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EFFECTS OF SOME PLANT GROWTH REGULATORS ON JASMONIC ACID INDUCED INHIBITION OF SEED GERMINATION AND SEEDLING GROWTH OF BARLEY

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Abstract: The effects of gibberellic acid, kinetin, benzyladenine, ethylene, 24-epibrassinolide and polyamines (spermine, spermidine, putrescine, cadaverine) on jasmonic acid inhibition of seed germination and seedling growth of barley were studied. All of the plant growth regulators studied were determined to have a succesful performance in reversing of the inhibitory effects of jasmonic acid on the seed germination and seedling growth. Moreover, the above mentioned growth regulators overcame the inhibitory effect of JA on the percentages of germination and coleoptile emergence in the same ratio, while GA_3 was the most successful hormone on the fresh weight and radicle and coleoptile elongation in comparison with the other growth regulators.

Key words: Barley, jasmonic acid, plant growth regulator, seed germination, seedling growth

ARPANIN TOHUM ÇİMLENMESİ VE FİDE BÜYÜMESİNİN JASMONİK ASİT TEŞVİKLİ İNHİBİSYONU ÜZERİNE BAZI BİTKİ BÜYÜME DÜZENLEYİCİLERİNİN ETKİLERİ

Özet: Arpanın tohum çimlenmesi ve fide büyümesinin jasmonik asit inhibisyonu üzerine gibberellik asit, kinetin, benziladenin, etilen, 24-epibrassinolit ve poliaminlerin (spermin, spermidin, putressin, kadaverin) etkileri araştırılmıştır. Çalışılan bitki büyüme düzenleyicilerinin tümünün tohum çimlenmesi ve fide büyümesi üzerinde jasmonik asitin engelleyici etkisini tersine çevirmede başarılı bir performansa sahip oldukları belirlenmiştir. Dahası, yukarıda sözü edilen büyüme düzenleyicileri çimlenme ve koleoptil çıkış yüzdeleri üzerinde aynı oranda etkili olurken, taze ağırlık ve radikula ve koleoptil uzaması üzerinde diğer büyüme düzenleyicileri ile karşılaştırıldığında en başarılı hormon GA_3 olmuştur.

Anahtar kelimeler: Arpa, jasmonik asit, bitki büyüme düzenleyicisi, tohum çimlenmesi, fide büyümesi

INTRODUCTION

Jasmonic acid (JA) and its derivatives including methyl jasmonate (JA-Me) have been regarded as endogenous plant growth regulators because of their ubiquitous occurence in plant kingdom and their pleiotropic effects on plant growth and development (SEMBDNER & PARTHIER 1993). These compounds were isolated from fungi (CROSS & WEBSTER 1970, FERNANDEZ-MACULET & YANG 1992), algae (KRUPINA & DATHE 1991, UEDA et al. 1991) and many higher plants (MEYER et al. 1984). Jasmonates applied exogenously to plants, for example, inhibit stem and root growth (STASWICK et al. 1992, SEMBDNER & PARTHIER 1993), induce pericarp or leaf senescence (YEH et al. 1995), prevent chlorophyll (ABALES et al. 1989) and carotenoid formation (SANIEWSKI & CZAPSKI 1983) and reduce fresh weight (TSAI et al. 1997), RNA and protein synthesis (ANANIEVA & ANANIEV 1997) and respiratory activity (POPOVA et al. 1988).

Moreover, exogenous jasmonates seem to have inhibitory effects on germination in many cases of non-dormant seeds, for instance, cocklebur (ASGHARI & ISHIZAWA 1998), *Amaranthus* (KEPCZYNSKI et al. 1999, BIALECKA & KEPCZYNSKI 2003), sunflower (CORBINEAU et al. 1988) and lettuce (YAMANE et al. 1981) seeds. But jasmonates break the seed dormancy of apple (RANJAN & LEWAK 1992) and other woody species (DALETSKAYA & SEMBDNER 1989, BERESTETZKY et al. 1991) and promote germination.

In the present investigation, we studied reverse the inhibitory effect of JA on seed germination and seedling growth of barley by gibberellic acid, kinetin, benzyladenine, ethylene, 24-epibrassinolide and polyamines.

MATERIAL AND METHODS

Seed and Growth Regulators

In this work, seeds of barley (*Hordeum vulgare* L. cv. Bülbül 89) were used. The seeds were surface sterilized with 1.0 % sodium hypochloride.

As test solutions 900 µM gibberellic acid (GA_3), 100 µM kinetin (Kin), 100 µM benzyladenine (BA), 400 µM ethylene (E), 3 µM 24-epibrassinolide (EBR), 10 µM spermine (Spm), 10 µM spermidine (Spd), 10 µM putrescine (Put) and 10 µM cadaverine (Cad) were used. Concentration of jasmonic acid (JA) was 3000 µM.

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 JA at the concentration preventing completely the germination of the seeds, and of the mixtures of its with GA_3, Kin, BA, E, EBR, Spm, Spd, Put and Cad alone. The seeds were left in an incubator to germinate at 20 ºC, in dark for 7 days. The seeds were considered germinated when the radicles reached to 10 mm in length.

At the end of 7^{th} day, following the estimation of germination percentage, percentages of coleoptile emergence were determined and radicle and coleoptile lengths were measured in mm. Furthermore, with special replicas for the experiments fresh weight of the seedlings were recorded.

Each treatment was repeated 4 times. Statistical analyses were done using SPSS program and Duncan's multiple range test.

RESULTS

Effects of the Plant Growth Regulators on JA-Inhibition of the Germination and Coleoptile Emergence Percentages

3000 µM JA completely inhibited germination and coleoptile emergence of barley. In removing JA inhibition of the germination and coleoptile emergence percentages, all of the growth regulators studied were effective in the same ratio. The germination and coleoptile emergence percentages reached 100 % when each of the growth regulators were added the medium contained JA. In the other words, the mentioned growth regulators perfectly overcame JA inhibition of the germination and coleoptil emergence (Table 1).

Effects of the Plant Growth Regulators on JA-Inhibition of the Radicle and Coleoptile Elongation

The complete inhibition of radicle and coleoptile elongation by JA was totally reversed by all of the growth regulators. GA_3 was the most effective hormone in reversing JA-induced elongation-inhibition of the radicle and coleoptile from barley seeds in a medium of JA. The other growth regulators were almost effective in the same ratio on these parameters. For example, radicle and coleoptile lengths reached 15.4 and 21.5 mm at $GA_{3,}$ respectively (Table 1).

Effects of the Plant Growth Regulators on JA-Inhibition of the Fresh Weight Increase

All of the growth regulators studied perfectly overcame the inhibitory effect of JA on fresh weight of barley seedlings. GA_3 was again the most effective hormone in reversing JA-induced fresh weight-reduction. Cytokinins (BA and Kin) were less successful than $GA_{3.}$ E and Spm were effective in the same ratio. In removing JA-induced fresh weight reduction, Spd, Put and Cad were the most ineffective in comparison with the other growth regulators. To exemplify, fresh weight of the seedlings reached 142.5, 137.6 and 136.4 mg at $GA_{3,}$ Kin and BA, respectively (Table 1).

Table 1. Percentages of seed germination and coleoptile emergence, radicle and coleoptile lengths, and fresh weights of the seedlings of barley in the media of various growth regulators

Growth regulator	Germination percentage (%)	Coleoptile emergence (%)	Radicle length (mm)	Coleoptile length (mm)	Fresh weight (mg/seedling)
JA	*0.0±0.0 [a]	0.0±0.0 [a]	0.0±0.0 [a]	0.0±0.0 [a]	0.0±0.0 [a]
+GA_3	100±0.0 [b]	100±0.0 [b]	15.4±0.9 [d]	21.5±0.7 [d]	142.5±0.9 [f]
+Kin	100±0.0 [b]	100±0.0 [b]	13.2±0.7 [c]	18.6±0.8 [c]	137.6±0.6 [e]
+BA	100±0.0 [b]	100±0.0 [b]	11.5±0.5 [b]	17.3±0.6 [b]	136.4±0.7 [e]
+E	100±0.0 [b]	100±0.0 [b]	10.8±0.3 [b]	16.8±0.5 [b]	116.5±0.5 [d]
+EBR	100±0.0 [b]	100±0.0 [b]	10.5±0.4 [b]	15.7±0.7 [b]	110.2±0.3 [c]
+Spm	100±0.0 [b]	100±0.0 [b]	11.2±0.7 [b]	19.2±0.9 [c]	118.1±0.6 [d]
+Spd	100±0.0 [b]	100±0.0 [b]	10.8±0.5 [b]	15.8±0.7 [b]	105.4±0.5 [b]
+Put	100±0.0 [b]	100±0.0 [b]	10.1±0.3 [b]	16.1±0.8 [b]	107.2±0.9 [b]
+Cad	100±0.0 [b]	100±0.0 [b]	10.3±0.1 [b]	15.4±0.5 [b]	105.9±0.2 [b]

* Shows values with insignificant difference ($P<0.05$) for each colomn shown with same letters

DISCUSSION

The germination of not only barley seeds (CAVUSOGLU & KABAR 2006), but also *Avena* (SATLER & THIMANN 1981), *Amaranthus* (KEPCZYNSKI et al. 1999, BIALECKA & KEPCZYNSKI 2003), *Agrostemma* (SEMBDNER & GROSS 1986), *Lactuca* (YAMANE et al. 1981), sunflower (CORBINEAU et al. 1988) and flax (WILEN et al. 1991) seeds were inhibited by JA-Me or JA. In all of these cases, high concentrations of JA or JA-Me are necessary to inhibit germination. However, SEMBDNER & PARTHIER (1993) and ASGHARI & ISHIZAWA (1998) pointed out that a physiological effects of JA_S on seed germination is doubtful. In the case of cocklebur seeds, significant inhibition of the germination was detected even at 1 µM JA-Me.

The complete inhibition of seed germination and coleoptile emergence by 3000 µM JA was totally reversed by all of the growth regulators (Table 1). Many investigators obtained similar results with GA_3 (KEPCZYNSKI & BIALECKA 1994), cytokinins (BIALECKA & KEPCZYNSKI 2003) and E (KEPCZYNSKI & BIALECKA 1997, ASGHARI & ISHIZAWA 1998, KEPCZYNSKI et al. 1999) during the germination of seeds of different species.

Moreover, we observed that JA completely inhibited the seedling growth (fresh weight, radicle and coleoptile elongation) such as the germination and coleoptile emergence (Table 1). Preventive effects of JA on root and stem elongation (YAMANE et al. 1980, KODA et al. 1991, STASWICK et al. 1992) and fresh weight (TSAI et al. 1997) have been shown previously.

On the other hand, all of the growth regulators studied have clearly reversed the inhibitory effect of JA on the seedling growth. Besides, GA_3 was the most effective hormone in reversing JA-induced-inhibition of the radicle and coleoptile elongation and fresh weight of barley seedlings in a medium of JA (Table 1). Similarly, TSAI et al. (1997) pointed out that GA_3 was able to reverse the inhibitory effect of JA-Me on root and shoot growth and fresh weight of rice seedlings and was more effective in preventing the inhibition of shoot growth caused by JA-Me than root.

In summary, the results show clearly that JA inhibits seed germination and seedling growth of barley at high concentrations. The inhibitory effects of JA on the growth and development may act through various ways; by reducing nucleic acid and protein synthesis (ANANIEVA & ANANIEV 1997), or by inhibiting cell division (SWIATEK et al. 2002) and hydrolitic activity (BIALECKA & KEPCZYNSKI 2003). JA also be effective on the growth and development by causing the reduction of endogenous amounts of stimulating hormones (ASGHARI & ISHIZAWA 1998).

Our results also indicate that all of the growth regulators studied have perfectly overcame the inhibitory effect of JA on seed germination and seedling growth of barley. Furthermore, the mentioned growth regulators are known for reversing inhibitory effects of adverse environmental factors on the growth and development by increasing nucleic acid and protein synthesis (WU & ZHAU 1993), amylase activity (KEPCZYNSKI et al. 1999, BIALECKA & KEPCZYNSKI 2003), cell division (KAUR-SAWHNEY et al. 1980) and stabilization of cell membranes (MANSOUR & AL-MUTAWA 1999). These growth regulators may perform their positive effects on the growth and development via one or more the above mentioned mechanisms.

The effects of exogenous GA_3, Kin, BA, E on JA inhibition of seed germination and seedling growth are insufficiently known, while for EBR and polyamines studied there is no extant literature data. To clarify the effect mechanism(s) dealt chemical further research, fine and detailed, is need and we believe that our study will contribute to future studies.

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