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# The Effects of Exogenous Gibberellin on Seed Germination of the Fruit Species

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**Abstract**

Gibberellins are diterpenoid, plant growth hormones and regulators, able to control some important processes in plant growing and breeding; including stem elongation, flowering initiation, increasing fruit set and size, improving fruit shapes, induction of seedlessness, retardation or acceleration of senescence, breaking seed dormancy, in increasing crop metabolic contents, activation preferred gender organs in flowers, pollen development and germination. Some of the chemical substances occur endogenously in some parts of plant organisms. The chemicals are also being produced commercially and commonly used in different aims via exogenous application. One of their uses is breaking seed dormancy and activation of seed germination of fruit species. The fruit trees are mostly propagated via grafting on rootstock derived from seed and the known, valuable seeds sometimes can be hard to germinate themselves because of external or internal factors. In the review study, usages and effects of the exogenous gibberellins on germination of some fruit seeds at *in vitro*, *ex vitro* and nursery germination conditions are presented.

**Keywords: Gibberellin, fruit species, seed dormancy, seed germination**

# Dışsal Uygulanan Gibberellinlerin Meyve Türlerinde Tohum Çimlenmesi Üzerine Etkileri

**Özet**

Gibberellinler diterpenoid yapıda, bitki gelişim düzenleyicileri ve hormonlardır. Gövde uzaması, çiçeklenmenin başlatılması, meyve tutumu ve büyüklüğü, meyve yapısı, çekirdeksiz meyve oluşumunun uyarılması, olgunlaşmanın yavaşlatılması veya hızlandırılması, tohum dormansisinin kırılması, ürün metabolik içeriğinin arttırılması, çiçekte tercih edilen cinsiyet organlarının gelişiminin aktive edilmesi, polen gelişimi ve çimlenmesi gibi bitki yetiştiriciliği ve ıslah çalışmalarında kullanılabilecek bazı önemli olayları kontrol altına alabilmektedir. Bu kimyasal bileşiklerin bazıları bazı bitki organlarında içsel olarak oluşmaktadır. Bununla birlikte ticari olarak da üretilmekte ve farklı amaçlar taşıyan çalışmalarda dışsal uygulamalar şeklinde de kullanılmaktadır. Kullanım alanlarından biri de meyvelerde tohum dormansisini kırmak ve çimlenmeyi aktive etmektir. Birçok meyve türünde tohumdan üretilen çöğür anaçlar üzerine aşılama yoluyla üretim yaygındır ve üstün nitelikleri nedeniyle seçilmiş olan tohumların içsel ve dışsal nedenlerle çimlenmeleri güç olabilmektedir. Bu derleme çalışmasında *in vitro*, *ex vitro* ve fidanlık şartları altında dışsal uygulanan gibberellinlerin bazı meyve tohumlarının çimlendirilmelerinde kullanımları ve çimlenme üzerine etkileri sunulmuştur.

**Anahtar Kelimeler:** Gibberellin, meyve türleri, tohum dormansisi, tohum çimlenmesi

# INTRODUCTION

Gibberellin was firstly identified and isolated from pathogenic fungus *Gibberella fujikuroi*, caused 'foolish-seedling' disease of rice [46]. Since the time more than 130 Gibberellins (GAs) have been identified in plants, fungi and bacteria in addition that found only a few GAs have biological activities [47]. The major bioactive GAs ($GA_1$, $GA_3$, $GA_4$ and $GA_7$) are derived from a diterpenoid carboxylic acid skeleton [47]. The plant hormone gibberellin regulates major aspects of plant growth and development [15]. The plant growth regulators commonly used in modern agriculture [29, 45]. Besides scientific studies on breaking seed dormancy and seed germination, we reached studies and knowledge on GAs effects in stem elongation [11], flowering initiation [3, 48], increasing fruit set and size, improving fruit shapes [43], induction of seedlessness [28], retardation or acceleration of senescence [5], pollen development and pollen germination [3, 40], increasing in crop metabolic contents and activation preferred gender organs in flowers [48]. A given species or variety responds to a wide range of concentrations, and different species and varieties within a species react differently to the same treatment and the stimulatory effects are temporary thus for a continuing response repeated dosages are necessary [45]. Seed dormancy, by controlling the timing of germination, can strongly affect plant survival. Seed dormancy can influence both population and species-level processes such as colonization, adaptation, speciation, and extinction [44]. Some of seeds can be hard to germinate themselves because of external or internal factors [27]. The factors well defined and classified in previous study [31] and modified by Baskin and Baskin [9]. Physiological dormancy is the most frequent dormancy class [9]. The adjustment of physiological dormancy seeds to their external environment is highly specific, and increased germination occurs in response to specific temperature, chemical, or light signals and conditions required for breaking dormancy include application of $GA_3$ or other hormones such as ethylene, dry storage (after-ripening) warm stratification, and cold stratification [10].

Commercially produced perennial fruits are mostly grown via grafting on rootstock plants derived from seeds of favorable stock plants. Only a few perennial fruits are grown via seed directly. In both of two growth types need activation of seed germination and obtaining healthy seedlings or saplings. Although there are some studies on effects of gibberellin usage on seed germination of perennial medicinal, aromatic, ornamental and forestry plants [6, 8, 12, 21, 24, 37], the review study focused on well-know fruit species for food and beverages have commercial importance.

**Laboratory based *in vitro* seed germination studies**

Laboratory based studies were carried out under controlled laboratory condition as aseptic tissue culture experiments. Used seeds or embryos are aseptic, used media are sterilized and environmental condition is under well-controlled. The used media for the germination studies were Murashige and Skoog Medium, Driver and Kuniyuki Medium or Lepoivre Culture Medium etc. with or without their modification. The studies were conducted under periodic light or darkness in *Petri* dishes or test tubes etc.. In some of the experiments gibberellic acid ($GA_3$) concentrations were used alone or in combination with other plant growth regulators. In the experiments mostly used parts were embryos after removing exocarp, mesocarp and endocarp.

According to study carried out on *Musa velutina* [33] $GA_3$ failed to promote embryo germination compared to control but the time requirement for germination was significantly reduced than control and caused a uniform germination. Another study was about *in vitro* clonal multiplication of *Prunus* rootstock [20]. In the study, no significant differences were observed among different $GA_3$ concentration for the germination rate, explained by the use of only the embryogenic axis without seed coat that would be responsible dormancy, but it was found that a positive effect of $GA_3$ on the growth of the stem apical meristem, a negative effect on root system that increased proportionally to the $GA_3$ concentration used. A germination experiment on walnut (*Juglans regia*) was carried out after epicarp removing. Treatment with $GA_3$ in combination with Kinetin and BAP at simultaneous low temperature gave maximum percent embryo germination in the experiment [22]. The other seed germination study [34] was on Pecan (*Carya illinoinensis*). They found that presence of $GA_3$ in combination with BAP or cold-dark condition was found effective on seed germination.

**Laboratory based *ex vitro* seed germination studies**

The *ex vitro* studies were conducted under laboratory condition with the minimum alteration and more controlled than experiment under natural conditions. For germination bed; sand, perlite, peat, filter paper, cotton etc. were used in *Petri* dishes, plastic bags or containers. In the studies sometimes exocarp, mesocarp and endocarp of seeds removed and pre- or past-incubation were treated in oven, incubator, chamber, storage room or laboratory conditions etc. In some cases stratification, scarification or pre-chilling methods were used before, after or in the presence of $GA_3$ treatments. In some of the experiments gibberellic acid ($GA_3$) concentrations were used alone or in combination with other plant growth regulators or chemicals.

One of the study was on *Arbutus unedo* and *Arbutus andrachne* seed germination [26]. In the study, there were 16 different pretreatments including $GA_3$ concentrations. It was showed that total $GA_3$ treatment resulted in well stable germination rate after stratification in a treated duration in all treatments in both of two species. Another study was on *Prunus mahaleb* seeds, an important rootstock for sour cherry and sweet cherry trees [19]. This was emphasized that $GA_3$ treatments were more effective in both treated seed with and without seed coat than the other applied techniques. Khan *et al*. [23] worked on *Citrus* species. They found that there were no differences in final percentage germination in any treatment but when $GA_3$ used, germination was little faster. Abdul Hussain and Abdul Hussain [1] studied on *Olea europea* seeds and concluded that gibberellic acid very significantly improves the capacity of germination of used seeds variety which germinates in difficulty. Koyuncu [25] studied on breaking seed dormancy in black mulberry (*Morus nigra*) and resulted that stratification or $GA_3$ treatment with stratification overcame seed dormancy and increased the germination percentage of black mulberry seeds. In another study was conducted in *Prunus avium* [14]. According to this study $GA_3$ was found significantly stimulative in parallel stratification time on germination percentage of all seed groups as being other used chemicals. Onursal and Gözlekçi [32] studied on *Arbutus andrachne* and they found that treatments of all $GA_3$ concentrations were effective on shortening germination time and germination rate except one of the stratification treatment. Abu-Qaoud [2] studied on three different *Pictacia* species. Together with scarification of seeds and $GA_3$ treatments significantly gave better results in germination percentage and shortened the germination time than control, but results indicated that there were big differences among the species. *Prunus avium* types, have a good capability as rootstock, also were studied [18]. This emphasized that the plant origin were important but in conclusion $GA_3$ treatment after certain stratification time effected on germination. Another study carried out on *Arbutus unedo* genotypes [17] showed that $GA_3$ improves emergence and emergence rate increased with increasing concentration of $GA_3$. Wada and Reed [41] studied on 17 *Rubus* species for standardizing germination protocols and used different pre-treatments with or without $GA_3$ addition. They recommended that with the help of $GA_3$ and another chemical to the other treatments can be effective on germination rate. Rahemi *et al*. [36] reported that for seed germination of wild almond (*Prunus* spp.) hormonal treatments via $GA_3$ were not effect on germination rate but accessions had effectiveness. According to another study on two cultivars of *Ficus carica* seed germination [13], application of $GA_3$ increased the germination and emergence. Pipinis *et al*. [35] also studied on *Prunus mahaleb*. It was concluded that for a large amounts of seeds, the removal of endocarp without damages to the embryo is practically difficult and the application of exogenous $GA_3$ during the cold stratification to seed with endocarp can be an effective treatment to enhance seed germination. Seed germination of *Elaeagnus rhamnoides* was studied by Vashistha *et al*. [39]. It was found that some $GA_3$ doses significantly improved germination rate in some population while another doses were found successful in shorten germination time. Another study [38] was conducted on *Prunus laurocerasus* seeds. Different seed dormancy breaking techniques were applied in this study and it was concluded that stratification in certain duration after threatening $GA_3$ dose was increased germination rate. Wani *et al*. [42] studied on apple seeds. It was found that all used concentrations of $GA_3$ endorsed germination percentage and growth of seedlings in the study. They concluded that $GA_3$ application was successful in breaking seed dormancy.

**Nursery based seed germination studies**

The studies were carried out under open air or greenhouse conditions as similar as farmer facilities and resources with the minimum alteration from the usual production. For these studies, field soil, sand, manure, peat and perlite alone or in combination with compost mixture were mostly used as seed germination bed. Seeds were sown by hand on pot, polyethylene bag, wooden box, tray or directly seed bed. $GA_3$ were applied sometimes with or without pericarp or seed coats. The cultures were maintained under natural conditions or a little controlled condition. In some of the experiments $GA_3$ doses were used alone or in combination with other plant growth regulators. In some of the studies stratification, scarification or cracking methods were used before or after $GA_3$ treatments.

One of the studies carried out on Duke Avocado [11] and found that some doses were the best in germination earliness and seedling height. In another study on *Prunus africana* was conducted by Negash [30]. It was found that $GA_3$ concentrations gave better germination rate than control plants in *Petri* dishes but this was no statistically significant. But they emphasized that seedlings derived from the $GA_3$-treated seeds showed higher initial growth than the control owing to rapid hypocotyl elongation in the glasshouse and in the nursery. Deligöz *et al*. [16] studied on *Zizyphus jujuba* seed germination. They found that some $GA_3$ doses gave the best response in different sowing time with or without seed coat cracking. Another study [7] was conducted on *Pistacia vera*. According to the results, certain concentrations in $GA_3$+BA combination gave the highest germination percentage. At the same time they emphasized that better seedling growth parameters were obtained from at certain dose of $GA_3$ alone. Another experiment was conducted in *Eriobotrya japonica* [4] and found that $GA_3$ had a significant effect on germination rate as compared to control.

# CONCLUSION

Gibberellins have lots of physiological bioactivities in plants via exogenous application. One of their uses is breaking seed dormancy and activation of seed germination of commercially important plant species as fruit types. Based on the criticized of the mentioned review, it can be concluded that $GA_3$ effectiveness in fruit seed germination depends on fruit genus, species or clones. In all studies above, used gibberellin was only $GA_3$ although another bioactive gibberellin compounds are available. $GA_3$ concentrations and seed soaking time were also variable according to studied plants. Sometimes another pre- or post-treatments and the other plant growth regulators and chemicals used for seed germination accompanied with the $GA_3$ treatments. Mostly *in vitro* and *ex vitro* studies could not be carried on to seedling growth that could be useful in field application. $GA_3$ treatment had better responsibility in germination percentage and earliness in most of seed although sometimes showed no statistically responses. The $GA_3$ treatments have a crucial importance in recalcitrant, and long term-dormant fruit seed types that have economic and biological importance. In the following studies, soaking time with $GA_3$ and sowing period that can be effective on the results and can help the progress of the study. In addition the other gibberellin compounds can be research as being other group of plant seed apart from fruit.

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