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Research Article

Effect of gibberellin and indole-3-butyric acid on germination indices and vigor of scallion (*Allium fistulosum*) seeds

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ABSTRACT- Scallion (*Allium fistulosum*) is one of the essential edible vegetables with various medicinal uses. The seeds of this plant have low germination power, which may disappear due to storage conditions. In this study, the germination characteristics of scallion seeds were experimented with a factorial arrangement based on a completely randomized design with three replications in the physiology laboratory of Khorasan Razavi Agricultural and Natural Resources Research and Education Center in 2019. The first factor was indole-3-butyric acid (IBA) at 0 (or control), 100, and 200 ppm, and the second factor was gibberellin (GA_3) at the same concentrations. The results showed that the maximum germination percentage was obtained by 200 ppm of gibberellin without using IBA. The maximum rootlet dry weight (7.02 mg) was recorded with 100 ppm of GA_3 and IBA. The maximum allometric coefficient was obtained using 100 ppm IBA and 200 ppm GA_3. The maximum seed vigor index was observed at 100 and 200 ppm of GA_3 with 0 ppm of IBA (2.18 and 2.33, respectively). The maximum seedling vigor length index (0.799) and seedling vigor weight index (6.77) were obtained when 200 ppm of GA_3 was applied with 0 ppm of IBA. In general, the results showed that the use of different concentrations of gibberellin has a significant effect on increasing germination and vigor index in scallion seeds.

INTRODUCTION

Seed is the most critical factor in propagating plants and preserving their hereditary. Seed propagation is one of the most effective methods of plant propagation (Rajabian et al., 2007). The growth cycle of plant species is determined by germination, which is the main factor in plant establishment and yield. The poor establishment of plants is one of the main factors in poor plant yield. It has been shown that the uniform germination and establishment rate are controlled by internal and external factors influencing the speed and amount of plant growth (Ashraf and Foolad, 2005).

Fast and uniform germination is necessary to achieve a uniform and desirable green surface, which can be attained by seed priming and using foreign materials before or during cultivation to obtain appropriate morphological indices and yield (Al Omrani Nejad and Rezvani Aqdam, 2013). It has been reported that in priming technology, the seeds are controlled, which receive a set of water-soluble substances under particular conditions (usually accelerating compounds) with water to permit the pre-germination metabolic activities, but there is no emergence of roots (Abotalebian and Meghisani, 2016). The germination uniformity, time reduction between planting and greening, and seed forcing to simultaneous seedling emergence in unfavorable conditions have been emphasized in this technology (Tavili and Saberi, 2010). Hydropriming (soaking in water) (Shakarami et al., 2011), osmopriming (soaking in osmotic solutions), halopriming (soaking in saline solutions) (Zkan Sivritepe et al., 2005), and seed priming with phytohormone (application of growth regulators) (Sytar et al., 2019) are some of the pre-treatment methods of seeds plant.

The seed germination percentage, germination rate, and seedling vigor can be increased in a wide range of environmental conditions (Tahmasebi et al., 2017). The plant hormones and growth regulators accelerate the metabolic interactions of the chain by affecting transcription factors (activating genes). These substances can also be effective in accelerating the synthesis of enzymes. Therefore, metabolic activation increases germination, elongates stem, produces flowers, and falls leaves or fruits (Mehdizadeh et al., 2012). Hormones are found in various derivatives, and specific effects depend on their biosynthesis process. The effect of substances, such as Indole-3-acetic acid (IAA), GA_3, Cytokinin, abscisic acid (ABA), and ethylene, depends on their proper composition or ratio in the solution (Illescas et al., 2021).

In some cases, the compounds including ABA, gibberellins (GA), and cytokinin have an antagonistic or synergic effect on growth (Saini et al., 2013). The indole-3- acetic acid group (auxins) accelerates the growth by affecting proton pumps in the membrane meristematic cell, which continuously generate organs and tissues and increase ATPase affinity. The affected protonation acidifies the apoplast space between cells, which opens up the building blocks of the cell wall, which is often made of pectin. In these conditions, the cell wall is elasticized for absorbing water and minerals and increasing cell turgidity, elongation and plant growth (Taiz et al., 2015).

More than 50 different forms of gibberellins have been identified so far, of which GA_3 is the most famous one, made in young leaves, root tips, and terminal buds and transported through the transpiration channels. Mierzwinska (1977) has suggested that gibberellic acid triggers a new synthesis of α-amylase, glucanase, ribonuclease, and protease enzymes. The synthesis of hydrolase, which is carried out by gibberellic acid results in the movement of necessary materials to stimulate and increase bud growth (Yan et al., 2017). Bhatt et al. (2005) showed that germination percentage was increased by using gibberellic acid treatment in *Swertia Angustifolia*, plants. Germination of this species under controlled conditions was below 32% and GA_3 had the best effect (96%) on germination.

Numerous studies have indicated that GA_3 increases germination in various plant species of *Ferula gummosa* (Nadjafi et al., 2006), *Achillea millefolium* (Shariati et al., 2002), and *Angelica glauca* (Butola and Badola, 2004). Moreover, the Indole-3-butyric acid (IBA) substance has long been considered a synthetic auxin. It has been shown that several types of this hormone are widely used in rooting cuttings and growing inappropriate roots in horticulture (Saini et al., 2013). Molecular studies have revealed that IBA β-oxidation releases Indole-3-acetic acid (IAA), and the IBA effect on early root growth is more significant than IAA effect (Bartel et al., 2001). Guney et al. (2017) recorded the maximum value of the morphologic traits through applied 1000 ppm IBA among hormone treatments of IAA, IBA, NAA, and GA_3 in *Lilium martagon* L. Also, the largest roots of *Lilium martagon* L. onion were obtained by using 3000 ppm of IBA plus 100 ppm of IAA (Sevik and Turhan, 2015).

The genus of *Allium* possesses more than 700 species scattered worldwide (Jafarian et al., 2006), among which more than 139 species have been observed In Iran, and 30 of them are native to this country. The most important species are the common onion, garlic, and scallion (Jafarian et al., 2006). All species of the *Alliaceae* family are rich in sulphur alkaloids and steroid saponins, which are beneficial to human health (Miri and Roughani, 2018). Scallion (*Allium fistulosum*) is a fragrant vegetable in traditional medicine for controlling colds, osteoarthritis, and headaches.

The seeds of the *Alliaceae* family lose their survival power faster than most crops, even under relatively favorable conditions (Padula et al., 2022). Weak seed yield is one of the vital factors in limiting the growth and production of scallion (Al Omrani Nejad and Rezvani Aqdam, 2013). It has been shown that numerous treatments of osmopriming and hydropriming have improved seed efficiency of welsh onion (*Allium fistulosum* L.) (Dong et al., 2014). Seed priming is a well-known method that increases seed vigor, germination, stress resistance, cell antioxidant activity, and plant productivity. This study aimed to investigate the effect of seed priming with IBA and GA_3 hormone treatments on germination and seed vigor indices in scallion seeds.

MATERIALS AND METHODS

An experiment was conducted in factorial arrangements based on the completely randomized design with three replications in the physiology laboratory of Khorasan Razavi Agricultural and Natural Resources Research and Education Center in 2019 to determine the germination indices of scallion seeds. The first factor was three concentrations of indole-3-butyric acid (IBA) including 0, 100, and 200 ppm prepared by Sigma Company, and the second factor was three concentrations of gibberellic acid (GA_3) including 0, 100, and 200 ppm purchased from Neogen Company.

The seeds (F1 generation) were provided from the natural resources and medicinal plants department of Khorasan Razavi agriculture research and education center with these specifications: final germination of 10 days, purity of 98%, and seed vigor of 90%. The seeds were disinfected with 3% sodium hypochlorite solution for 30 seconds, washed with distilled water, and disinfected with 0.2% benomyl fungicide solution for 30 seconds. About 0.2 g of gibberellin powder was first weighed and poured into the beaker to prepare a 200 ppm of GA_3 solution. Then, 10 ml of NaOH solution 1 normality (N) was added, and the resulting solution was placed on the shaker for 5 minutes. In the following step, 10 ml of 1 N HCl solution was added to neutralize the solution. Finally, 980 ml of distilled water was added to the solution. This solution was prepared for 200 ppm of gibberellin, and other solution treatments were prepared in the same way. A total of 100 seeds were prepared for each treatment, and petri dishes (90 mm diameter and 15 mm height) were disinfected. Whatman paper No. 1 was placed inside them, and 3 ml of the prepared hormone treatments were added. The seeds were arranged regularly inside petri dishes and placed in a germinator at 25 °C and 45% humidity. On the last day of germination, the number of germinated seeds, as well as the length and weight of the rootlets and seedlings were measured. The rootlets and seedlings were dissected two weeks after the experiment to measure rootlet and seedling dry weight. The prepared samples were inserted into an oven at 74 C for 48 hours, and then the traits of the samples were measured. The collected data were used to calculate the following indicators:

A) final germination percentage (FGP):

$$FGP = \left(\frac{n}{N}\right) * 100$$

where n is the number of germinated seeds and N is the total number of seeds.

B) determination of allometric coefficient (Aghaeipour et al., 2013):

$$AC = Wr/Ws$$

AC is the Allometric coefficient, Wr and Ws are rootlet and seedling dry weight, respectively.

C) seed vigor index (SVI) (Saeidi et al., 2014):

$$SVI = \left(FGP * (LR + LS)\right)/100$$

FGP: final germination percentage, LR: length of rootlet, LS: length of the seedling.

D) seedling vigor length index: SVLI (Nemathi Khoei et al., 2018):

$$SVLI = \left(\frac{SG}{100}\right) * LS$$

E) seedling vigor weight index: SVWI (Nemathi Khoei et al., 2018):

$$SVWI = \left(\frac{SG}{100}\right) * SDW$$

SG: standard germination, LS: length of seedling and SDW: seedling dry weight.

The analysis of variance was done by MINITAB ver. 13 software and MSTAT-C software. The diagrams were drawn with EXCEL and a comparison of means was also performed by using an LSD test at 1% probability level.

RESULTS AND DISCUSSION

Final Germination Percentage

The interaction effect of IBA and GA_3 on the final germination percentage (FGP) was significant ($P \leq 0.01$) (Table 1). The interactions of the treatments revealed that the maximum FGP (94.0%) was recorded by 200 ppm of GA_3 and 0 ppm of IBA, and the minimum FGP (66.6%) was obtained by 100 ppm IBA and 100 ppm GA_3 (Table 2). It has been reported that IBA often exhibits poor activity in the auxins biosynthesis (Woodward and Bartel, 2005). It has also shown that some amino acids and peptides or sugars are hydrolyzed and transferred to an active growth site by the presence of this substance (Bartel et al., 2001). Ansari et al. (2012) reported that FGP and GR were increased following the pre-treatment of rye seeds with GA_3 under stress conditions. These hormones had an antagonistic effect on activating biochemical reactions of germination in scallion plants. However, activating plant biosynthetic pathways depends on the availability of elements such as the release of phosphates in the emergence of plant organs. Various enzymes, including the phytase (a specific phosphatase enzyme), release phosphate from phytic acid (Senna et al., 2006). Sharma et al. (2004) reported that gibberellin increased acid phosphatase in the fetus and endosperm in sorghum.

Length of Rootlet and Seedling

Rootlet length was significantly affected by IBA and the interaction between IBA and GA_3 ($P \leq 0.01$) (Table 1). The maximum seedling length was at 0 ppm of IBA and 200 ppm of GA_3, and the minimum seedling length (0.920 cm) was at 0 ppm of GA_3 and 200 ppm of IBA (Table 2). The studies of Jemaa et al. (2011) showed that IBA significantly increased the number of root and stimulated the lateral roots in the *Arabidopsis* plants In addition, it has been reported that the slow release of IAA from the IBA hormone helps to stimulate the rooting mechanisms in the plant (Saini et al., 2013). In another study it was found that the use of IBA had a most significant effect on the formation of adventitious roots in the cuttings of mung bean (V*igna radiate* L.), and it has been shown that this substance was much higher at the upper part of the plant cutting (Nag et al., 2013). Increasing the activity of this substance was not due to different synthesis or transport pathways unless the better source of free auxin (Saini et al., 2013). Yamazaki et al. (2015) indicated that the number of tillers increased using 40 ppm of GA_3 in the scallion plant and stated that GA_3 prolonged the longitudinal development of plant cells by elongating microtubules along cell axes. Therefore, the effect of GA_3 was weak in regions with transverse microtubules. Hence, the above-mentioned mechanism is supposed to be one of the reasons for the effect of GA_3 on increasing seedling length.

Rootlet Fresh and Dry Weight

The analysis of variance showed that IBA and IBA×GA_3 interaction significantly ($P \leq 0.01$) affected the rootlet fresh and dry weight, but different amounts of GA_3 did not have a significant ($P \leq 0.01$) effect on them (Table 1). The results of the interaction of IBA×GA_3 showed that the maximum rootlet fresh (70.5 mg) and dry weight (7.02 mg) values were at 100 ppm of GA_3 and IBA (Table 2 and Fig. 1). Guney et al. (2017) showed that the maximum root length was obtained at 3000 ppm of IBA, and the maximum stem diameter was achieved at 5000 ppm of IBA in the lily (*Lilium martagon* L.) plant. In many plants has been shown that the external application of GA_3 has little effect on root growth (Tanimoto, 2002). Compared to the IAA hormone, IBA has little ability to blend into the composition and slowly release into the environment to prevent oxidation (Woodward and Bartel, 2005). Therefore, the increase in root production enhancement in the presence of IBA can be attributed to persistence in the environment and the activation of root metabolism production (Tanimoto, 2005).

Seedling Fresh and Dry Weight

There was a significant difference in the fresh and dry weight of seedlings in the application of all treatments (Table 1). The interaction of treatments demonstrates that all GA_3 concentrations had the maximum seedling fresh weight at 0 IBA without a significant difference between them. The minimum seedling fresh weight was recorded at 100 and 200 ppm of GA_3 and 200 ppm of IBA (Table 2). The maximum seedling dry weight (7.39 mg) was at 100 ppm of IBA and 100 ppm of GA_3, and the minimum value of this trait (3.76 mg) was at 100 ppm of GA_3 and 200 ppm of IBA (Fig. 1). According to the findings, alpha-amylase increases when rice seeds are soaked in a solution containing GA_3 under salinity stress, increasing the total soluble sugar of the seed

(Mierzwinska, 1977). However, another research represented that the α-amylase activity was higher in soaking seeds using IAA than GA_3 (Kim et al., 2006). GA_3 biosynthesis was a reinforcement in the presence of IAA in chickpea seedlings. It has been shown that the ineffectiveness of IBA in increasing the seedling's fresh and dry weight is the disturbance of hormonal balance in the biosynthesis of necessary substances (Saini et al., 2013). Guangwu and Xuwen (2014) suggested that exogenously applied GA3 increases the indigenous GA_3 concentration and enhances the germination biosynthesis activity in seeds in *Pinus massoniana*.

Table 1. Analysis of variance (mean squares) for the germination characteristics affected by IBA and GA_3 hormones in scallion seeds

S.O.V	df	FGP	LR	LS	FWR	FWS	DWR	DWS	AC	SVI	SVLI	SVWI
IBA	2	1178^{**}	0.031^{**}	0.440^{**}	680^{**}	1484^{**}	15.8^{**}	1.76^{**}	0.305^{**}	1.76^{**}	0.129^{**}	7.14^{**}
GA_3	2	36.1^{ns}	0.007^{ns}	0.120^{*}	14.1^{ns}	370^{**}	0.387^{ns}	0.226^{*}	0.112^{**}	0.226^{*}	0.018^{*}	2.60^{ns}
IBA×GA_3	4	34.2^{**}	0.087^{**}	0.043^{**}	441^{**}	236^{**}	2.33^{**}	0.113^{**}	0.094^{**}	0.103^{**}	0.003^{**}	2.62^{**}
Error	18	17.7	0.002	0.024	15.5	24.3	0.404	0.042	0.010	0.042	0.003	0.593
CV		7.85	9.25	11.5	10.5	6.54	7.44	9.04	4.01	3.22	5.08	4.55

FGP: final germination percentage, LR: length of rootlet, LS: length of shoot, FWR: fresh weight of rootlet, FWS: fresh weight of shoot, DWR: dry weight of rootlet, DWS: dry weight of shoot, AC: allometric coefficient, SVI: seedling vigor index, SVLI: seedling vigor length Index, SVWI: seedling vigor weight index.

ns, * and ** refer to non-significant and significant at 5% and 1% probability level, respectively.

Table 2. Mean comparison for the effect of IBA and GA_3 on germination indices in scallion seeds

Treatment	FGP (%)	LR (cm)	LS (cm)	FWR (mg)	FWS (mg)	DWR (mg)	DWS (mg)	AC (Coefficient)	SVI Index	SVLI Index	SVWI (Index)
IBA1	92.2^{a}	0.748^{a}	1.47^{a}	41.0^{b}	76.9^{a}	4.21^{b}	6.25^{ab}	0.675^{c}	2.05^{a}	0.692^{a}	5.80^{a}
IBA2	75.5^{b}	0.712^{a}	1.1^{5b}	45.5^{b}	69.6^{b}	4.51^{b}	6.50^{a}	1.04^{a}	1.31^{b}	0.501^{b}	4.58^{b}
IBA3	70.0^{b}	0.633^{b}	1.05^{b}	58.0^{a}	51.9^{c}	6.65^{a}	5.4^{5b}	0.868^{b}	1.26^{b}	0.471^{b}	4.06^{b}
$GA_3$1	77.3^{a}	0.666^{a}	1.09^{b}	46.5^{a}	72.9^{a}	4.05^{a}	6.64^{a}	0.737^{b}	1.36^{b}	0.509^{b}	5.13^{a}
$GA_3$2	79.1^{a}	0.705^{a}	1.29^{a}	48.8^{a}	65.3^{b}	4.96^{a}	5.40^{b}	0.953^{a}	1.60^{ab}	0.559^{ab}	4.19^{a}
$GA_3$3	81.3^{a}	0.722^{a}	1.30^{a}	49.1^{a}	60.2^{b}	6.35^{a}	6.18^{ab}	0.896^{a}	1.67^{a}	0.596^{a}	5.11^{a}

continued Table 2.

Treatment		FGP (%)	LR (cm)	LS (cm)	FWR (mg)	FWS (mg)
IBA1	$GA_3$1	90.3^{ab}	0.573^{bc}	1.26^{abc}	38.4^{c}	74.2^{ab}
	$GA_3$2	92.3^{a}	0.823^{a}	1.54^{ab}	40.7^{c}	78.1^{a}
	$GA_3$3	94.0^{a}	0.850^{a}	1.62^{a}	56.0^{b}	78.3^{a}
IBA2	$GA_3$1	71.6^{c}	0.623^{bc}	1.10^{bc}	61.1^{ab}	75.7^{ab}
	$GA_3$2	66.6^{c}	0.820^{a}	1.27^{abc}	70.5^{a}	71.6^{ab}
	$GA_3$3	73.3^{c}	0.693^{ab}	1.06^{bc}	43.0^{c}	61.5^{b}
IBA3	$GA_3$1	70.0^{c}	0.803^{a}	0.920^{c}	39.8^{c}	68.8^{ab}
	$GA_3$2	78.3^{bc}	0.473^{c}	1.05^{bc}	41.6^{c}	46.1^{c}
	$GA_3$3	76.6^{bc}	0.623^{bc}	1.18^{abc}	42.4^{c}	40.8^{c}

IBA1: 0 ppm, IBA2: 100 ppm, IBA3: 200 ppm, $GA_3$1, 0 ppm, $GA_3$2: 100 ppm, $GA_3$3: 200 ppm.

FGP: final germination percentage, LR: length of rootlet, LS: length of shoot, FWR: fresh weight of rootlet, FWS: fresh weight of shoot, DWR: dry weight of rootlet, DWS: dry weight of shoot, AC: allometric coefficient, SVI: seedling vigor index, SVLI: seedling vigor length Index, SVWI: seedling vigor weight index.

Means with same alphabet letter didn't have significant different at 1% probability level.

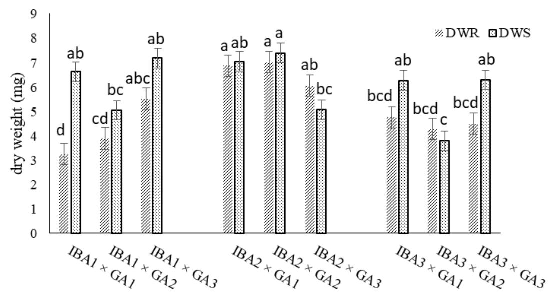

Fig. 1. Means of the interaction effect of IBA and GA_3 on the dry weight of rootlet (DWR) and shoot (DWS) of scallion seedlings. IBA1: 0 ppm, IBA2: 100 ppm, IBA3: 200 ppm, $GA_3$1: 0 ppm, $GA_3$2: 100 ppm, $GA_3$3: 200 ppm. DWR: Dry Weight of Rootlet, DWS: Dry Weight of Shoot.

Allometric Coefficient (AC)

The hormonal treatments (IBA, GA_3, and IBA×GA_3) significantly affected the allometric coefficient (AC) (Table 1). The results of the IBA×GA_3 interaction showed that the maximum AC was achieved using 200 ppm of GA_3 and 100 ppm of IBA (Fig. 2A), signifying a balanced growth ratio between the shoot and the rootlet in these concentrations of tested hormones. Therefore, the allometric model can help estimate plant growth status. It has been shown that the growth of any plant species' root and shoot is regulated by genetics and the environment, where different conditions are involved (Enquist and Niklas, 2002). Robinson et al. (2010) suggested an exponential equation between root and shoot in two *Dactylis glomerata* and *Plantago lanceolate* species.

Seed Vigor Index (SVI)

The effect of GA_3, IBA, and GA_3×IBA interaction was significantly different on SVI (Table 1). The interaction effect showed that using 200 ppm of GA_3 at 0 ppm of IBA reached the maximum SVI index (Fig. 2B). The number of seedlings at the beginning of the growing season determined plant density, and the low SVI index indicated that the green seedlings are weak and affect the optimum plant density as Fazeli Kakhki et al., 2014 have shown. Khalesro and Aghaalikhani (2007) expressed that SVI index in sorghum control seeds was 80.34, which decreased with increasing stress severity (salinity and drought stress).

Seedling Vigor Length Index (SVLI) and Seedling Vigor Weight Index (SVWI)

Analysis of variance showed that SVLI was affected by IBA, GA_3, and IBA×GA_3 treatments (Table 1). Results of interaction effects showed that the SVLI index was increased at 0 ppm of IBA and adding 100 and 200 ppm GA_3 (Fig. 2C). However, the maximum SVLI was recorded at 200 ppm of GA_3 and 0 ppm of IBA (0.799) (Fig. 2C).

The seedling vigor weight index (SVWI) was affected by IBA and IBA×GA_3 interaction, and GA_3 did not significant affect in this index (Table 1). The maximum SVWI index (5.80) was recorded at 0 ppm of IBA, which decreased with increasing the concentration of IBA up to 100 and 200 ppm (Table 2). However, statistically this value for the 0 ppm of IBA treatment was not significantly different form the values of GA_1, GA_2 and GA_3 treatments. The interaction effect (IBA×GA_3) showed that the amount of SVWI index had different trends, however, the maximum of SVWI index (6.77) was found at IBA1×GA_3 treatment and the minimum of this trait was recorded at IBA3×$GA_3$2 (Fig. 2D). Azad et al. (2017) observed the maximum SVLI (67.70) in the control treatment (0 salinity level) using 40 ml of humic acid in the hibiscus tea plant (*Hibiscus sabdariffa*), which decreased by increasing stress. In the same experiment, the maximum SVWI was recorded from the interaction of 0 salinity level, jasmonic acid (0 mM), and 40 mM of humic acid, and the minimum SVWI was obtained at 210 mM of salt and 0 mM jasmonic acid and humic acid. IBA hormone is produced during β-oxidation in peroxisomes as one of the natural auxins found in the most plants, synthesized from IAA. Therefore, these two substances can be converted under certain conditions. β-oxidation of lipids stored in peroxisomes in seeds, especially in oilseed rape, can provide energy during germination. In the case of any defect in the production of IBA and β-oxidation of long chains of fatty acids, the required energy is obtained from the breakdown of sugar molecules. Therefore, the root growth decreases in plants, lacking the gene for producing this hormone (Woodward and Bartel, 2005). It seems that, the SVLI and SVWI indices are not affected by IBA higher levels due to sufficient reserves of IBA hormone in scallion plant.

CONCLUSIONS

This study indicated that germination indices in scallion seed positively reacted using gibberellin levels, but the most germination traits decreased with increasing IBA concentrations from 0 to 100 and 200 ppm. The interaction between the two hormones showed that all germination indices increased using 200 ppm of GA_3 and 0 ppm of IBA. The maximum SVLI and SVWI were obtained at 200 ppm of GA_3 and 0 ppm of IBA.

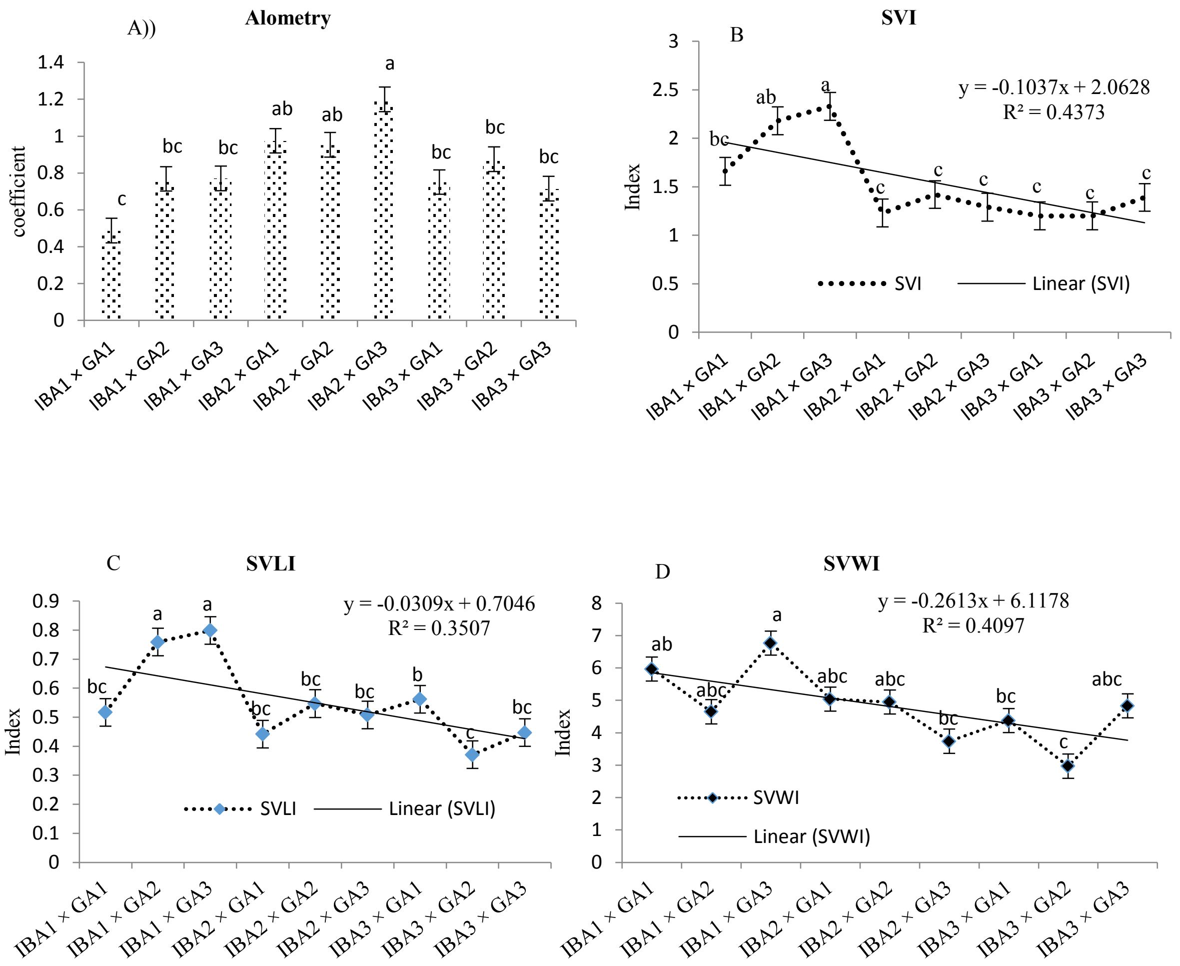

Fig. 2. Means of interaction effect of IBA and GA_3 on allometric coefficient (A), seedling vigor index (SVI, B), seedling vigor length index (SVLI, C) and seedling vigor weight index (SVWI, D) of scallion seedlings. IBA1: 0 ppm, IBA2: 100 ppm, IBA3: 200 ppm, $GA_3$1: 0 ppm, $GA_3$2: 100 ppm, $GA_3$3: 200 ppm.

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اثر جیبرلین و ایندول-۳- بوتیریک اسید بر مؤلفه‌های جوانه‌زنی و بنیه بذرهای پیازچه (*Allium fistulosum* L.)

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چکیده - پیازچه (*Allium fistulosum*) یکی از سبزی‌های خوراکی ضروری با مصارف دارویی مختلف است. بذرهای این گیاه قدرت جوانه‌زنی پایینی داشته که ممکن است به دلیل شرایط انبار، از بین بروند. در این مطالعه در سال ۱۳۹۸، خصوصیات جوانه‌زنی بذرهای پیازچه به صورت فاکتوریل در قالب طرح کاملاً تصادفی در سه تکرار در آزمایشگاه فیزیولوژی مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی خراسان رضوی مورد آزمایش قرار گرفت. فاکتور اول ایندول-۳-بوتیریک اسید (IBA) در غلظت‌های صفر (یا شاهد)، ۱۰۰ و ۲۰۰ پی‌پی‌ام و فاکتور دوم جیبرلین (GA_3) در سه غلظت مذکور بود. نتایج نشان داد که بیش‌ترین درصد جوانه‌زنی از غلظت ۲۰۰ پی‌پی‌ام جیبرلین بدون استفاده از هورمون IBA حاصل شد. در استفاده از غلظت ۱۰۰ پی‌پی‌ام هر دو هورمون بکار برده شده، بیش‌ترین وزن خشک ریشه‌چه (۷/۰۲ میلی‌گرم) ثبت شد. با استفاده از غلظت‌های ۱۰۰ پی‌پی‌ام IBA و ۲۰۰ پی‌پی‌ام GA_3 بیش‌ترین مقدار ضریب آلومتری حاصل شد. بیش‌ترین شاخص بنیه بذر (به ترتیب ۲/۱۸ و ۲/۳۳)در ۱۰۰ و ۲۰۰ پی‌پی‌ام GA_3 همراه با صفر پی‌پی‌ام IBA مشاهده شد. بیش‌ترین شاخص طولی (۰/۷۹۹) و وزنی (۶/۷۷) بنیه گیاهچه زمانی حاصل شد که ۲۰۰ پی‌پی‌ام GA_3 به‌کار برده شد و از IBA استفاده نشد. به طور کلی نتایج نشان داد که استفاده از غلظت‌های مختلف جیبرلین تاثیر معنی‌داری بر افزایش جوانه‌زنی و شاخص بنیه بذرهای پیازچه دارد.