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Enhancement of growth, flowering and seed yield through GA_3 seed priming in sunflower

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ABSTRACT

Sunflower (Helianthus annuus) is a globally significant oilseed crop, widely cultivated for its high-quality oil, rich in unsaturated fatty acids, and its dietary fiber content, both of which are recognized for their substantial contributions to human health and nutrition. In addition, being cultivated as a magnificent ornamental plant for both indoor and outdoor landscaping. In sunflower, there are issues with decreased seed germination, field emergence, seed vigor, and yield. Therefore, the present field experiment was conducted to study the effect of various GA_3 seed priming treatments on growth, flowering, and seed yield in sunflower carried out during 2020-22. The experiment comprised ten priming treatments, viz. 8 concentrations of GA_3 (25, 50, 75, 100, 125, 150, 175, 200 ppm) and hydropriming, both for a duration of 12 hours along with an absolute control. The study revealed that seed priming with GA_3 @ 100 ppm for 12 hours resulted in maximum values for field emergence (88.94 %), plant height (131.27 cm), the diameter of capitulum (18.05 cm), number of total seeds per capitulum (584.83), number of filled seeds per capitulum (455.55), seed setting percentage (77.89 %), seed yield (29.95 g per plant, 363.91 g per plot and 1213.37 kg per hectare) and 100 seed weight (5.46 g), as well as minimum days to first flowering (47.50). Hence, it was concluded that to produce higher yield of quality seeds, the sunflower seeds be primed with GA_3 @ 100 ppm for 12 hours. The study will help the growers to optimize the seed yield, plant growth and flowering.

Keywords: *DRSH-1, GA3, Helianthus annuus, Plant growth, Seed priming, Seed yield, Seed setting, Sunflower*

INTRODUCTION

Sunflower is commercially grown as an oil seed crop in the nation, particularly in the southern regions of India and abroad aside of being grown as a magnificent ornamental plant for outdoor and indoor landscaping. Due to its short life span, photo-insensitivity, wider adaptability, and drought tolerance this crop very promising [19]. Sunflower holds a leading position as one of the world's top three high-yielding oilseed crops [1]. Because sunflower oil has higher quality unsaturated fatty acids that are essential for a healthy diet and lower cholesterol, consumers are now more inclined to purchase it than mustard oil or other types of oils. Owing to its high nutritional content and absence of anti-nutritional elements, sunflower meal has the potential to be a good source of high-quality proteins for human consumption [7].

Despite their many benefits, sunflowers are becoming less common in agricultural areas for a number of reasons, such as poor germination, inability to obtain viable seeds for farmers and unfavorable weather conditions that have limited their ability to reach their full potential along food value chains [4]. Temperature increases and decreased rainfall frequency are the two primary climate factors influencing crop location-specific planting seasons. These changes eventually result in lower yields for some annual crops [25]. Therefore, certain procedures for improving seed quality, including priming, must be used to reduce these issues.

Seed priming is a pre-sowing technique that produces a physiological condition that is better suited for successful seed germination. In the early phases of germination, seed priming regulates hydration, which initiates the regular metabolic process prior to the radicle protrusion [8]. Hence, following the seed priming of several crop plants may result in the establishment of a good crop stand leading to the production of a higher yield of quality seeds [24]. GAs is essential for several critical plant growth and development processes, including seed germination, flower and fruit development, stem elongation, leaf expansion, and floral transition [6]. So, keeping in mind, the above facts, the present investigation was carried out to study the effect of different GA_3 seed priming treatments on plant growth, flowering and seed yield in sunflower.

MATERIAL AND METHODS

Experimental Site and Treatment Details

The field investigation was accomplished at the Experimental farm of the Department of Seed Science and Technology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, H.P., India during 2020-21 and 2021-22. The farm was situated 1020 meters above mean sea level with the latitude of 30°51'08'' N and longitude 77°11'09'' E (Fig 1.). The Mean monthly meteorological data from July to December for the years 2021 and 2022 is presented in Fig 2.

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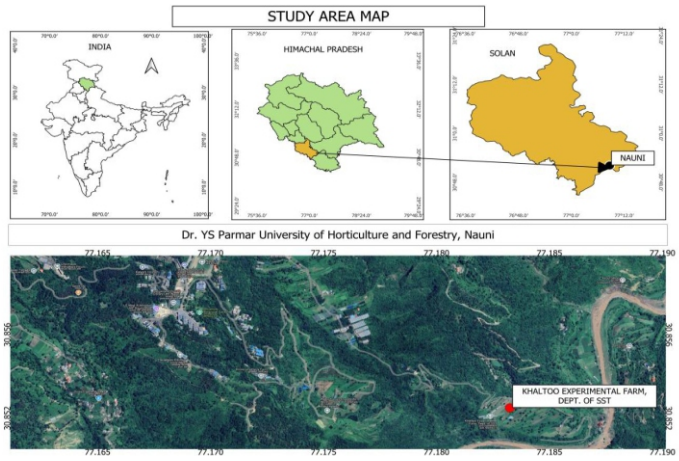

Fig 1. Location of Khaltoo Experimental Farm (The study area map was created with QGIS)

The seeds of sunflower 'DRSH-1' obtained from Indian Institute of Oilseeds Research, Hyderabad, were initially surface sterilized with sodium hypochlorite (1%) solution and then primed by soaking in a beaker 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. There were total ten 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 period of twelve hours. Then, the primed seeds were planted in 1.5 x 1.5 m plots spaced at 45 x 30 cm apart for both years. Using a Randomized Complete Block Design, the field experiment was set up with three replications. The field experiment was laid out in a Randomized Complete Block Design (RCBD) design with three replications. Observations on various parameters *i.e.* field emergence, plant height (cm), days to first flowering, diameter of capitulum (cm), number of total seeds per capitulum, number of filled seeds per capitulum, seed setting percentage (%), seed yield per plant (g) and per plot (kg) were recorded. The data of the experiment were interpreted by analysis of variance at 5 % level of significance. The analysis of variance (ANOVA) was done using Randomized Complete Block Design (RCBD) [16].

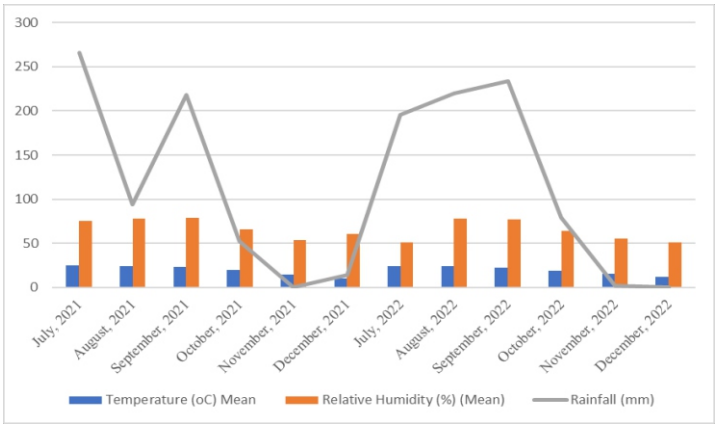

Fig 2. Monthly meteorological data of rainfall (mm), temperature (°C) and relative humidity (%) during two cropping seasons

RESULTS AND DISCUSSION

Field emergence (%): The maximum percentage of field emergence (88.94 %) was recorded in plants which were grown from the seeds that were primed with GA_3 @ 100 ppm for 12 hours (T_6) which was significantly higher over all other treatments (Table I). It is possible due to the fact that growth regulators in general and GA_3 in particular, stimulate the activation of various enzymatic activities that might have led to the repair of various substrate deficits. The findings might be corroborated in bitter gourd [10] and okra [23].

Plant Height (cm): The tallest plants of sunflower (131.73 cm) were noticed in T_6 *i.e.* when the plants were raised from the seeds that were primed with GA_3 @ 100 ppm for 12 hours and found to be significantly taller over all other priming treatments (Table I). This may be explained by the fact that the increase in plant height may be due to the beneficial effects of GA_3 on seed structure, biochemistry, enzyme activities and organic substances during the different phases of seed germination. The same results were reported the same results in brinjal [20] and okra [21].

Days to First Flowering: The plants that were grown from the seeds treated with T_6 *i.e.* GA_3 @ 100 ppm for 12 hours displayed minimum time to first flowering (47.50 days) and found to be significant amongst all other treatments (Table I). The fact that earliness in flowering in may be due to the reason that GA_3 showed a positive response in manipulating the flowering at the requisite dose and for sunflower this particular concentration might be the required one. These results are very similar to those in peanuts [12] and tulip bulbs [18] steeped in a solution of GA_3 (100 ppm).

Flower Diameter: When compared to control, T_6 (plants that were raised from the seeds treated with GA_3 @ 100 ppm for 12 hours) produced capitula of significantly larger size (18.05 cm) over all the other priming treatments (Table II).

The reason for this could be that GA_3 may have improved a number of physiological, biochemical and metabolic processes related to blooming, because more metabolites must have been translocated at the site of inflorescence development, GA_3 may have a role in increasing the size of both floral buds and inflorescences. The results have got supported from the findings in tulip bulbs [18]. After using GA_3, larger capitula was reported in China aster and marigold [11].

Number of Total Seeds: A perusal of analyzed data presented in Table II indicated that the maximum number of total seeds per capitulum (584.83) was produced in T_6 (plants that were raised from the seeds treated with GA_3 @ 100 ppm for 12 hours) and found to be significantly more over all other priming treatments. This might be explained by the possibility that an external supply of GA_3 could have encouraged flowering, pollination and fertilization as well as improved seed setting and the growth of better quality capitula. Therefore, leading to the generation of more seeds per capitulum. The outcomes closely match with those in safflower [2].

Number of Filled Seeds: A cursory glance of the data (Table II) also revealed that the maximum number of filled seeds per capitulum (455.55) were recorded in T_6 and found to be significantly highest over all other treatments. This may be due to the fact that primed seeds had generated more seeds in comparison to other type of seeds that might have contributed to an increase in the overall number of seeds per head and thereby the chances of filled seeds also increased due to enhanced activity of pollination, fertilization thereby leading to more seed setting. These outcomes are consistent with the observations recorded by other researchers in sunflower [13],[17],[14].

Seed Setting percentage (%): The data in Table III are clearly indicate that the maximum seed setting (77.89 %) was recorded in T_6 *i.e.* when the plants were raised from seed lot primed with GA_3@ 100 ppm for 12 hours and found to be significantly highest over all other treatments. This could be explained by the fact that GA_3 synchronized and stimulated blooming, which may have contributed to a higher rate of seed setting. Similar results were found in maize [5] and okra [15].

Seed Yield Per Plant (g): A cursory glance of the data (Table III) indicates strictly the significant role of seed priming treatments in increasing seed yield per plant and seed yield per plot of sunflower. The highest seed yield per plant (29.95 g) were recorded in T_6 and found to be significantly higher over the other treatments. This might be due to the reason that the increase in sunflower yield is primarily due to the benefits of priming with GA_3 (100 ppm). The plants that were produced from the primed seed lot subsequently had higher maximum head diameter and seed setting percentage, which raised the total yield per plant. Similar results were found in sunflowers by another researcher [17] who asserted that GA_3 primed seed produced more seeds. Similar results were made in maize [5].

Seed Yield Per Plot (g): A critical perusal of data in Table III indicates the among different seed priming treatments, maximum seed yield per plot (363.91 g) was obtained in T_6 *i.e.* priming of seeds with GA_3 @ 100 ppm for 12 hours and found to be significantly highest among all the treatments.

This could be explained by the fact that GA_3 seed treatment produced higher-quality plants with more flowers, faster pollination and fertilization, more capitula, better seed setting, and more and bolder seeds developing in each capitulum. Consequently, a greater seed yield per plot was the total result. The outcomes are in line with the conclusions drawn from the study on summer annuals [22] about the use of greater dosages of Ga_3.

Seed Yield per hectare (kg): Data presented in Table IV highlight that among different seed priming treatments, maximum seed yield per plot (1213.37 kg) was recorded in T_6 *i.e.* priming of seeds with GA_3 @ 100 ppm for 12 hours and found to be significantly highest among the other treatments. A primed seed lot could therefore yield plants with higher maximum head diameter and seed setting percentage, increasing the total yield per plant, per plot, and per hectare. Similar results were found in sunflower by another researcher [14] who asserted that GA_3 primed seed produced more seeds.

100 Seed Weight (g): The data recorded Table IV, clearly shows the maximum weight of 100 seeds (5.46 g) was recorded in T_6 *i.e.* priming of seeds with GA_3 @ 100 ppm for 12 hours and found to be significantly higher over all other treatments. This might be possible that the seeds primed with GA_3 (100 ppm) for 12 hours oxidized more food stores and absorbed more priming solution. Better-quality plants could be produced as a result, and these plants finally produced bolder and heavier test-weight seeds. These results are consistent with *Brassica napus*, [3] in which plants were capable of producing higher-quality seeds when GA_3 primed seeds were sown. The results are further corroborated in chickpea [9] which recorded the highest weight of 100 seeds after priming with GA_3 (100 ppm).

CONCLUSION

Based on the results of this study, it was determined that the seed primed with GA_3 at a concentration of 100 ppm was significantly better than all other treatments in terms of growth, flowering, and seed yield. This treatment resulted in the highest field emergence, plant height, capitulum diameter, seed setting percentage, seed yield, and 100 seed weight, while also reducing the days to first flowering. The findings recommend the use of this particular GA_3 priming treatment to optimize seed quality and yield for sunflower growers. The research offers a strong basis for future investigation and advancement by refining the GA_3 application procedures, including different concentrations, exposure times, and treatment techniques for a range of agroclimatic conditions and sunflower genotypes. It is important to examine its effects on abiotic stress tolerance, seed nutritional content, and oil quality. Additionally, molecular studies on gene expression and integration with sustainable crop management practices could further enhance productivity, economic feasibility, and applicability to other oilseed crops.

Compliance with Ethical Standards

Conflict of interest: The authors declare that they have no conflict of interest.

Acknowledgment

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Author's contribution

A.T. (Ankita Thakur) conducted the experiment and analyzed the data; B.S.D. (BS Dilta) conceptualized the research and guided throughout the experiment; R.V. and S.K. helped in main manuscript writing and forming tables; Vinay helped in data curation.

Table I. Effect of GA3 seed priming on growth flowering and flowering parameters in sunflower

Treatments/ Parameters		Field emergence (%) *			Plant height (cm)			Days to first flowering		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (untreated)	71.11	71.44	71.28 (8.50)	110.93	110.97	110.95	55.33	55.00	55.16
T_2	Hydropriming of seeds	74.44	74.77	74.61 (8.70)	113.27	113.60	113.43	52.67	52.33	52.50
T_3	GA_3 @ 25 ppm	80.33	80.66	80.50 (9.03)	117.53	117.60	117.57	52.33	52.00	52.16
T_4	GA_3 @ 50 ppm	81.11	81.44	81.28 (9.07)	118.53	118.83	118.68	51.33	51.00	51.16
T_5	GA_3 @ 75 ppm	83.11	83.55	83.33 (9.18)	121.47	122.53	122.00	50.33	50.00	50.16
T_6	GA_3 @100 ppm	88.88	88.99	88.94 (9.48)	131.27	131.73	131.50	47.67	47.33	47.50
T_7	GA_3 @ 125 ppm	86.66	86.88	86.77 (9.37)	130.33	130.60	130.47	49.67	49.33	49.50
T_8	GA_3 @ 150 ppm	84.44	84.77	84.61(9.25)	123.67	123.90	123.78	50.67	50.33	50.50
T_9	GA_3 @ 175 ppm	82.22	82.77	82.50 (9.14)	124.73	124.90	124.82	51.33	51.00	51.16
T_{10}	GA_3 @ 200 ppm	80.33	80.78	80.56 (9.03)	116.93	117.00	116.97	52.33	52.00	52.16
Mean		81.26	81.61		120.87	121.17		51.37	51.03	
$CD_{0.05}$		T		0.11			0.91			1.02
		Y		NS			NS			NS
		T × Y		NS			NS			NS

**Figure in the parenthesis represents square root transformation*

Table II. Effect of GA3 seed priming on flowering and seed yield parameters in sunflower

Treatments/ Parameters		Flower diameter (cm)			No. of filled seeds			No. of total seeds		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (untreated)	15.32	15.34	15.33	328.77	329.20	328.99	491.07	491.58	491.32
T_2	Hydropriming of seeds	16.12	16.16	16.14	356.25	356.58	356.41	528.00	528.33	528.17
T_3	GA_3 @ 25 ppm	16.42	16.44	16.43	369.70	370.17	369.93	541.33	541.71	541.52
T_4	GA_3 @ 50 ppm	16.38	16.40	16.39	398.51	399.31	398.91	556.07	556.80	556.43
T_5	GA_3 @ 75 ppm	16.42	16.59	16.51	413.60	414.08	413.84	556.47	556.90	556.68
T_6	GA_3 @100 ppm	18.03	18.07	18.05	455.20	455.89	455.55	584.40	585.27	584.83
T_7	GA_3 @ 125 ppm	17.38	17.40	17.39	438.77	439.03	438.90	583.87	583.89	583.88
T_8	GA_3 @ 150 ppm	16.85	16.88	16.87	421.60	422.29	421.95	576.73	576.93	576.83
T_9	GA_3 @ 175 ppm	16.62	16.64	16.63	405.27	406.18	405.72	560.13	560.52	560.33
T_{10}	GA_3 @ 200 ppm	16.35	16.37	16.36	382.93	384.13	383.53	549.93	550.00	549.97
Mean		16.59	16.63		397.06	397.69		552.8	553.19	
$CD_{0.05}$		T		0.17			1.41			1.00
		Y		NS			NS			NS
		T×Y		NS			NS			NS

Table III. Effect of GA3 seed priming on seed yield parameters in sunflower

Treatments/ Parameters		Seed setting percentage (%)			Seed yield per plant (g)			Seed yield per plot(g)		
		2020-21	2021-22	Pooled*	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (untreated)	66.95	66.97	66.96 (54.89)	19.34	19.49	19.41	243.77	244.16	243.97
T_2	Hydropriming of seeds	67.47	67.49	67.48 (55.21)	21.56	21.97	21.76	253.02	253.50	253.26
T_3	GA_3 @ 25 ppm	68.29	68.33	68.31 (55.72)	23.59	23.81	23.70	269.75	269.97	269.86
T_4	GA_3 @ 50 ppm	71.67	71.71	71.69 (57.83)	24.87	24.95	24.91	287.46	287.52	287.49
T_5	GA_3 @ 75 ppm	74.33	74.35	74.34 (59.54)	26.73	26.99	26.86	297.59	298.00	297.79
T_6	GA_3 @100 ppm	77.89	77.90	77.89 (61.93)	29.93	29.97	29.95	363.85	363.96	363.91
T_7	GA_3 @ 125 ppm	75.15	75.19	75.17 (60.09)	27.59	27.81	27.70	329.47	329.82	329.64
T_8	GA_3 @ 150 ppm	73.10	73.20	73.15 (58.77)	26.41	26.97	26.69	313.99	314.13	314.06
T_9	GA_3 @ 175 ppm	72.35	72.46	72.41 (58.29)	25.78	25.99	25.89	291.66	292.68	292.17
T_{10}	GA_3 @ 200 ppm	69.63	69.84	69.74 (56.60)	23.54	23.70	23.62	255.63	256.80	256.22
Mean		71.68	71.75		24.93	25.17		290.62	291.05	
$CD_{0.05}$		T		0.19			1.01			0.99
		Y		NS			NS			NS
		T×Y		NS			NS			NS

**Figure in the parenthesis represents angular transformation*

Table IV. Effect of GA3 seed priming on seed yield parameters in sunflower

Treatments/ Parameters		Seed yield per hectare (kg)			100 Seed weight (g)		
		2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	Control (untreated)	812.58	812.98	812.78	4.79	4.80	4.79
T_2	Hydropriming of seeds	843.40	844.69	844.05	4.87	4.88	4.88
T_3	GA_3 @ 25 ppm	899.16	900.37	899.76	4.93	4.94	4.94
T_4	GA_3 @ 50 ppm	958.20	959.04	958.62	5.17	5.18	5.18
T_5	GA_3 @ 75 ppm	991.96	992.94	992.45	5.29	5.30	5.29
T_6	GA_3 @100 ppm	1212.82	1213.92	1213.37	5.45	5.47	5.46
T_7	GA_3 @ 125 ppm	1098.23	1099.08	1098.66	5.31	5.32	5.32
T_8	GA_3 @ 150 ppm	1046.62	1047.37	1047.00	5.23	5.24	5.23
T_9	GA_3 @ 175 ppm	972.21	973.81	973.01	5.19	5.20	5.20
T_{10}	GA_3 @ 200 ppm	852.11	853.52	852.82	4.99	5.00	4.99
Mean		968.73	969.77		5.12	5.13	
$CD_{0.05}$		T		2.43			0.02
		Y		NS			NS
		T×Y		NS			NS

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