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Effect of Deteriorated Seed Soaking with Different Concentrations of Gibberellin (GA_3) on Germination and Seedling Growth of Two Oat (*Avena sativa* L.) Cultivars

ABSTRACT

A factorial experiment with two factors was carried out at the Seed Technology Lab., College of Agriculture, University of Baghdad in 2018 in order to study the effect of seed priming with gibberellic acid (GA_3) (0, 100, 300 and 500 mgL^{-1}) on germination and seedling growth of deteriorated seed of two oat cultivars (Shifaa, and Shofan11). The complete randomized design was used with four replications. The results showed that cultivars, soaking in different concentrations of GA_3 and their interactions had a significant effect on studied traits. Shofan11, GA_3 (500 mg L^{-1}) and their interaction gave the highest values of germination ratio (74.1, 85 and 85%), lengths of radical (7, 8.5 and 8.6 cm) and plumule (9.3, 10.8 and 10.9 cm), fresh (71.95, 74.74 and 74.76 mg) and dry (18.41, 23.14 and 25.07 mg) weights of seedling and seedling vigour index (1270.2, 1644 and 1655.5), respectively. It can be concluded that soaking of deteriorated seed with GA_3 led to increasing germination ratio and improved seedling growth in oat.

INTRODUCTION:

Oat has many uses such as crushed grain for the human nutrition, preparation of some children's foods and making some types of biscuits to facilitate the benefit of grain components which has high nutritional value and its flour containing many antioxidants (Ahmad et al., 2014). The grain of oat can use as concentrated forage to the animals, the hay or straw is used in animals feeding for its high feed value, it can provide as green fodder or direct grazing, and it can be planted in intercropping with many leguminous crops such as clover and alfalfa, etc., and used as green fodder or made in the form of silage (Ahmad et al., 2014). Oat uses in the industry of painting and packaging paper (Yakoob and Nimer, 2011). Some estimations of oat crop were83 and 9433141 ha for the total harvested area, 2.169 and 2.4437 ton ha^{-1} for yield, and 180 and 22,917,808 tons for productivity in Iraq and world, respectively (FAO, 2016).Iraq is at the bottom of the countries list which planting the oat crop. Iraq ranked in 74 out of 78 countries (FAO, 2016) as a result of its limited areas cultivation, as well as the lack of studies and research due to the lack of focus on the importance, weak guidance of the relevant agricultural institutions and this crop didn't enter into programs to provide feed or nutrition besides the barley crop, which led to the abstention of farmers to grow and deprive Iraq of an important economic resource.

Six common genotypes of oat were studied in Western Canada (AC Mustang, CDC Bell, CDC Pacer, OT 288, Riel and Triple Crown). The highest mean of germination time was related with CDC Bell (6.9 days), while AC Mustang gave the highest final germination ratio (98%) (Willenborg, 2005).Five genotypes of oat were studied (Mozart, CROA 60, Detvan, Eva 1 and AC Belmont) and

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the highest germination ratio was belonged to the genotypes of CROA 60 (97.8%), Eva 1 (97.6%) and AC Belmont (97.6%), while, AC Belmont genotype gave the longest radical (3.5 cm) and plumule (1.5 cm) lengths (Mut and Akay, 2010).A total of 55 oat genotypes were collected from Europe, North and South America, Asia and Oceania, and the highest germination ratio was for Evita genotype (88.6%) followed by Flämingsplus, Pajaz, Iltis, Lvovskii Ranni, Marta, Auteuil and Samsun (83.5, 83.4, 83.3, 82.7, 82.1, 82 and 80.8%), respectively, and the highest lengths of radicle (5.5 cm) and plumule (2.4 cm) belonged to the Centennial genotype (Mut et al., 2010).

The bread wheat seed were stimulated by soaking in GA_3 (0.5 mg L^{-1} for 6 hours) to improve the vitality and vigour of the deteriorated seed and their embryos, which positively affected the callus induction (Hamza et al., 2013). Maize seed soaking in GA_3 (300 mg L^{-1} for 24 hours) resulted in an increase of standard germination ratio at the first and final counts, the speed and mean of germination time at standard germination, radicle and plumule lengths and fresh and dry weights of seedling (50.2%, 88.4%, 19.2seedlingday^{-1},4.7day, 16.8 cm, 16.0 cm, 1041.1 mg, 97.5 mg), respectively, (Mohammed and Rasheed, 2016).Also, soaking of maize seed in GA_3 (300 ppm for 24 hours) gave the fastest initiation of germination (2.5 and 3.7 day), the ratio of sodium to potassium with the lowest mean (0.4 and 0.42%), the highest germination ratio at the first (67.6 and 46.8%) and final (73.6 and 70.8%) count, the highest chlorophyll content (45.1 and 36.7 SPAD), the best values for the last day of emergence (4.7 and 5.4 day), emergence ratio (88 and 84.7%), emergence rate index (30.5 and 27.2 % day^{-1}), seedling length (13.7 and 10.5 cm) and seedling dry weight (0.0383 and 0.0432 mg) in both autumn and spring seasons (Hamza, Ali, 2014 and 2017a,b).The produced sorghum seed from plants that their planted seed were soaked in GA_3 (300 mg L^{-1}) before planting were significantly exceeded when gave the highest germination ratio (30.7 and 35.9%) at cold test during fall and spring seasons (Cheyed and Jaddoa, 2013).The soaked sorghum seed in GA_3 (600 mg L^{-1}) gave the highest germination rate (63.6%), final germination ratio (83%), lengths of radical (2.69 cm) and plumule (11.65 cm), seedling dry weight (151 mg) and seedling vigour index (1204) in comparison with other chemical solutions that used (Jaddoa and Najem, 2017).Seed germination is one of the basic and vital stages in the plant life cycle, which determines the field establishment and crop production. The crop production influence by the nature of the genetic structure and seed soaking in activated substances, so this study aimed to activate the deteriorated seed with GA_3 to improve germination and seedling vigour in two oat cultivars.

MATERIALS AND METHODS:

A factorial experiment was conducted with two factors in the Seed Technology Laboratory, College of Agriculture, University of Baghdad in 2018 in order to study the effect of seed priming with GA_3 (0, 100, 300 and 500 mg L^{-1}) on germination and seedling growth of deteriorated seed of two oat cultivars (Shifaa and Shofan11). Complete randomized design with four replications was used. The initial concentration of GA_3 ($C_{19}H_{22}O_6$) was prepared by dissolving 1 g of GA_3 in one liter of distilled water to obtain 1000 mg L^{-1} of GA_3 solution. Then the dilutions done according to the required concentrations by dilution calculator equation: C1V1 = C2V2; whereas C1 = Initial concentration of solution, V1 = Initial volume of solution, C2 = Final concentration of solution, and V2 = Final volume of solution. Therefore, 100, 300 and 500 ml of stock solution of GA_3 (1000 mg L^{-1}) added to 900, 700 and 500 ml of distilled water to prepare the required concentrations. The seed of Oat cultivars that used in this study were old and deteriorated already, because of it didn't store under optimum conditions. Seed were soaked for 12 h in each concentration of GA_3 and then dried to safe moisture content (13.5%) by natural air drying and then sterilized by immersing in 1% sodium hypochlorite solution for 2 minutes and then washed with distilled water after planting. Studied traits were as follows:

- Germination ratio (%): 25 pure seed per experimental unit were planted in paper towels in the roll method after being soaked for 12 h with the required concentrations of GA_3 and with distilled water for control treatment. Seed were placed vertically in the germinator at 20 °C ±2, 80% ±2 and 8 h lighting in accordance with the procedures and recommendations of ISTA (ISTA, 2013).

The normal seedlings were calculated only after the end of the test period (14 days) and the results were converted as a ratio.

- Lengths of the radical and plumule (cm) and seedling fresh and dry weight (mg): 10 normal seedlings were taken at the end of germination test, and then lengths of radical and plumule each separately were measured using a ruler. Then fresh weight had been taken directly and dry seedling was weighted after placing it in a paper bag perforated at 80 °C for 24 hours (Hampton and Tekrony, 1995).
- Seedling vigour index: It calculated according to the equation of Abdul-Baki and Anderson (1973): Seedling vigour index =germination ratio (radical length + plumule length).

Statistical analysis of the data was performed according to the variance analysis, and the means were compared using the test of least significant difference (LSD) at P≤0.05 (Steel and Torrie, 1980).

RESULTS:

Germination ratio at final count (%)

Table 1 showed the supremacy of Shofan11 cultivar, treatment soaking of oat seed with GA_3 (500 mg L^{-1}) and their interaction (Shofan11×500) which gave the highest germination ratio (74.1, 85, and 85%), respectively. There wasn't significant difference between soaking treatment of 300 and 500 mg L^{-1}, and between Shofan11×500, Shifaa×500 and Shofan11×300. The treatments of control and Shifaa×control gave the lowest ratio (44 and 46%), respectively.

Table 1. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on germination ratio at final count (%) in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	44	78.5	82.8	85	72.6
Shofan11	48	80	83.5	85	74.1
LSD 5%	2.04				1.02
Mean	46	79.2	83.1	85	
LSD 5%	1.44				

Radicle length (cm):

Table 2 showed significant differences between cultivars, among soaking in different concentrations of GA_3 and their interaction on radicle length.Sofan11 cultivar was significantly superior to Shifaa cultivar in radicle length (7 and 5.9 cm), respectively. The treatment of soaking oat seed with GA_3 (500 mg L^{-1}) was surpassed significantly the remainder treatments and gave the highest radicle length (8.5 cm), while the control treatment gave the lowest radical length (3 cm). The treatment of the interaction between Shofan11 cultivar and soaking seed with GA_3 (500 mg L^{-1}) was superior to give the highest radical length (8.6 cm), which did not differ significantly with the treatments of Shifaa×500 and Shofan11×300 (8.5 and 8.2 cm), respectively, while the interaction treatment between Shifaa×control gave the lowest radical length (2.9 cm).

Table 2. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on radicle length (cm) in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	2.9	4.4	7.8	8.5	5.9
Shofan11	3.2	7.8	8.2	8.6	7
LSD 5%	0.5				0.3
Mean	3	6.1	8	8.5	
LSD 5%	0.4				

Plumule length (cm):

There was a significant difference between cultivars, soaking in different concentrations of GA_3 and their interaction on the plumule length. Table 3 showed that Shofan11 recorded the highest value (9.3 cm) in comparison with Shifaa (8 cm). Plumule length impacted significantly by soaking seed in 500 mg $L^{-1}$of GA_3 and surpassed remainder treatments significantly when gave the highest value (10.8 cm), while the lowest value belonged to control (5.2 cm). Interaction between Shofan11 and 500 mg L^{-1} ofGA_3 was superior when gave the highest plumule length (10.9 cm), and didn't differ significantly with Shifaa×500, Shofan11×300 and Shofan11×100 (10.8, 10.7 and 10.1 cm), respectively, while the lowest plumule length recorded in Shifaa×control (5 cm).

Table 3. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on plumule length (cm) in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	5	6.5	9.6	10.8	8
Shofan11	5.4	10.1	10.7	10.9	9.3
LSD 5%	0.9				0.4
Mean	5.2	8.3	10.1	10.8	
LSD 5%	0.6				

Seedling fresh weight (mg):

A significant effect for cultivars, soaking in different concentrations of GA_3 and their interaction were found in the seedling fresh weight (Table 4). Shofan11 gave higher seedling fresh weight (71.95 mg) than Shifaa (66.43 mg). Soaking seed in GA_3 (500 mg L^{-1}) hadn't significant difference with 100 and 300 mg L^{-1}, except control treatment and the highest and lowest seedling fresh weight were 74.74 and 60 mg. Interaction between Shofan11×500 hadn't significant difference with other interactions, except shifaa×control and their highest and lowest seedling fresh weight were 74.76 and 51.57 mg (Table 4).

Table 4. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on seedling fresh weight (mg) in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	51.57	68.49	70.95	74.73	66.43
Shofan11	68.43	70.49	74.11	74.76	71.95
LSD 5%	7.84				3.92
Mean	60	69.49	72.53	74.74	
LSD 5%	5.55				

Seedling dry weight (mg):

Cultivars, soaking in different concentrations of GA_3 and their interaction had significant difference on the seedling dry weight (Table 5). Shofan11 gave 18.41 mg for seedling dry weight and surpassed Shifaa significantly which gave 15.44 mg. GA_3 (500 mg L^{-1}) gave the highest mean (23.14 mg) for seedling dry weight and surpassed remainder treatments significantly, while the lowest seedling dry weight belonged to control (10.99 mg). The interaction of Shofan11× GA_3 (500 mg L^{-1}) gave higher mean than other interactions (25.07 mg) without difference significantly with Shofan11×500 (24.65 mg), while Shifaa×control gave the lowest seedling dry weight (10.68 mg) (Table 5).

Table 5. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on seedling dry weight (mg) in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	10.68	12.16	17.51	21.22	15.44
Shofan11	11.11	12.81	24.65	25.07	18.41
LSD 5%	1.56				0.78
Mean	10.99	12.48	21.08	23.14	
LSD 5%	1.1				

Seedling vigour index:

Table 6 showed the significant effect of cultivars, soaking in different concentrations of GA_3 and their interaction on the seedling vigour index.Shofan11 cultivar was significantly superior to Shifaa cultivar in seedling vigour index (1270.2 and 1067.2), respectively. The treatment of soaking oat seed with GA_3 (500 mg L^{-1}) was significantly superior the remainder treatments and gave the highest seedling vigour index (1644), while the control treatment gave the lowest seedling vigour index (378.5). The treatment of the interaction between the Shofan11 cultivar and soaking seed with GA_3 (500 mg L^{-1}) was superior to give the highest seedling vigour index (1655.5), which did not differ significantly with the treatments of Shifaa×500 and Shofan11×300 (1632.4 and 1579), respectively, while the interaction treatment between Shifaa×control gave the lowest seedling vigour index (347.8).

Table 6. Effect of seed soaking with GA_3 (mg L^{-1}) and cultivar on seedling vigour index in oat

Oat cultivars	Soaking seed with GA_3 concentrations (mg L^{-1})				Mean
	Control	100	300	500	
Shifaa	347.8	854.5	1434.1	1632.4	1067.2
Shofan11	409.2	1437	1579	1655.5	1270.2
LSD 5%	119.3				59.7
Mean	378.5	1145.7	1506.5	1644	
LSD 5%	84.4				

DISCUSSION:

The results showed the superiority of Shofan11, GA_3 (500 mg L^{-1}) and their interaction in all studied traits. The superiority in lengths of radical and plumule (Tables 2 and 3) were due to the pre-superiority of germination ratio (Table 1). In addition, the superiority in seedling fresh and dry weight, as well as seedling vigour index (Tables 4, 5 and 6) maybe due to the pre-superiority in traits of germination ratio and lengths of radical and plumule (Tables 1, 2 and 3). This indicates the effective effect of genetic on variance in germination ratio and seedling growth properties, reflecting the inherent energy or potential of the seed according to their genetic. This is in line with the findings of Willenborg (2005), Mut, Akay (2010) and Mut (2010) who found significant differences in germination ratio, germination speed and seedling growth between a number of oat genotypes.

Seed soaking in different concentrations of GA_3 had a clear effect on germination ratio and seedling growth properties. The greatest proportion of variance in the studied traits was due to the effect of GA_3 compared to the effect of cultivars. This may be due to the role of GA_3 in the stimulation of oat seed and improve the vitality and vigour of the seed, resulting in increased germination ratio, lengths of radical and plumule, seedling fresh and dry weight and seedling vigour index compared to soaking seed in distilled water only. The role of GA_3 can indicated by its effect in activation of hydrolysis enzymes, especially α-amylase, embryo feed acceleration and increase germination ratio. GA_3 contributes on activation of division operations, elongation that cause increasing embryo axis length and reflect that on increasing of protein and carbohydrate formation in embryo parts, which lead to increase fresh and dry weight. This is in line with what mentioned by Hamza et al. (2013),

Cheyed and Jaddoa (2013), Hamza and Ali (2014), Mohammed and Rasheed (2016), Hamza and Ali (2017a,b), Jaddoa and Najem (2017).Most physiological activities and plant growth are regulated by plant hormones such as gibberellin. The external addition of gibberellin affects the transfer of cytokines during the membranes, which have an important role in the occurrence of biochemical processes that necessary for germination. The role of gibberellins is decomposition the stored main materials in seed, such as lipids, proteins and carbohydrates, to micromaterials and then transferred to embryo to provide a source of energy and growth. The genes ofα-amylase, β-amylase, protease and other hydrolysis enzymes are inhibited before seed germination. In the early germination phase, the embryo produces an effective factor (gibberellin), which is transferred to the aleurone cells to activate the genes controlling the synthesis of enzymes, which lead to producing energy and necessary proteins to format new cellular components. This is in line with what mentioned by Lovegrove and Hooley (2000), Richards et al. (2001), Subedi and Bhattarai (2003), Chen et al. (2008) and Villasuso et al. (2008).

Genetic variance had a role on cultivars response to GA_3 that reflected on the studied traits. The interaction between cultivars and soaking seed with different concentrations of GA_3 has a clear role in improving the germination ratio and seedling growth properties of deteriorated seed. This difference evident in performance of two cultivars according to soaking their seed in GA_3 indicated difference in seed response of Shofan11 and Shifaa to seed soaking in GA_3. In addition to confirm the role of GA_3 in stimulating of deteriorated seed and increase germination ratio and improve seedling growth through its catalytic and regulatory role of hydrolysis enzymes and formation of new proteins that contribute to embryo growth and increase germination ratio and seedling growth, especially for the deteriorated seed.

CONCLUSIONS:

It can be concluded that seed soaking with GA_3 increases the germination ratio and improves seedling growth of deteriorated seed of oats cultivars, as well as seed may be responding to concentrations higher than 500 mg L^{-1} of GA^3. It can be recommended soaking deteriorated oat seed with GA_3 (500 mg L^{-1}) before planting, as well as higher concentrations of GA_3 than 500 mg $L^{-1}$are recommended to investigate.

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تأثير نقع البذور المتدهورة بتراكيز مختلفة من الجبرلين (GA_3) في انبات ونمو بادرات صنفين من الشوفان (*Avena sativa* L.)

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المستخلص

نفذت تجربة عاملية بعاملين في مختبر تكنولوجيا البذور – كلية الزراعة – جامعة بغداد في العام 2018 لمعرفة تأثير تنشيط البذور بحامض الجبرليك (GA_3) (0 و 100 و 300 و 500 ملغم لتر$^{-1}$) في الإنبات ونمو البادرة للبذور المتدهورة لصنفين من الشوفان (شفاء وشوفان11). أستعمل تصميم تام التعشية (CRD) بأربعة تكرارات. أظهرت النتائج ان الاصناف والنقع بتراكيز مختلفة من حامض الجبرليك والتداخل بينهما كان له تأثير معنوي في صفات الدراسة. وقد اعطى شوفان11 و GA_3 (500 ملغم لتر$^{-1}$) والتداخل بينهما اعلى القيم في كل من نسبة الانبات (74.1 و 85 و85%) وطولي الجذير (7 و 8.5 و 8.6 سم) والرويشة (9.3 و 10.8 و 10.9 سم) والوزنين الرطب (71.95 و 74.74 و 74.76 ملغم) والجاف (18.41 و 23.14 و 25.07 ملغم) ودليل قوة البادرة (1270.2 و 1644 و 1655.5) على التتابع. ويمكن الاستنتاج ان نقع البذور المتدهورة بحامض الجبرليك يمكن ان يزيد من نسبة الانبات ويحسن من نمو البادرة في الشوفان.

الكلمات المفتاحية: حامض الجبرليك ، الرويشة ، الجذير ، البادرة ، قوة البذور.