed in plastic bags were stratified at 5°C for 0, 10, 20 or 30 days or they were scarified either by immersion in concentrated sulphuric acid for 15 minutes or by abrasion with sand for 15 minutes. After treatment, the seeds were germinated at a constant 25°C or at room temperature, either on paper or in sand. A combination of scarifying in sand and germinating

in sand gave the best total germination (98.15%). Germination generally occurred between 8 and 11 days after sowing (Tavares *et al.*, 42). Seeds of guava were subjected to ten different treatments namely, naked seeds, 24 hours water soaking, 48 hours water soaking, 24 hours hot water (40°C) soaking, 24 hours hot water (5% sulphuric acid) soaking, 24 hours water leaching, 24 hours gibberellic acid (100 ppm) soaking, seed scrapping and seed coat breaking. In case of Indian Olive and Jujube, besides the above treatments additional treatments of seeds with flesh were considered. Observation indicated that acid treated seeds showed best performance in respect of seed germination and seedling vigour. While with Jujube and Indian Olive scrapped seeds and 24 hours water soaked seeds showed best performance (Rahman and Quadir, 28). The effects of seed size (small, medium and large) and pre-sowing treatment (soaking in H<sub>2</sub>SO<sub>4</sub> for 10 minutes then washing with water, soaking in H<sub>2</sub>SO<sub>4</sub> for 10 minutes then in 1% thiourea for 12 hours, mechanical cracking of seeds, chilling for 24 hours in the refrigerator and soaking in water for 24 hours, control) on the seed germination and seedling growth of ber were studied. The greatest seed germination was obtained with the use of medium seeds (50.93%) and treatment with H<sub>2</sub>SO<sub>4</sub> for 10 minutes (54.22%). The mechanical cracking of seeds resulted in the lowest number of days to germination (23.66 days). The tallest seedlings were obtained with medium seeds (25.26 cm) and water-soaked seeds (26.33 cm). Water-soaked seeds and large seeds gave the greatest stem diameters (0.54 and 0.51 cm, respectively) (Singh *et al.*, 36). Seeds of the ber cv. Local Desi Gola were soaked in water for 48 hours (control) or in concentrated sulphuric acid for 3-15 minutes. The seeds were sown at monthly intervals between 20 March and 20 July. Soaking in acid for 6 minutes and sowing on 20 May gave the highest germination (90%). The diameter of the seedling stem (15 cm above ground) at 90 days after sowing was greatest (0.74 cm) after soaking in acid for 6 minutes and sowing on 20 April (Singhrot and

Makhija, 38). Ber seeds were soaked in sulphuric acid for 3, 6, 9, 12 or 15 minutes or in water for 48 hours. Unsoaked seeds were used as a control. Seeds were sown in the 1<sup>st</sup> week of January, March or June at a depth of 2, 4 or 6 cm. Transplanting was carried out at the 2, 4, 6 or 8 leaf stage. Budding was done 90 days after sowing on seedlings that were 0.53, 0.65 or 0.75 cm in diameter at a height of 10, 20 or 30 cm above ground level. The 6 minutes soak in sulphuric acid resulted in highest percentage germination at all sowing dates (36.6-71.3%). Germination success increased from January to June and decreased with increasing depth of sowing. Budding success decreased with increasing plant diameter and budding height, greatest budding success (93.5%) was obtained with 0.53 cm diameter seedlings budded at 10 cm above ground level (Chattopadhyay and Dey, 4).

#### *Effect of Chemical Treatment*

Plant hormones play a key role in fruit crop production by influencing directly or indirectly various plant processes like germination, rooting, growth and productivity. The some plant growth regulators have been helpful in germination of guava seeds by increasing water uptake and exerting an effect on membrane permeability. These results indicate that use of plant growth regulator might have helped to break the embryo dormancy and induction of synthesis of alpha amylase and other hydrolytic enzymes (Looney, 16). The pre-sowing soaking improved seed germination of guava seeds up to 60% with GA<sub>3</sub> 100 ppm in comparison to 46% in untreated seeds (Kumar *et al.*, 15). Seeds of guava cv. Allahabad Safeda were treated by soaking in water for 24 h, in boiling water for 3 minutes, in GA<sub>3</sub>, Ethrel or Thiourea for 12 hours or in concentrated HCl or H<sub>2</sub>SO<sub>4</sub> for 3 minutes. Seeds were then washed with distilled water before sowing in polyethylene bags. Maximum germination, 6 weeks after sowing was obtained with seeds soaked in 3000 ppm GA<sub>3</sub> (83.2%) followed by seeds soaked in water (80.1%). These results were significantly higher

than those obtained with other treatments and with untreated controls (53.0%). Soaking seeds in 3000 ppm GA<sub>3</sub> also resulted in the greatest plant height, number of leaves/plant and leaf size recorded 5 months after sowing. Seed treatment with boiling water was lethal (Chandra and Govind, 3). The highest germination rates after 1 and 17 months from ber seeds treated with 200 ppm GA<sub>3</sub> (98.76 and 77.82 %, respectively) (Hore and Sen, 13). The effects of seed treatments viz., soaking in 100 ppm gibberellic acid, 1% thiourea, 1000 ppm maleic hydrazide, 1% potassium orthophosphate and 10-3 M ferulic acid for 12 hours, on the germination and growth of jackfruit. The highest germination percentage (95.33%) and coefficient of velocity of germination (27.67), tallest plants (26.78 cm), shortest span of germination (13 days) and fastest germination (average of 3.61 days) were recorded for 100 ppm GA. (Singh *et al.*, 37) concluded that treatment of seeds with 1000 ppm maleic hydrazide gave the highest stem diameter (2.56 cm). Seeds of a local jackfruit cultivar were used fresh or stored at 6°C for 15 days. Seeds were then soaked in solutions of NAA (10, 25 or 50 ppm) or GA<sub>3</sub> (50, 100 or 250 ppm) or in distilled water (control) for 24 h before being sown. Growth regulator treatment did not affect percentage germination, time taken for germination or survival percentage of seedlings in the field. Fresh seeds had a higher percentage germination (66.0 vs. 62.1%), more rapid germination (15.1 vs. 16.7 days) and higher seedling survival percentage in the field (63.9 vs. 59.6%) than stored seeds (Chiesotsu *et al.*, 5).

Karonda seeds, treated with GA<sub>3</sub> at 25-100 ppm for 24 h, were planted and germination was assessed 43, 50 and 58 days later. Germination after 43 days was 0.4% in the control and 1.6-6.8% in the treated seeds. On the 58<sup>th</sup> day control germination was 49.2% and in seeds treated with GA<sub>3</sub> at 25 ppm it was 67.0%. This treatment (Bankar, 1) also gave good seedling vigour (19.6 cm high compared with 12.2 cm in the control). Papaya seeds collected from unripe fruits in Somalia were submitted to

various treatments. They were desiccated in the sun or in the shade for 3, 6, 9, 12 or 15 days and then stored in paper bags at 20°C for 2 months. The effects of removing the sarcotesta and soaking in 300 ppm GA<sub>3</sub> for 24h were examined. Germination percentage increased in seeds desiccated in the shade and treated with GA<sub>3</sub> while average germination time decreased as the duration of the desiccation increased in seeds deprived of their sarcotesta and treated with GA<sub>3</sub> (Bertocci *et al.*, 2). Aonla seeds were soaked in distilled water, 250, 500 or 750 ppm GA<sub>3</sub> or 250, 500 or 750 ppm thiourea prior to germination in Petri dishes. Controls received no soaking treatment. The highest percentage germination (75.98% after 35 days, compared with 50.76% in controls) was obtained in the 250 ppm GA<sub>3</sub> treatment. This treatment also resulted in the greatest plumule and radicle lengths (11.56 and 5.97 cm, respectively, 35 days after sowing) but the thiourea treatments resulted in the most roots/seedling, the highest number (3.60, 35 days after sowing) being obtained in the 750 ppm treatment (Dhankhar *et al.*, 6). Seeds of Aonla were soaked for 12 h in 100-400 ppm gibberellic acid (GA<sub>3</sub>) or water, or not soaked (controls). Treatment with 400 ppm GA<sub>3</sub> resulted in the highest percentage germination (87.25%, compared with 56% and 46.25% in seeds soaked in water and controls, respectively). Seedling development (plant height, number of leaves/plant and root development) was best following seed treatment with 400 ppm GA<sub>3</sub> (Wagh *et al.*, 43). Aonla (cv. Gujarat Aonla 1) seeds were treated with 250, 500 or 750 ppm gibberellic acid (GA<sub>3</sub>) or thiourea. Seed germination was earliest and percentage germination was highest (75.98% and 64.14% in the laboratory and in pots) in seeds treated with 250 ppm GA<sub>3</sub>. This treatment also gave the best results in terms of plumule and radicle length, seedling height (28.84 cm 75 days after sowing), seedling girth (0.90 cm 75 days after sowing) and seedling fresh and dry weight. Treatment with 750 ppm thiourea resulted in the highest number of roots (Dhankhar *et al.*, 7). The

effect of pre-germination seed treatments on the germination and vigour of Aonla seeds were studied. The treatments included gibberellic acid (GA<sub>3</sub>) at 50 and 100 ppm, soaking in water for 24 hours and hot water soaking at 60°C for 5 minutes. GA<sub>3</sub> at 50 and 100 ppm increased the percentage seed germination. The tallest plants were obtained following seed treatment with 100 ppm GA<sub>3</sub> and soaking for 24 hours (Pawshe et al., 25).

The effect of seed treatments with growth regulators (250 and 500 ppm GA<sub>3</sub>, 250 and 500 ppm thiourea), chemicals (sulphuric acid) and distilled water on seed germination of wild ber (*Zizyphus nummularia*) were studied and the highest percentage of seed germination was recorded with 500 ppm GA<sub>3</sub>. A maximum plant height (34.39 cm), plant girth (1.43 cm) and internode length (1.40 cm) were recorded with 250 ppm GA<sub>3</sub>. In a related study, the combined effect of seed treatments and foliar applications of growth regulators GA<sub>3</sub> and maleic hydrazide (MH) at 50 ppm on seedling growth of wild ber was assessed. Foliar spray of 50 ppm GA<sub>3</sub> on seedlings obtained from different seed soaking treatments accelerated seedling vigour. GA<sub>3</sub> gave maximum plant height (56.29 cm), plant girth (2.75 cm) and internode length (2.69 cm). Foliar spray of 50 ppm MH reduced plant height and internode length (Rajwar et al., 29). The combined effect of stratification with hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) or gibberellic acid (GA<sub>3</sub>) pre-treatments on seed germination in peach and three different wild almond species (*Prunus scoparia*, *Prunus communis*, and *Prunus haussknechtii*) was investigated by Imani et al., (14). Seeds with shells were rinsed three times for 2 minutes each in sterile distilled water and then imbibed for 24 hours in either distilled water (control), H<sub>2</sub>O<sub>2</sub> (0.5 and 1%, 24 h) or GA<sub>3</sub> (250 and 500 ppm, 30 min). Treated seeds were then stratified at 7°C for 1 to 9 weeks. The number of germinated seeds was recorded weekly for each species. There were significant differences in the percentage and time of seed germination between

species and treatments although germination was earlier and more uniform in the treated seeds in comparison with the control in all species. The most effective pre-treatments for breaking dormancy during subsequent stratification were 0.5% H<sub>2</sub>O<sub>2</sub> (*Prunus scoparia*), 500 ppm GA<sub>3</sub> (*Prunus haussknechtii*) and 250 ppm GA<sub>3</sub> (*Prunus persica*) Zhang and Xia (44) carried out an experiment with seeds of *Prunus persica* collected from wild trees. Before stratification, seeds were separately soaked in water with different concentrations of GA for 2 and 4 days. All concentrations of GA promoted seed germination. Germination increased by 15% after soaking in 1500 mg GA/ml for 4 days (Zhang and Xia, 44). The effects of gibberellic acid (GA) and ethrel on sapota cv. Kalipatti seed germination and seedling growth. Cracked seeds were soaked for 24 h in 100 ml solution on GA, ethrel and GA+ethrel (at 200, 300 and 400 ppm). Pre-soaking of seeds in GA at 400 ppm+ethrel at 400 ppm resulted in high (90%) and early (12.15 days) germination and the highest emergence rate. Seedlings raised from seeds presoaked on 400 ppm GA<sub>3</sub> produced the highest shoot and root length. The number of leaves per seedling and seedling vigour were highest in seedlings raised from seeds pre-soaked in GA + ethrel (Pampanna and Sulikeri, 22). The effect of pre-soaking treatments, application of growth promoting substances and method and season of grafting on seed germination and growth enhancement of *Khirnee* rootstock and graft success in sapota. To improve the seed germination of *Khirnee* rootstock, seeds were subjected to pre-soaking treatments for 24 h in gibberellic acid (GA<sub>3</sub>) at 100 and 200 ppm, thiourea and KNO<sub>3</sub>, each at 1 and 2%, cow dung slurry and water. Pre-soaking of *Khirnee* seeds in cow dung slurry for 24 h resulted in the highest (66.83%) seed germination. To enhance the growth rate of *Khirnee* seedlings to attain graftable size rootstock, an experiment was carried out, consisting of GA<sub>3</sub> at 100 and 200 ppm, extracts of neem cake, *Pongamia* and cow dung, vermicompost (Vermiwash),

triacontanol at 0.1 and 0.2% and a control. *Khirnee* seedlings sprayed with GA<sub>3</sub> at 200 ppm on the 3<sup>rd</sup> and 6<sup>th</sup> months enhanced the seedling growth (Shirol *et al.*, 32).

### Future Aspects

To meet the growing demand of planting material (grafts), nursery man has to produce more number of rootstocks with graftable size in a shorter time. It is, therefore, highly essential to accelerate the seed germination and growth of seedlings with pre-sowing treatments to attain graftable size earlier and reduce the nursery cost. Therefore, enhancement of seed germination is important in propagation and breeding programmes, as well as for testing and using germplasm. In this aspect pre-sowing treatments seems to be the most promising in many fruit species. Therefore, it can be concluded that pre-sowing treatments are effective to get higher germination and better seedling growth of fruit crops.

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