



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

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Received: 29 December 2014

Accepted: 03 February 2015

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 artırılması, 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 (GA₁, GA₃, GA₄ and GA₇) 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 GA₃ 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 (GA₃) 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] GA₃ 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 GA₃ 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 GA₃ on the growth of the stem apical meristem, a negative effect on root system that increased proportionally to the GA₃ concentration used. A germination experiment on walnut (*Juglans regia*) was carried out after epicarp removing. Treatment with GA₃ 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 illinoensis*). They found that presence of GA₃ 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 GA₃ treatments. In some of the experiments gibberellic acid (GA₃) 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 GA₃ concentrations.

It was showed that total GA₃ 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 GA₃ 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 GA₃ 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 GA₃ 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 GA₃ 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 GA₃ concentrations were effective on shortening germination time and germination rate except one of the stratification treatment. Abu-Qaoud [2] studied on three different *Pistacia* species. Together with scarification of seeds and GA₃ 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 GA₃ treatment after certain stratification time effected on germination. Another study carried out on *Arbutus unedo* genotypes [17] showed that GA₃ improves emergence and emergence rate increased with increasing concentration of GA₃. Wada and Reed [41] studied on 17 *Rubus* species for standardizing germination protocols and used different pre-treatments with or without GA₃ addition. They recommended that with the help of GA₃ 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 GA₃ 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 GA₃ 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 GA₃ 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 GA₃ 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 GA₃ dose was increased germination rate. Wani *et al.* [42] studied on apple seeds. It was found that all used concentrations of GA₃ endorsed germination percentage and growth of seedlings in the study. They concluded that GA₃ 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. GA₃ 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 GA₃ 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 GA₃ 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 GA₃ concentrations gave better germination rate than control plants in *Petri* dishes but this was not statistically significant. But they emphasized that seedlings derived from the GA₃-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 GA₃ 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 GA₃+BA combination gave the highest germination percentage. At the same time they emphasized that better seedling growth parameters were obtained from a certain dose of GA₃ alone. Another experiment was conducted in *Eriobotrya japonica* [4] and found that GA₃ 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 GA₃ effectiveness in fruit seed germination depends on fruit genus, species or clones. In all studies above, used gibberellin was only GA₃ although another bioactive gibberellin compounds are available. GA₃ 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 GA₃ treatments. Mostly *in vitro* and *ex vitro* studies could not be carried on to seedling growth that could be useful in field application. GA₃ treatment had better responsibility in germination percentage and earliness in most of seed although sometimes showed no statistically responses. The GA₃ 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 GA₃ 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.

Acknowledgment

This article was orally presented at Balkan Agriculture Congress, Edirne/Turkey, 08-11 September, 2014.

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