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Hormonal Priming Improves Seed Quality Parameters in Sunflower

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Abstract

The experiment was conducted during June–July 2021 at Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP), to determine the effect of priming sunflower seeds at varying GA_3 concentrations on the seed quality parameters. The sunflower seeds were subjected to different seed priming treatments with GA_3. There were ten treatments with eight concentrations of GA_3 @ 25, 50, 75, 100, 125, 150, 175, and 200 ppm and one of hydropriming, both for a duration of 12 hours along with control. From the study, it was observed that among all the treatments, treatment in which the seeds were primed with GA_3 @100 ppm significantly enhanced the seed germination (92.50%), speed of germination (56.54), seedling length (28.20 cm), seedling fresh weight (582.20 mg), seedling dry weight (28.96 mg), SVI-I (2607.72), SVI-II (2678.51), oil content (43.99%) and resulted in the lowest EC (299.00 µS m^{-1}). Whereas, minimum values for seed germination (76.75%), speed of germination (36.90), seedling length (22.94 cm), seedling fresh weight (445.48 mg), seedling dry weight (26.26 mg), SVI-I (1760.00), SVI-II (2014.77) and oil content (41.83%) as well as maximum seed electrical conductivity (444.75 µS m^{-1}) was recorded in non-primed seeds (control). Consequently, it was concluded that seed primed with GA_3 @ 100 ppm for 12 hours performed foremost amid all the treatments tested for seed quality parameters.

Keywords: GA_3, *Helianthus annuus*, oil content, quality parameters, seed priming

1. Introduction

Sunflower (*Helianthus annuus*) is an oilseed crop belonging to the family Asteraceae and is indigenous to North America. Sunflower is one of the three main oilseed crops grown in the world today, next to soybean and rapeseed (Pal et al., 2015). Sunflower seeds are naturally high in linoleic acid (55–70%) and low in oleic acid (20–25%), with an oil content of 35–42% (Premnath et al., 2016). The oil content of the seeds was originally 25%, but new sunflower hybrids with an oil content of 40% (Adeleke and Babalola, 2020; Romanic, 2020) were produced with the use of contemporary plant breeding techniques such as induced mutation, hybridization, and molecular breeding (Ahmar et al., 2020). Sunflower seeds one of the four most universally grown and consumed oil crops in the world (Xiang et al., 2024). Worldwide it is grown and the majority of its products have been commercialized as culinary or livestock feed (Yegorov et al., 2019). It is widely acknowledged as a significant source of high-quality edible oil, particularly for use in cooking (Pal et al., 2015).

Nowadays, consumers are more interested in purchasing sunflower oil than mustard oil or other types of oils, mostly because sunflower seed oil is characterized by a relatively high proportion of unsaturated fatty acids, especially linoleic acid and oleic acid, conferring high nutritional value (Yang et al., 2022). In addition to its many advantages, sunflowers are becoming less prevalent in agricultural areas for a variety of reasons, including the lack of viable seeds available to farmers and adverse weather conditions have caused limitations in harnessing its full potential along food value chains (Bassegio et al., 2016). Also, the ongoing climate change has significantly impacted the rainfed crop production dependent places around the world (Bassu et al., 2014). The two main climatic concerns that affect crop location-specific planting season are temperature rise and a decrease in rainfall frequency and amount. Eventually, yields for a number of annual crops are reduced as a result of these modifications (Asseng et al., 2015; Zhao et al., 2017). Therefore, to solve these issues certain methods for enhancing seed quality, such as priming must be used.

Seed priming is a pre-sowing procedure that creates a physiological condition more favorable for successful seed germination. Prior to the radicle protrusion during the early stages of germination, seed priming regulates hydration, which initiates the regular metabolic process (Lutts et al., 2016; Johnson and Puthur, 2021). Hormonal seed priming is the process of priming seeds with hormone solutions, it is crucial to seed metabolism (Rhaman et al., 2020). Nowadays, hormonal seed priming is a widely utilized approach to increase crop production, seed germination, and seedling growth in unfavorable conditions (Hasanuzzaman et al., 2019). Gibberellic acids (GA_3) (Chunthaburee et al., 2014), abscisic acid (ABA) (Wei et al., 2017), or salicylic acid (SA) (Dotto and Silva, 2017; Ulfat et al., 2017) are examples of plant growth regulators that are commonly used in hormone priming to increase synchronized seed germination, seedling growth, and yield of a variety of crop species, including rice (Khaliq et al., 2015), corn (Pallaoro et al., 2016), wheat (Ulfat et al., 2017), beet (Dotto et al., 2017), and sunflower (Jafri et al., 2015). GA_3 play a crucial role in numerous vital plant growth and development processes, such as floral transition, stem elongation, leaf expansion, flower and fruit development, and seed germination (Sakata et al., 2014; Castro-Camba et al., 2022). The purpose of this experiment was to determine the impact of priming sunflower seeds at varying GA_3 concentrations on the seed quality parameters.

2. Materials and Methods

The study was conducted at the laboratory of the Department of Seed Science and Technology, Dr. YS Parmar UHF, Nauni, Solan (H.P.) during the year 2021. The seeds were acquired from the Indian Institute of Oilseeds Research, Hyderabad var. 'DRSH-1'. There were ten different seed priming treatments viz., T_1 (control or untreated seeds), T_2 (Hydropriming of seeds), T_3 (GA_3 @ 25 ppm), T_4 (GA_3 @ 50 ppm), T_5 (GA_3 @ 75 ppm), T_6 (GA_3 @ 100 ppm), T_7 (GA_3 @ 125 ppm), T_8 (GA_3 @150 ppm), T_9 (GA_3 @ 175 ppm) and T_{10} (GA_3 @ 200 ppm) all for a duration of 12 hours. The experiment was laid out in Completely Randomized Design (CRD) with four replications of each treatment and each replication comprising 100 seeds. The seeds were first surface sterilized with a 1% sodium hypochlorite solution. They were then five times rinsed with distilled water and allowed to dry at room temperature using a ceiling fan. The seeds were soaked in beakers containing solution (as per treatment) which was 5 times the volume of seeds for a duration of 12 hours at room temperature and were shade-dried for 24 hours on a thin blotting paper to reclaim the original moisture content (8%) of seed. Following priming, the seeds were evaluated using the paper towel method. Observations on various parameters i.e. seed germination (%), speed of germination, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg), and electrical conductivity ($\mu S\ m^{-1}$) were performed as per the standard procedures. Seed vigor indices were calculated as per the formula given by Abdul-Baki and Anderson (1973). Oil content (%) was calculated using the Soxhlet Extraction apparatus as per the formula given:

$$\% \text{ crude fat} = (W_2 - W_1) \times (100/S)$$

Where,

W_1=Weight of empty flask (g)

W_2=Weight of flask and extracted fat(g)

S=Weight of sample

The data were analyzed with the use of Windows-based computer package OPSTAT Sheoran (2006), with the help of which the critical difference (CD) between treatments at a 5% level of significance was determined. The analysis of variance (ANOVA) was done using a Completely Randomized Design (CRD) Panse and Sukhatme (1961).

3. Results and Discussion

3.1. Seed germination (%)

Significant variations in seed quality parameters were observed with different treatments. The seed primed with GA_3 @ 100 ppm for 12 hours (T_6) had the highest percentage of seed germination (%) (92.50%) compared to all other treatments (Table 1). One explanation for this could be that priming sunflower seeds with GA_3 (100 ppm) sped up all of the biochemical, metabolic, and molecular processes of the seed and increased the amount of nuclear, cytoplasmic, and enzymatic contents in the cells, cell organelles, etc. Consequently, the seeds exhibited a greater proportion of germination. Similar findings were made by Varier et al. (2010) who noted that priming with GA_3 increased the China aster seed germination percentage. Furthermore, seeds treated with GA_3 at 100 ppm in China aster showed the maximum germination rate, according to Selvakumari et al. (2007).

3.2. Speed of germination

Similarly, the use of seeds primed with GA_3 @ 100 ppm for 12 hours makes it abundantly evident that among the various priming treatments, the maximum speed of germination (56.54) was observed in T_6 and was discovered to be significantly higher (Table 1). The germination rate has reacted well to the seed priming treatments, the highest germination rate was seen when seeds were primed with 100 ppm of GA_3. Furthermore, these seeds also needed to include higher amounts of RNA, proteins, and carbohydrates since these substances can quicken the metabolic and biochemical processes necessary for germination. These findings also support those of Kumar and Singh (2013), who discovered that the application of GA_3 at a concentration of 100 ppm induced the fastest germination of bitter gourd seeds.

3.3. Seedling length

The data gathered in Table 1 makes it abundantly evident that, of the several priming treatments, the maximum seedling length (28.20 cm) was observed in T_6 i.e. seed lot primed with GA_3 @ 100 ppm for 12 hours and was discovered to be

Table 1: Effect of seed priming with different concentrations GA_3 on seed quality parameters in sunflower seeds

Tr. No.	Treatments	Seed germination (%)*	Speed of germination	Seedling length (cm)	Seedling fresh weight (mg)	Seedling dry weight (mg)	SVI-I (Length)	SVI-II (Mass)	Seed EC (μSm^{-1})	Oil content (%)
T_1	Control	76.75 (8.82)	36.90	22.94	445.48	26.26	1760.00	2014.77	444.75	41.83
T_2	Hydropriming of seeds for 12 hours	82.75 (9.15)	39.75	23.97	469.32	25.55	1984.33	2113.79	432.50	42.45
T_3	GA_3 @ 25 ppm for 12 hours	84.75 (9.26)	42.52	24.47	547.45	25.80	2073.43	2186.32	427.75	42.74
T_4	GA_3 @ 50 ppm for 12 hours	85.75 (9.31)	47.54	25.06	550.73	25.95	2148.93	2224.80	399.25	42.81
T_5	GA_3 @ 75 ppm for 12 hours	89.00 (9.49)	47.30	25.94	565.35	26.25	2308.75	2336.00	358.00	43.08
T_6	GA_3 @ 100 ppm for 12 hours	92.50 (9.67)	56.54	28.20	582.20	28.96	2607.72	2678.51	299.00	43.99
T_7	GA_3 @ 125 ppm for 12 hours	90.25 (9.55)	51.29	26.53	570.02	27.28	2394.47	2462.16	310.00	43.34
T_8	GA_3 @ 150 ppm for 12 hours	89.75 (9.53)	49.20	26.25	569.11	26.85	2355.66	2409.82	348.00	43.15
T_9	GA_3 @ 175 ppm for 12 hours	86.50 (9.35)	47.11	25.43	556.51	26.14	2199.07	2261.18	392.00	42.89
T_{10}	GA_3 @ 200 ppm for 12 hours	85.50 (9.30)	46.68	24.60	549.84	25.84	2103.41	2208.85	414.00	42.77
Mean		86.35 (9.34)	46.48	25.34	540.60	26.49	2193.58	2289.62	382.53	42.90
CD (p=0.05)		0.08	1.04	1.07	4.59	0.63	104.02	55.60	2.07	0.80

*Figure in the parenthesis represents square root transformation

significantly longer. This may be explained by the fact that the faster and more synchronized germination might possibly be caused by an increase in a variety of metabolic activities, especially GA_3 primed seeds (@ 100 ppm for 12 hours). The more robust and longer-growing seedlings were also a result of higher cell division within the apical meristems of the roots and shoots of the seedlings. Furthermore, there might have been an increase in the amount of proteins, carbohydrates, and RNA, which would have improved seedling growth and germination speed, producing longer seedlings. It seems that early seed germination may have contributed to longer seedlings or better seedling growth by giving the seedlings the energy they needed to develop and establish more effectively Mayer and Polijakoff-Mayer (1982). The results closely correspond with those of Selvakumari et al. (2007) in China aster.

3.4. Seedling fresh weight

T_6 (seeds treated with GA_3 @ 100 ppm for 12 hours) displayed the maximum fresh weight (582.20 mg) among all the treatments was significantly higher. The fact that GA_3 is known to enhance seedling water uptake may have activated the enzymes and mobilized reserve materials that were subsequently transported into the embryo, resulting in stronger seedlings as a result of improved embryo growth, which could account for the increase in seedling fresh weight in T_6.

3.5. Seedling dry weight

When compared to the control, T_6 (seeds primed with GA_3 @ 100 ppm for 12 hours) showed the maximum seedling dry weight (28.96 mg) among the different priming treatments and it was found to be significantly higher over all other treatments (Table 1). The explanation for this could be that GA_3 is known to promote the seedling's increased intake of water, which may have triggered the enzymes that mobilize the embryo's food reserve resources and efficiently use them to build stronger, taller seedlings. The strongest seedlings could be created as a result of improved embryo growth. Consequently, the fresh weight of the seedling increases, which may have contributed to the corresponding increase in the seedling dry weight. Eisvand et al. (2011) reported an increase in sunflower seedling length and dry weight following seed priming with GA_3. After priming seeds with gibberellic acid, the researchers concluded that this may have increased ATP production, RNA activity induction, protein synthesis,

and respiration activities. According to Pratibha et al. (2015), seedlings cultivated from GA_3-treated seeds had the highest root dry weight.

3.6. Seed vigor index-I

The maximum value of seed vigor index-I (2607.72) was obtained in T_6 i.e. seeds treated with GA_3 @ 100 ppm for 12 hours and found to be significantly higher over control and all other priming treatments (Table 1). As these seeds showed the highest percentage of germination and produced tall, robust seedlings, it is possible that the seeds primed with GA_3 @ 100 ppm had the highest seed vigor index-I. Since the seed vigor index-I is calculated as the product of the germination percentage of seeds and the seedling length. Similar results were observed by Kumar and Singh (2013) when they studied bitter gourd. Similar results were found by Yari et al. (2011) and Sharma et al. (2023) for bell pepper.

3.7. Seed vigor index- II

Seed treatment with GA_3 @ 100 ppm for 12 hours resulted in maximum Seed vigor index-II in T_6 (2678.51) found to be significantly higher over all other treatments (Table 1). Higher germination rates, longer seedlings, and heavier seedlings were all seen in GA_3 primed seeds. Thereby explained the increased seed vigor index-II. The results of Arefi et al. (2012), who found that caper seeds primed with GA_3 (100 ppm) produced taller, more vigorous seedlings, which accounted for the highest values of SVI-I and SVI-II, and a higher percentage of seed germination further support these findings.

3.8. Seed electrical conductivity ($\mu S\ m^{-1}$)

The minimum value of seed electrical conductivity (299.00 $\mu S\ m^{-1}$) was observed in T_6 (primed seeds with 100 ppm GA_3 for 12 hours) and found to be significantly lowest over all other treatments (Table 1). Given that the seeds may have leaked more solutes while hydrated in water and thus became less vigorous, the maximum electrical conductivity of the seeds was recorded in the control. The GA_3 (100 ppm) treated seeds, on the other hand, had the lowest recorded electrical conductivity. This could be because the seeds were very active and had leached the least number of solutes. The findings of Selvakumari et al. (2007) in China aster which revealed that primed seeds exhibited minimal electrical conductivity, corroborated these results.

3.9. Oil content (%)

A cursory glance at the data in Table 1 also infers that maximum oil content (43.99%) was found in T_6 (seeds primed with GA_3 @ 100 ppm for 12 hours) followed by T_7 (43.34%) and T_8 (43.15%) and found to be statistically at par with each other. The fact that GA_3 activates enzymes involved in fatty acid synthesis and regulates hormonal balance, facilitating efficient nutrient mobilization and carbohydrate conversion into oils may be the reason for the greatest oil content (%) reported in the seed lot primed with GA_3 @ 100 ppm, which in turn enhanced the percentage oil content too. These results are consistent with those of Jafri et al. (2015), who found that GA_3 seed priming significantly raised the sunflower seed oil content (%).

4. Conclusion

Therefore, it can be concluded that priming sunflower seeds with plant hormones such as GA_3 @ 100 ppm was an effective treatment for improving the quality parameters of the seeds such as seed germination (%), speed of germination, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg), SVI-I, SVI-II, seed electrical conductivity ($\mu S\ m^{-1}$) and oil content (%).

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