Tr. J. of Botany
22 (1998) 1-6


Research Article

# Comparative Effects of Kinetin, Benzyladenine, and Gibberellic Acid on Abscisic Acid Inhibited Seed Germination and Seedling Growth of Red Pine and Arbor Vitae

Kudret KABAR
Süleyman Demirel Üniversitesi, Fen Edebiyat Fakültesi, Biyoloji Bölümü, Isparta-TURKEY

Received: 9 / 10 / 1995
Accepted: 26 / 6 / 1997

**Abstract:** The effects of kinetin, benzyladenine (BA), and gibberellic acid ($GA_3$) on abscisic acid (ABA) inhibition of seed germination and seedling growth of red pine *(Pinus brutia* Ten.) and arbor vitae *(Thuja orientalis* L.) were studied. For this purpose, the seeds of these two species were germinated in Petri dishes containing ABA and the mixtures of its with kinetin, BA, and $GA_3$ alone or in combination at 20°C for 12 or 15 days for arbor vitae and red pine, respectively. The inhibitory effect of ABA on percentages of the seed germination and hypocotyl emergence, the time course of the germination, and the radicle and hypocotyl elongation of the seedlings was overcome very successfully by $GA_3$ alone in comparison with kinetin, BA, and the combinations of these two cytokinins alne with $GA_3$. Kinetin or BA alone did not mostly fail to overcome ABA inhibition on the mentioned parameters. There were the cases that also the combinations of these cytokinins with $GA_3$ were successful or not. $GA_3$ alone was the most successful hormone at all the cases in general.

**Key Words:** Germination, abscisic acid, gibberellic acid, kinetin, benzyladenine, *Pinus brutia* Ten, *Thuja orientalis* L.

## Kızılçam ve Mazı Tohumlarının Çimlenme ve Fide Büyümesindeki Absisik Asit Engellemesine Kinetin, Benziladenin ve Gibberellik Asitin Mukayeseli Etkileri

**Özet:** Bu araştırmada kızılçam (*Pinus brutia* Ten.) ve mazı (*Thuja orientalis* L.) tohumlarının çimlenmesi ve fide büyümesindeki absisik asit (ABA) engellemesi üzerine kinetin, benziladenin (BA) ve gibberellik asitin ($GA_3$) etkileri incelendi. Bu amaçla bu iki türün tohumları, ABA ve bu hormonun kinetin, BA ve $GA_3$ ile ayrı ayrı ve kombinasyon halindeki karışımlarını içeren petrilerde 20°C'de 12 (mazı) veya 15 gün (çam) boyunca çimlendirildi. Tohum çimlenmesi ve hipokotil çıkış yüzdeleri, zamana bağlı çimlenme ile fidelerin radikula ve hipokotil uzaması üzerindeki ABA'nın engelleyici etkisi kinetin, BA ve bu iki sitokininin $GA_3$ ile ayrı ayrı yaptıkları kombinasyonlara nazaran tek başına $GA_3$ ile çok başarılı bir şekilde yenildi. Tek başına kinetin veya BA, adı geçen parametreler üzerindeki ABA engellemesini yenmeyi çoğunlukla başaramadı. Bu sitokininlerin $GA_3$ ile kombinasyonlarının ise başarılı veya başarısız olduğu durumlar vardı. Tek başına $GA_3$, genellikle her durumda en başarılı hormondu.

**Anahtar Sözcükler:** Çimlenme, absisik asit, gibberellik asit, kinetin, benziladenin, Pinus brutia Ten., Thuja orientalis L.

## Introduction

In relation to the variable responses given by angiospermous seeds to various growth regulator applications, Khan (1) has proposed a model whereby gibberellins, cytokinins, and ABA play primary, permissive, and preventive roles, respectively, in germination. Thus, it appears that germination will occur in the presence of ABA only if both cytokinin and gibberellin are present, but in the presence of gibberellin alone if ABA is absent. On the basis of this model, primary agent is gibberellins, and cytokinins act in the presence of ABA to remove its blockage, and gibberellin-mediated germinative processes cannot occur in the presence of ABA unless there is sufficient cytokinin present to overcome its inhibitory effects. This model has been accepted by most of workers (e.g. 2-4). However, evidence that this model may also apply to conifers, as far as we know, is lacking. In the studies with conifers, it has been mostly utilized either gibberellin or cytokinin alone and these two growth regulators have not been compared in general. Pharis and Kuo (5) cited numerous studies in which exogenously applied gibberellins were found to stimulate germination in a variety of conifer species. Le Page-Degivry (6) also found good evidence for an interaction between gibberellin and ABA in regulation of seed germination in *Taxus baccata* L. Cytokinins have been less widely tested in conifers than gibberellins, and it has been mostly used BA, but not kinetin and with even more variable results, BA being promotive of germination in *Pinus taeda* L. (7) but not in *P. ponderosa* Dogl. (8) or *Taxodium distichum* (L.) Rich. (7).

The present work was carried out to test Khan's hypothesis (1) in two species of conifers, red pine *(Pinus brutia* Ten.) and arbor vitae *(Thuja orientalis* L.), and to contribute to studies with conifers on this subject. Moreover, it has been also aimed to participate to very few studies with cytokinins in conifers by using two different cytokinins, BA and kinetin, and to compare these two gowth regulators. For this purpose, the seeds of the mentioned species were germinated by adding kinetin, BA, and $GA_3$ to the media of ABA preventing their germinations to a great extent, and the effects of these promoter hormones on ABA inhibition on the seed germination, hypocotyl emergence and the elongations of the radicle and hypocotyl of the seedlings were compared.

## Materials and Methods

### The Seeds and Hormones

In this work, seeds of red pine *(Pinus brutia)* and arbor vitae *(Thuja orientalis)* were used. The seeds were surface sterilized with 1.0 % sodium hypochloride.

As test solutions 50 μM kinetin and benzyladenine (BA), and 300 μM gibberellic acid ($GA_3$) were used for both species. Concentrations of abscisic acid (ABA) were 15 and 30 μM for red pine, and also 80 and 100 μM for arbor vitae. Hormone concentrations were determined in a preliminary investigation.

### Germination of Seed

25 seeds were placed in 10 cm Petri dishes lined by two sheets of Whatman No. 1 filter paper and containing sufficient amount of solutions of ABA at the two different concentrations preventing importantly the germination of the seeds, and of the mixtures of its with kinetin, BA, and $GA_3$ alone or in combination. The seeds were left in an incubator to germinate at 20ºC, in dark for 12 or 15d (days) for arbor vitae and red pine, respectively. Reaching of the radicle a visible length, 1-2 mm, was accepted as a criterion of germination. The germination percentages were recorded on the $8^{th}$, $10^{th}$, and $12^{th}$ d for arbor vitae, and $11^{th}$, $13^{th}$, and $15^{th}$ d for red pine. After recording the final percentages of germination at the end of the experiment, hypocotyl emergence percentages were also determined and the radicle and hypocotyl lengths of the seedlings were measured in mm. In a preliminary experiment the seeds of both species was observed to germinate about 100 % in distilled water and not to be light-sensitive.

The experiments were repeated 4 times.

Data obtained were evaluated with analysis of variance (9).

## Results

### Effects of Kinetin, BA, and $GA_3$ on ABA Inhibition of Seed Germination

The retardative and preventive effect of ABA on the germination of red pine (Table 1) and arbor vitae (Table 2) seeds was enormously overcome by $GA_3$ alone. Neither BA nor kinetin were able to show a success at all the cases, except relative success of BA on 15 μM ABA inhibition of the final germination of red pine. BA, although it could not overcome ABA inhibition, was mostly statistically superior to kinetin in arbor vitae. However, while the combinations of BA and kinetin with $GA_3$, even though they were not so successful as $GA_3$ alone, exhibited success to varying

Table 1. Percentages of seed germination and final emergence of hypocotyl, and radicle and hypocotyl lengths of the seedlings of *Pinus brutia* in the media of various hormones. KIN: kinetin, 50 μM, BA: 50 μM, $GA_3$: 300 μM, ABA: μMs are shown in the Table. Values in each column followed by the same letter are not significantly different at the 1 % level.

| Hormone, μM | Germination, % Days 11 | 13 | 15 | Hypocotyl emergence, %, $15^{th}$ d | Radicle Length, mm | Hypocotyl Length, mm |
|---|---|---|---|---|---|---|
| ABA, 15 | $12^{b} \pm 2.8$ | $20^{b} \pm 2.8$ | $40^{d} \pm 2.8$ | $11^{c} \pm 1.7$ | $10.6^{d} \pm 0.6$ | $7.0^{b} \pm 0.7$ |
| + KIN | $12^{b} \pm 2.8$ | $26^{b} \pm 4.4$ | $42^{cd} \pm 4.5$ | $18^{bc} \pm 2.0$ | $19.1^{b} \pm 2.4$ | $3.9^{b} \pm 0.7$ |
| + BA | $13^{b} \pm 1.7$ | $24^{b} \pm 6.3$ | $52^{b}c \pm 2.8$ | $20^{bc} \pm 2.8$ | $16.6^{bc} \pm 1.4$ | $3.9^{b} \pm 0.3$ |
| + $GA_3$ | $30^{a} \pm 4.5$ | $56^{a} \pm 2.8$ | $75^{a} \pm 3.3$ | $41^{a} \pm 5.9$ | $27.8^{a} \pm 3.2$ | $15.2^{a} \pm 2.4$ |
| + KIN+$GA_3$ | $10^{b} \pm 2.0$ | $28^{b} \pm 2.8$ | $54^{b} \pm 4.5$ | $25^{b} \pm 3.3$ | $15.4^{bc} \pm 2.7$ | $5.8^{b} \pm 0.4$ |
| + BA+ $GA_3$ | $13^{b} \pm 1.7$ | $26^{b} \pm 4.4$ | $60^{b} \pm 4.5$ | $21^{b} \pm 4.3$ | $14.3^{cd} \pm 0.2$ | $5.5^{b} \pm 0.4$ |
| ABA, 30 | $2^{c} \pm 2.0$ | $4^{c} \pm 2.8$ | $20^{c} \pm 2.8$ | $8^{b} \pm 2.8$ | $5.6^{de} \pm 0.7$ | $4.8^{bc} \pm 0.3$ |
| + KIN | $6^{bc} \pm 2.0$ | $8^{c} \pm 2.8$ | $24^{c} \pm 2.8$ | $9^{b} \pm 3.3$ | $5.1^{e} \pm 0.2$ | $6.6^{a} \pm 0.7$ |
| + BA | $6^{bc} \pm 4.4$ | $10^{c} \pm 2.0$ | $24^{c} \pm 2.8$ | $8^{b} \pm 2.8$ | $8.7^{cd} \pm 0.5$ | $3.1^{d} \pm 0.3$ |
| + $GA_3$ | $22^{a} \pm 2.0$ | $36^{a} \pm 6.3$ | $69^{a} \pm 7.1$ | $25^{a} \pm 5.9$ | $16.2^{a} \pm 1.3$ | $5.6^{ab} \pm 0.3$ |
| + KIN + $GA_3$ | $5^{c} \pm 3.3$ | $29^{ab} \pm 4.3$ | $47^{b} \pm 5.9$ | $21^{a} \pm 5.2$ | $11.8^{bc} \pm 2.7$ | $3.4^{d} \pm 0.2$ |
| + BA+$GA_3$ | $13^{b} \pm 3.3$ | $20^{b} \pm 2.8$ | $56^{b} \pm 2.8$ | $20^{a} \pm 2.8$ | $14.4^{ab} \pm 1.7$ | $4.1^{cd} \pm 0.5$ |

extents at some cases, e.g. the final germination of both species at the both levels of ABA, and the germination of red pine on the 13th d at 30 µM ABA, they became also unsuccessful at the other cases, e.g. red pine germination on the 11th and 13th d in the medium of 15 µM ABA. On the other hand, BA + $GA_3$ combination was more successful at a few cases than kinetin + $GA_3$, e.g. red pine germination on the 11th d in 30 µM ABA, and in arbor vitae the final germination at the both levels of ABA and the germination on the 10th d in 100 µM ABA. Kinetin + $GA_3$ never showed a statistically superiority in comparison with BA + $GA_3$.

### Effects of Kinetin, BA, and $GA_3$ on ABA Inhibition of the Hypcotyl Emergence

The inhibitory effect of ABA on the emergence of hypocotyl was importantly overcome by $GA_3$ alone in both species (Table 1,2). Kinetin and BA were unsuccessful at all the cases. The combinations of these two promoters with $GA_3$ overcame ABA inhibition on the hypocotyl emergence of red pine seedlings at the same degree in statistical, whereas in arbor vitae kinetin + $GA_3$ showed no success, but BA + $GA_3$ was rather successful in this species too. However, $GA_3$ alone was the most effective hormone at all the cases, except the successes of the combinations of BA and kinetin with $GA_3$ on the hypocotyl emergence of red pine seedlings in 30 µM ABA.

### Effects of Kinetin, BA, and $GA_3$ on ABA Inhibition of the Radicle and Hypocotyl Elongation

$GA_3$ played a primary role in overcoming ABA inhibition of the radicle elongation except one case, 100 µM ABA in arbor vitae (Table 1,2). BA + $GA_3$ combination became more successful on the elongation of arbor vitae radicles in 100 µM ABA than $GA_3$ alone. $GA_3$, here, was secondarily important. Kinetin and BA, separately or in combinations with $GA_3$, exhibited success to varying extents. On the other hand, they had also failures at some cases, e.g., BA + $GA_3$ and kinetin in the cases of 15 and 30 µM ABA, respectively, in red pine, and also in arbor vitae kinetin at the both levels of ABA, and kinetin + $GA_3$ in 100 µM ABA. BA alone had statistically more effect in arbor vitae than kinetin.

The circumstance in the elongation of hypocotyl was not different from the previous findings. Here also, ABA inhibition was primarily broken by $GA_3$. Kinetin, except its success on the elongation of red pine hypocotyl in 30 µM ABA, and kinetin + $GA_3$ were unsuccessful at all the cases. BA + $GA_3$ showed an equal success to that of $GA_3$ in arbor vitae, even if it exhibited no success in red pine.

Table 2. Percentages of seed germination and final emergence of hypocotyl, and radicle and hypocotyl lengths of the seedlings of *Thuja orientalis* in the media of various hormones. Symboles see Table 1.

| Hormone, µM | Germination, % Days 8 | 10 | 12 | Hypocotyl emergence, %, 12th d | Radicle Length, mm | Hypocotyl Length, mm |
|---|---|---|---|---|---|---|
| ABA, 80 | $1^{c}\pm1.7$ | $11^{cd}\pm1.7$ | $22^{d}\pm4.5$ | $0^{c}\pm0.0$ | $2.9^{d}\pm0.2$ | $0.0^{b}\pm0.0$ |
| + KIN | $0^{c}\pm0.0$ | $3^{d}\pm3.3$ | $7^{e}\pm3.3$ | $0^{c}\pm0.0$ | $2.5^{d}\pm0.4$ | $0.0^{b}\pm0.0$ |
| + BA | $2^{c}\pm2.0$ | $11^{cd}\pm1.7$ | $23^{d}\pm3.3$ | $0^{c}\pm0.0$ | $4.1^{c}\pm0.1$ | $0.0^{b}\pm0.0$ |
| + $GA_3$ | $26^{a}\pm4.5$ | $59^{a}\pm5.9$ | $83^{a}\pm5.9$ | $82^{a}\pm4.5$ | $14.8^{a}\pm0.2$ | $8.6^{a}\pm0.3$ |
| + KIN±$GA_3$ | $6^{bc}\pm4.4$ | $18^{bc}\pm4.4$ | $36^{c}\pm2.8$ | $0^{c}\pm0.0$ | $4.0^{c}\pm0.2$ | $0.0^{b}\pm0.0$ |
| + BA + $GA_3$ | $12^{b}\pm2.8$ | $23^{b}\pm3.3$ | $54^{b}\pm4.4$ | $34^{b}\pm4.5$ | $11.9^{b}\pm1.4$ | $8.7^{a}\pm0.3$ |
| ABA, 100 | $0^{c}\pm0.0$ | $9^{c}\pm1.7$ | $17^{d}\pm3.3$ | $0^{c}\pm0.0$ | $2.3^{d}\pm0.2$ | $0.0^{b}\pm0.0$ |
| + KIN | $0^{c}\pm0.0$ | $1^{d}\pm1.7$ | $5^{e}\pm1.7$ | $0^{c}\pm0.0$ | $2.4^{d}\pm0.2$ | $0.0^{b}\pm0.0$ |
| + BA | $0^{c}\pm0.0$ | $10^{c}\pm2.0$ | $19^{cd}\pm3.3$ | $0^{c}\pm0.0$ | $3.6^{c}\pm0.1$ | $0.0^{b}\pm0.0$ |
| + $GA_3$ | $11^{a}\pm3.3$ | $26^{a}\pm4.5$ | $58^{a}\pm4.5$ | $27^{a}\pm3.3$ | $6.3^{b}\pm0.4$ | $7.2^{a}\pm0.2$ |
| + KIN+$GA_3$ | $2^{bc}\pm2.0$ | $10^{c}\pm2.0$ | $26^{c}\pm4.5$ | $0^{c}\pm0.0$ | $2.9^{cd}\pm0.1$ | $0.0^{b}\pm0.0$ |
| + BA+$GA_3$ | $7^{ab}\pm3.3$ | $18^{b}\pm4.5$ | $46^{b}\pm4.5$ | $19^{b}\pm1.7$ | $8.6^{a}\pm0.3$ | $7.4^{a}\pm0.3$ |

## Discussion

In this work, it was observed that $GA_3$ alone, in contrast to expected, alleviated mostly excellently ABA inhibition on the germination and hypocotyl emergence, the radicle and hypocotyl elongations of seeds of red pine and arbor vitae, compared to kinetin, BA and the combinations of these two with $GA_3$. Kinetin and BA alone did not generally show a success on the inhibition of the germination and hypocotyl emergence. However, while kinetin became unsuccessful on the inhibition of the radicle elongation particularly in arbor vitae, BA was rather successful on this parameter in both species. The response of the hypocotyl elongation to both cytokinins was mostly negative, especially in arbor vitae. The combinations of these two cytokinins with $GA_3$ showed performances varying from failure to success. Though the germination and the radicle elongation of arbor vitae responded better to BA + $GA_3$ than kinetin + $GA_3$, the hypocotyl gave no response to kinetin + $GA_3$. In the case of red pine, the performances of these two combinations were about at the same degree at all the cases in general.

The findings obtained suggest that ABA and gibberellin interaction may have a competitive nature in conifers, at least in red pine and arbor vitae investigated. Le Page-Degivry (6) also demonstrated, indeed, this interaction in germination of *Taxus baccata.* Exogenously applied gibberellin counteracted the inhibitory effect of ABA in this species. In addition, it was reported that dormancy-breaking treatments in conifers usually cause a marked increase in levels of endogenous gibberellin (5, 6, 10). Cytokinin activity was also found to increase for seed of *Pinus lambertiana Dogl.* (10), *P. slyvestris* and *Picea sitchensis* (Bong.) Carr. (7), but not that of *Psedotsuga menziesii* (Mirb.) Franco (10). On the other hand, Kabar (11) and Kabar and Baltepe (12) reported that exogenous application of kinetin was more successful in dicots, but $GA_3$ in *Gramineae* in remowing secondary dormancy imposed by enviromental stresses such as high temperature and salinity.

The quantitative and qualitative responses of plants to different cytokinins may differ considerably. Thomas et al. (13) and Biddington and Thomas (14) demonstrated that BA is more active than any other cytokinin in germination and in breaking dormancy of celery and lettuce seeds. The seeds of red pine and arbor vitae used in this work gave generally a positive response to neither BA nor kinetin singly in overcoming the inhibitory effect of ABA on their germination. In the germination and radicle elongation of arbor vitae in the medium of ABA, however, BA, although it was not successful on the germination, made more its presence felt than kinetin, and also BA + $GA_3$ combination than kinetin + $GA_3$. In addition, while arbor vitae hypocotyl gave no response to kinetin + $GA_3$ combination, BA + $GA_3$ became rather effective on this parameter. Red pine responded generally equally to these two combinations at all the cases. The reasons for these differences in activity are not clear. BA and kinetin singly may not probably be effective in red pine and arbor vitae. The different degress of effectiveness of different cytokinins and also different gibberellins as it will be indicated below may be due to variations in metabolism or to active forms or to differences in primary mechanisms of action. Alternatively, responses of plants to cytokinins and gibberellins and their different types may also change according to species, ecotype (e.g., halophytes, 15-17), and even presumably location of plants in systematic. It seems, therefore, more appropriate not to make a generalization including all plants about roles of these two promoters in germination and breaking dormancy of seeds.

On the other hand, gibberellins have the unique ability among plant hormones to promote extensibility of intact plants of many species. But several species of *Pinaceae,* e.g., *Abies grandis* Lindl., *Pinus radiata* Dor., *Pseudotsuga menziesii,* show few or no elongation responses to $GA_3$ (5). However, they respond well to a mixture of $GA_4$ and $GA_7$ (18), e.g., *Pinus elliottii, P. radiata.* There are also conifers showing positive response to $GA_3$, e.g., *Pinus pungens* Lam., *P. strobus* L., *P. siberica* L., *Thuja occidentalis* L., (7). It has not been encontered and report about the response of *P. brutia* and *T. orientales* to $GA_3$. In this investigation, the seeds of these species responded very well to $GA_3$ in removing both germination and seedling growth inhibition of ABA.

It has been emphasized before (1, 10) that seeds of the same or different species may contain different levels of gibberellins, cytokinins and inhibitors leading to various depths of dormancy, from no apparent dormancy to absolute dormancy. The seeds, therefore, should not be expected to give the same response to application of a gibberellin or cytokinin. There is evidence from plant tissues that during primary (4) or secondary dormancy (19-20) ABA is at a supra-optimal level and cytokinins and/or gibberellins at a sub-optimal level. Under this situation, addition of a favorable promoter hormone, cytokinin or gibberellin, might be expected to release the dormancy by restoring the promoter/inhibitor ratio to an effective level for removal of dormancy.

The most common response of cells to ABA is, as known, growth inhibition. Numerous studies concerning the possible importance of ABA in causing seed dormancy have been conducted (4, 21). Exogenous ABA is also a potent inhibitor of seed germination in many species. ABA can inhibit nucleic acid (22) and protein synthesis (23). Reversal of ABA inhibition of germination by cytokinin (24) or gibberellin (25, 26) may be accompanied by and increase in RNA synthesis. Moreover, both cytokinins (27, 28) and gibberellins (23, 29, 30) may also remove ABA-incluced dormancy by elevating polyribosome level and protein synthesis. The function of ABA in controlling dormancy and inhibition of germination may be to prevent these basic metabolic processes which start very soon after the beginning of imbibition. Thus, germination will be inhibited in its early stages and dormancy will then be marked by lowered metabolic activity. ABA, depending on its concentration, may have delayed and/or prevented the germination of red pine and arbor vitae seeds for the reasons mentioned, and in addition, may have blocked growth of the seedlings. $GA_3$ may have also overcome these inhibitions by counteracting ABA through its mentioned and other actions.

There is also supporting evidence for a number of alternative mechanisms of cytokinins and gibberellins. For example, it was reported that both cytokinins (31) and gibberellins (32) may stimulate the growth and development by promoting cell division. Gibberellins can also be effective on the growth and development by causing and increase in hydrolytic activity (33) and in cell wall plasticity (34).

That gibberellins do also perform some functions such as stimulation of cell division and polisome formation, the effects at the level of transcription and translation of cytokinins put forward to have a permissive role under situations of endogenous and exogenous inhibition is interesting. The similarity of some functions of cytokinins and gibberellins seems like and insurance for life of plant so that if which of them is more effective in a plant, it will succeed these functions. As seen, the explanation of the problem is difficult and far from clear.

The obtained data in the present work and the others (11, 12) may serve to provide a new conceptual tool for designing hypotheses of seed dormancy and germination and for reinterpreting old concepts and findings.

## References


1. Khan, A.A., Cytokinins: Permissive Roles in Seed Germination, Science, 171, 853-859, (1971).
2. Thomas, T.H., Cytokinins, Cytokinin-Active Compounds and Seed Germination, In: The Physiology and Biochemistry of Seed Dormancy and Germination, Than, A.A., ed., North-Holland Publishing Co., Amsterdam, (1977).
3. Bewley, J.D., Black, M., The Release From Dormancy, In: Physiology and Biochemistry of Seeds in Relation to Germination, 2, Bewley, J.D., Black M., eds., Springer-Verlag, Berlin, Heidelberg, New York, (1982).
4. Berrie, A.M.M., Germintion and Dormancy, In: Advanced Plant Physiology, Wilkins, M.B., ed., Pitman, London, (1984).
5. Pharis, R.P., Kuo, C.G., Physiology of Gibberellins in Conifers, Can. J. For. Res., 7, 299-325, (1977).
6. Le Page-Degivry, T., Influence de L'acide Abscissique sur de Developpement des Embryous de Taxus baccata L. Cultives in Vitro, Z. Pflanzenphysiol., 70, 406-413, (1973).
7. Ross, S.D., Pharis, R.P., Binder, W.D., Growth Regulators and Conifers: Their Physiology and Potential Uses in Forestry, In: Plant Growth Regulating Chemicals, 2, Nickell, L.G. (ed.), CRC Press, Inc., Boca Raton, Florida, (1983).
8. Heidmann, L.J., Overcoming Temperature-Dependent Dormancy of Southwestern Ponderosa Pine Seed, USDA For. Serv., Rocky Mt. For. and Range Exp. Sta. Res. Note RM-406, (1981).
9. Düzgüneş, O., Kesici, T., Gürbüz, F., İstatistik Metotları, 2. baskı, A.Ü. Zir. Fak. Yay., No. 1291, Ankara (1993).
10. Taylor, J.S., Wareing, P.F., The Effect of Stratification on the Endogenous Levels of Gibberellins and Cytokinins in Seeds of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and Sugar Pine (Pinus lambertiana Dougl.), Plant Cell Environ., 2, 165-172, (1979).
11. Kabar, K., Comparison of Kinetin and Gibberellic acid Effects on Seed Germination under Saline Conditions, Phyton (Horn, Austria), 30 (2), 291-298, (1990).
12. Kabar, K., Baltepe, Ş., Effects of Kinetin and Gibberellic acid in Overcoming High Temperature and Salinity (NaCl) Stresses on the Germination of Barley and Lettuce Seeds, Phyton (Horn, Austria), 30 (1), 65-74, (1990).
13. Thomas, T.H., Palevitch, D., Biddington, N.L., Austing, R.B., Growth Regulators and the Phytochrom-Mediated Dormancy of Celery Seeds, Physiol. Plant., 35, 101-106, (1975).
14. Biddington, N.L., Thomas, T.H., Influence of Different Cytokinins on the Germination of Lettuce (Lactuca sativa) and Celery (Apium graveolens) Seeds, Physiol. Plant., 37, 12-16, (1976).
15. Ungar, I.A., Alleviation of Seed Dormancy in Spergularia marina, Bot. Gaz., 145, 33-36, (1984).
16. Khan, M.A., Weber, D.J., Factors Influencing Seed Germination in Salicornia pacifica var. utahensis, Am. J. Bot., 73, 1163-1167, (1986).
17. Khan, M.A., Studies on Germination of Cressa cretica, Pak. J. Weed Sci. Res., 4, 89-98, (1991).
18. Pharis, R.P., Evans, L.T., King, R.W., Mander, L.N., Gibberellins and Flowering in Higher Plants: Differing Structures Yield Highly Specific Effects, In: Plant Reproduction: From Floral Induction to Pollination, 1, Lord, E., Bernier, G. (eds.), The American Society of Plant Physiologists Symposium Series, (1989).
19. Boucaud, J., Ungar, I.A., Hormonal Control of Germination under Saline Conditions of Three Halophytic Taxa in the Genus Suaeda, Physiol. Plant., 37, 143-148, (1976).
20. Khan, A.A., Incorporation of Bioactive Chemicals into Seeds to Alleviate Environmental Stress, Acta Hort., 83, 225-235, (1978).
21. Bewley, J.D., Black, M., Dormancy, In: Physiology and Biochemistry of Seeds in Relation to Germination, 2, Bewley, J.D., Black, M. (eds.), Springer-Verlag, Berlin, (1982).
22. Walbot, V., Clutter, M., Sussex, I., Effects of Abscisic acid on Germinating Bean Axes, Plant Physiol., 56, 570-574, (1975).
23. Fountain, D.W., Bewley, J.D., Modulation of Pre-germination Protein Synthesis by Gibberellic acid, Abscisic acid, and Cytokinin, Plant Physiol., 58, 530-536, (1976).

24. Ananiev, E.D., Karagyozov, L.K., Karanov, E.N., Effect of Cytokinins on Ribosomal RNA Gene Expression in Excised Cotyledons of Cucurbita pepo L., Planta, 170, 370-378, (1987).

25. Akazawa, T., Mitsui, T., Hawashi, M., Recent Progress in Alpha-Amylase Biosynthesis, In: The Biochemistry of plants, 14, Preiss, J. (ed.), Academic Press, San Diego, (1988).

26. Fincher, G.B., Molecular and Cellular Biology Associated with Endosperm Mobilization in Germinating Cereal Grains, Ann. Rev. Plant Physiol. and Plant Mol. Biol., 40, 305-346, (1989).

27. Flores, S., Tobin, E.M., Benzyladenine Regulation of the Expression of two Nuclear Genes for Chloroplast Proteins, In: Molecular Biology of Plant Growth Control, Fox, J.E., Jacobs, M. (eds.), Alan R. Liss, New York, (1987).

28. Ohya, T., Suzuki, H., Cytokinin-Promoted Polyribosome Formation in Excised Cucumber Cotyledons, J.Plant Physiol., 133, 295-298, (1988).

29. Evins, W.H., Enhancement of Polyribosome Formation and Induction of Tryptophan-Rich Proteins by Gibberellic Acid, Biochemistry, 10, 4295-4303, (1971).

30. Jones, R.L., MacMillan, J., Gibberellins, In: Advanced Plant Physiology, Wilkins, M.B. (ed.), Pitman, London, (1984).

31. Houssa, C., Jacqmard, A., Bernier, G., Activation of Replicon Origins as a Possible Target for Cytokinins in Shoot Meristems of Sipanis, Planta, 181, 324-326, (1990).

32. Liu, P.B.W., Loy, J.B., Action of Gibberellic Acid on Cell Proliferation in the Subapical Shoot Meristem of Watermelon Seedlings, Am. J. Bot., 63, 700-704, (1976).

33. Mozer, T.J., Control of Protein Synthesis in Barley Aleurone Layers by the Plant Hormones Gibberellic Acid and Abscisic Acid, Cell, 20, 479-485, (1980).

34. Taylor, A., Cosgrove, D.J., Gibberellic Acid Stimulation of Cucumber Hypocotyl Elongation: Effects on Growth, Turgor, Osmotic Pressure, and Cell Wall Properties, Plant Physiol., 90, 1335-1340, (1989).