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Optimizing Seed Priming Techniques to Enhance Growth and Yield Traits in Sunflower (*Helianthus annuus* L.)

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ABSTRACT: Seed priming is one of the economical and feasible technologies for uniform crop development in most of the field crops. This technique is very important as a pre-sowing practice in oil seed crops that easily lose vigour during storage. The present investigation aimed to optimize seed priming technique in Indian sunflower genotypes. The field experiment was conducted in 'J' Block, AICRP on Seed (Crops), NSP, University of Agricultural Sciences, GKVK, Bangalore. Out of 6 priming treatments, the treatment hydropriming for 18 h was recorded higher growth and yield parameters *viz.,* field emergence (76.94%), plant height (37.50, 110.95 and 140.68 cm at 30, 45 and 60 DAS), number of leaves (13.32, 19.32 and 23.56 at 30, 45 and 60 DAS), days to first flowering (49.20), days to 50% flowering (55.20). Highest capitulum diameter (20.77 cm), total number of achenes per capitulum (1842.62) and yield per plant (46.47 g) was recorded in hydropriming for 18 h followed by priming with 2% KNO_3 for 18 h (19.32 cm, 1779.99 and 45.68 g, respectively). Hence, it is concluded that hydropriming for 18 h and priming with 2% KNO_3 for 18 h had a major impact on growth and yield in sunflower.

Keywords: Sunflower seeds, KBSH 41, hydropriming, yield traits

INTRODUCTION

Oilseed crops play a vital role in the Indian economy, contributing significantly to the agricultural sector. Currently, oilseeds occupy about 14% of the total area under major field crops in India. On the global stage, India holds a prominent position in oilseed production. Historically, oilseed crops have been the backbone of several agricultural economies and continue to play a crucial role in agro-industries and international trade.

Among the major oilseed crops cultivated for edible oil are soybean, groundnut, mustard, sunflower, rapeseed, safflower, sesame, castor, and linseed. Sunflower (*Helianthus annuus* L.), known in India as "Surajmukhi," ranks fourth among oilseed crops globally, following soybean, groundnut, and mustard. The name *Helianthus* is derived from the Greek words *helios* meaning "sun" and *anthos* meaning "flower." It belongs to the genus *Helianthus*, which includes about 70 species, and is classified under the family Asteraceae, tribe Heliantheae, and subtribe Helianthinae. Sunflower (2n = 34) is a protein-rich oilseed crop valued for its high content of oleic and linoleic acids. Due to its high linoleic acid content, sunflower oil has excellent oxidative stability and helps reduce cholesterol deposits in the coronary arteries, thus contributing to heart health. It is widely used in culinary applications, salads, and various industries.

Despite its nutritional and economic importance, sunflower production faces challenges. A major limitation in open-pollinated sunflower varieties is the occurrence of empty or partially filled seeds in the capitulum, leading to lower yields. This issue, along with the expansion of sunflower cultivation to diverse regions and growing conditions, has necessitated the development of hybrid varieties in India.

As sunflower is a key oilseed crop, there is increasing demand for high-quality seeds to enhance oil production. However, sunflower seeds tend to lose vigour and viability rapidly due to lipid peroxidation, which results in free radical formation that damages cellular membranes. To mitigate this deterioration, researchers have explored various seed enhancement techniques. Seed priming—using treatments such as bio-ingredients, growth regulators, antioxidants, chemicals, fungicides, and vitamins—has shown promise in maintaining seed vigour, viability, and field performance. Such invigorated seeds exhibit faster germination, improved growth, and higher yields [1,2].

MATERIAL AND METHODS

The field experiment was undertaken at AICRP on Seed (Crops), National Seed Project, 'J' Block, University of Agricultural Sciences, Bengaluru, in Factorial Randomized Complete Block Design with three replications and six different treatments were tested by using two different vigor seed lots of KBSH-41 Sunflower hybrid with three replications (Spacing: 60 x 30 cm. Plot size: 2 x 2 m).

Treatment details: Treatment details were Factor A: Seed vigour levels (L1 - Fresh seed lot (80.0% germination), L2 -Old seed lot (55.0% germination); Factor B:T_1 - Control (Untreated)**,** T_2 - Hydropriming for 18 h, T_3 - Priming 2% KNO_3 for 18 h, T_4 - Priming with 20% *Pseudomonas fluorescens* for 12 h, T_5 - Thermoinvigouration at 35°C for 24 h, T_6 - Pre-chilling at 7.5°C for a period of 7 days

RESULTS AND DISCUSSION

Field emergence percentage is an important index that indicates the optimum plant stand of a crop. Treatments resulting in higher field emergence percentages are considered more beneficial than those with lower values. Various seed priming techniques significantly improved the field emergence percentage of sunflower compared to control seeds across different seed vigour levels (Table 1).

Among the seed lots, the fresh seed lot 1 (L1) recorded a significantly higher field emergence (83.10%), whereas the old seed lot 2 (L2) showed a lower field emergence (60.08%). Among the different treatments, T2 (hydropriming for 18 hours) recorded the highest field emergence (76.94%), followed by treatment T4 (74.82%). The lowest field emergence was observed in the control (65.31%).

The interaction of L1T2 and L2T2 (hydropriming for 18 hours) resulted in the highest first count emergence (90.86% and 63.02%, respectively) at different seed vigour levels. These results were followed by L1T4 and L2T4 (priming with 2% KNO_3), which showed field emergence percentages of 87.32% and 62.32%, respectively.

The enhanced field emergence may be attributed to rapid and synchronized germination, driven by the activation of pre-germinative processes that induce both quantitative and qualitative biochemical changes. These include membrane repair and strong synthesis and activation of enzymes involved in the degradation and mobilization of seed reserves. [1] reported that priming improves and synchronizes DNA replication in all embryo cells, advancing the cell cycle from the G1 to the G2 phase.

Table 1. Influence of different seed vigour and seed priming treatments on field emergence and plant stand in sunflower

Treatments	Field emergence (%)	Plant stand (%)
Lots (L)		
L_1 - Fresh lot	83.10	82.04
L_2 - Old lot	60.08	58.19
Mean	71.59	70.12
SEm ±	1.29	1.06
CD @ 5 %	3.77	3.09
Treatments (T)		
T_1 – Control	65.31	64.53
T_2 - Hydropriming for 18 h	76.94	76.23
T_3 - Priming with 20 % *Pseudomonas fluorescens* for 12 h	72.04	69.07
T_4 - Priming with 2 % KNO_3 for 18 h	74.82	72.32
T_5 - Thermoinvigouration at 35 ºC for 24 h	70.60	70.28
T_6 - Pre-chilling at 7.5ºC for a period of 7 days	69.82	68.63
Mean	71.59	70.18
SEm ±	2.24	1.83
CD @ 5 %	6.54	5.36
Interaction (L x T)		
L_1T_1	81.74	80.13
L_1T_2	90.86	90.11
L_1T_3	85.18	84.70
L_1T_4	87.32	86.19
L_1T_5	83.86	82.34
L_1T_6	84.13	82.97
L_2T_1	48.88	47.82
L_2T_2	63.02	62.35
L_2T_3	60.91	58.44
L_2T_4	62.32	60.44
L_2T_5	61.35	60.77
L_2T_6	61.03	59.31
Mean	72.55	71.29
SEm ±	3.17	2.63
CD @ 5 %	9.25	7.67
CV (%)	7.67	6.51

The effect of different seed priming treatments across various seed vigour levels was found to be significant in terms of plant stand (Table 1). The highest plant stand (82.04%) was recorded in the fresh seed lot (L1), while the lowest (58.19%) was observed in the old seed lot

(L2). Among the seed priming treatments, T2 (hydropriming for 18 hours) showed the highest plant stand (76.23%), which was statistically on par with T4 (72.32%). The control treatment recorded the lowest plant stand (64.53%).

The interaction between L1T2 and L2T2 (hydropriming for 18 hours) resulted in the highest plant stands (90.11% and 62.35%, respectively) across the different vigour levels. These results were followed by L1T4 and L2T4, with plant stands of 86.19% and 60.77%, respectively. Better seedling emergence from hydroprimed seeds is attributed to early and enhanced germination, which ensures an optimum plant stand. Enhanced growth of the plumule and radicle, associated with improved seed vigour and field emergence, contributes to the better plant stand. [2] reported that seed hydration in wheat, barley, and oat improved seedling emergence uniformity. Similarly, maintaining the optimal hydropriming duration ensures optimum plant stand in maize [3], and rapid seedling emergence leads to more vigorous plants [4].

Among the seed vigour levels in sunflower, hydropriming for 18 hours produced significantly taller plants compared to all other treatments (Table 2). This was followed by the 2% KNOƒ treatment. Plant height at 30, 45, and 60 days after sowing (DAS) in L1 and L2 was 39.85 cm and 27.71 cm; 119.09 cm and 91.72 cm; and 147.56 cm and 117.90 cm, respectively. The T2 treatment resulted in plant heights of 37.50 cm (30 DAS), 110.95 cm (45 DAS), and 140.68 cm (60 DAS). These were followed by T4, with plant heights of 35.49 cm, 108.41 cm, and 137.81 cm, respectively. The control (T1) recorded the lowest plant heights (30.24, 95.07, and 122.19 cm at 30, 45, and 60 DAS, respectively). Maximum plant heights were recorded under L1T2 and L2T2 (44.77 and 30.23 cm at 30 DAS; 127.62 and 94.28 cm at 45 DAS; 159.02 and 122.34 cm at 60 DAS, respectively).

Improvement in plant height is likely due to increased root length, which enhances water and nutrient uptake, leading to better photosynthesis, enzyme activity, and protein synthesis. Enhanced photosynthesis is also associated with increased stomatal conductance and transpiration. [5] reported that priming (hydro- and osmo-priming) improves photosynthetic efficiency, PSII quantum yield, stomatal conductance, and evapotranspiration in wheat under both normal and stress conditions. These findings are in agreement with [6].

Significant differences were observed among seed vigour levels and priming treatments for days to first flowering

Table 2. Influence of different seed vigour and seed priming treatments on plant height at 30, 45 and 60 DAS in sunflower

Treatments	Plant height (cm) 30 DAS	45 DAS	60 DAS
Lots (L)			
L_1 - Fresh lot	39.85	119.09	147.56
L_2 - Old lot	27.71	91.72	117.90
Mean	33.78	105.41	132.73
S. Em ±	0.60	1.12	2.01
CD @ 5 %	1.76	3.27	5.86
Treatments (T)			
T_1 – Control	30.24	95.07	122.19
T_2 - Hydropriming for 18 h	37.50	110.95	140.68
T_3 - Priming with 20 % *Pseudomonas fluorescens* for 12 h	32.76	106.81	135.28
T_4 - Priming with 2 % KNO_3 for 18 h	35.49	108.41	137.81
T_5 - Thermoinvigouration at 35 ºC for 24 h	32.64	105.31	126.46
T_6 - Pre-chilling at 7.5ºC for a period of 7 days	34.05	105.88	133.95
Mean	33.78	105.40	132.73
S. Em ±	1.05	1.94	3.48
CD @ 5 %	3.05	5.68	10.16
Interaction (L x T)			
L_1T_1	33.75	103.02	131.33
L_1T_2	44.77	127.62	159.02
L_1T_3	41.09	120.54	151.02
L_1T_4	42.09	123.11	155.55
L_1T_5	37.93	121.51	133.76
L_1T_6	39.48	118.73	154.67
L_2T_1	26.73	87.11	113.05
L_2T_2	30.23	94.28	122.34
L_2T_3	24.44	93.09	119.54
L_2T_4	28.89	93.70	120.06
L_2T_5	27.35	89.11	119.16
L_2T_6	28.62	93.03	113.23
Mean	33.78	105.41	132.73
S. Em ±	1.47	2.75	4.92
CD @ 5 %	4.31	8.03	14.37
CV (%)	7.58	4.52	6.43

(Table 3). The fresh seed lot (L1) took the fewest days to first flowering (50.02 days), while the old seed lot (L2) took the most (54.41 days). Among the treatments, T2 (hydropriming for 18 hours) required the least time to first flowering (49.20 days), followed by T4 (50.80 days). The control (T1) took the longest (56.23 days). However, the interaction between seed vigour levels and priming treatments was not statistically significant for days to first flowering.

Statistically significant variation was also observed in days to 50% flowering among seed vigour levels. L1 achieved 50% flowering in 56.07 days, whereas L2 required 61.34 days. T2 recorded the minimum number of days to 50%

Table 3. Influence of different seed vigour and seed priming treatments on Days to first flowering and Days to 50 % flowering in sunflower

Treatments	Days to first flowering	Days to 50% flowering
Lots (L)		
L_1 - Fresh lot	50.02	56.07
L_2 - Old lot	54.41	61.34
Mean	52.22	58.71
SEm ±	0.87	0.99
CD @ 5 %	2.56	2.91
Treatments (T)		
T_1 - Control	56.23	64.13
T_2 - Hydropriming for 18 h	49.20	55.20
T_3 - Priming with 20 % *Pseudomonas fluorescens* for 12 h	51.32	59.00
T_4 - Priming with 2 % KNO_3 for 18 h	50.80	57.58
T_5 - Thermoinvigouration at 35 ºC for 24 h	51.99	58.66
T_6 - Pre-chilling at 7.5ºC for a period of 7 days	53.75	60.65
Mean	52.22	59.20
SEm ±	1.52	1.73
CD @ 5 %	4.44	5.05
Interaction (L x T)		
L_1T_1	54.54	62.12
L_1T_2	46.26	52.59
L_1T_3	48.96	56.85
L_1T_4	48.67	55.35
L_1T_5	50.30	56.99
L_1T_6	51.40	58.54
L_2T_1	57.92	66.15
L_2T_2	52.13	57.82
L_2T_3	53.68	61.15
L_2T_4	52.92	59.82
L_2T_5	53.67	60.33
L_2T_6	56.11	62.77
Mean	52.21	59.20
SEm ±	2.15	2.44
CD @ 5 %	NS	NS
CV (%)	7.13	7.16

flowering (55.20), followed by T4 (57.58 days), which was on par with T2. The control (T1) again took the longest (64.13 days). The interaction effect between seed vigour levels and priming treatments was not significant.

A significant difference in capitulum diameter was observed between seed vigour levels (Table 1). L1 recorded the highest diameter (20.11 cm), while L2 recorded the lowest (16.54 cm). Among treatments, T2 (hydropriming for 18 hours) recorded the largest capitulum diameter (20.77 cm), which was on par with T4 (19.32 cm). The control treatment showed the lowest (14.73 cm). The highest diameters (23.53 and 18.01 cm) were recorded in L1T2 and L2T2, respectively, followed by L1T4 and L2T4 (21.29 and 17.34 cm).

Significant differences were also recorded in the total number of achenes per capitulum (Table 4). L1 recorded the maximum (1814.89 achenes), while L2 recorded the minimum (1579.89). T2 resulted in the highest number of achenes (1842.62), followed by T4 (1779.99), with the control (T1) showing the lowest (1543.88). L1T2 and L2T2 recorded the maximum number of achenes (1995.75 and 1689.50, respectively), followed by L1T4 and L2T4 (1920.85 and 1639.13).

Significant variations were also observed in yield per plant (Table 4). L1 had the highest yield per plant (45.81 g), while L2 had the lowest (42.06 g). Among treatments, T2 recorded the highest yield (46.47 g), followed by T4 (45.68 g), and the control (41.60 g) recorded the lowest. The interaction L1T2 and L2T2 recorded the highest yields (50.00 and 47.37 g), followed by L1T4 and L2T4 (47.37 and 42.99 g).

A significant difference was also found for yield per hectare. L1 produced the highest yield (25.26 q/ha), while L2 recorded the lowest (22.83 q/ha). T2 (hydropriming for 18 hours) recorded the highest yield (25.67 q/ha), followed by T4 (25.35 q/ha). The lowest yield (22.04 q/ ha) was recorded in the control. The highest yields per hectare were observed in L1T2 and L2T2 (27.12 and 26.82 q/ha), followed by L1T4 and L2T4 (24.22 and 23.88 q/ha), respectively.

Seed priming resulted in earlier and more uniform emergence, which improved biological yield. Increased achene yield from primed seeds appears to be a result of enhanced yield-contributing factors, including plant population, plant height, head diameter, and the number of filled achenes per head. The beneficial effects of hydropriming on yield have been supported by [7, 8]. The performance of seeds primed for 24 hours aligns with findings by [9], who reported increased head number, seed count, and seed weight in safflower. Similar improvements in seed yield have been reported in hydroprimed sunflower seeds [10, 11, 12, 13] and in chickpea [14, 15, 16, 17, 18].

CONCLUSION

Seed priming with water (hydropriming) for a duration of 18 hours was found to be highly effective in enhancing the growth and yield parameters of sunflower. This treatment significantly improved field emergence (up to

Table 4. Influence of different seed vigour and seed priming treatments on total number of achenes per capitulum, yield per plant and yield per hectare in sunflower

Treatments	Total number of achenes per capitulum	Yield per plant (g)	Yield per hectare (q)
Lots (L)			
L_1 - Fresh lot	1814.89	45.81	25.26
L_2 - Old lot	1579.89	42.06	22.83
Mean	1697.39	43.93	24.04
SEm ±	26.96	0.55	0.26
CD @ 5 %	78.71	1.62	0.76
Treatments (T)			
T_1 - Control	1543.88	41.60	22.04
T_2 - Hydropriming for 18 h	1842.62	46.47	25.67
T_3 - Priming with 20 % *Pseudomonas fluorescens*for 12 h	1693.04	43.51	23.76
T_4 - Priming with 2 % KNO_3 for 18 h	1779.99	45.68	25.35
T_5 - Thermoinvigouration at 35 ºC for 24 h	1645.92	42.44	23.60
T_6 - Pre-chilling at 7.5ºC for a period of 7 days	1678.9	43.90	23.35
Mean	1697.39	43.93	24.04
SEm ±	46.71	0.87	0.45
CD @ 5 %	136.34	2.55	1.33
Interactions (L x T)			
L_1T_1	1559.47	42.15	23.51
L_1T_2	1995.75	50.00	27.12
L_1T_3	1872.55	46.89	25.49
L_1T_4	1920.85	47.37	26.82
L_1T_5	1674.99	44.48	24.63
L_1T_6	1865.73	43.97	24.00
L_2T_1	1528.30	37.05	20.57
L_2T_2	1689.50	43.95	24.22
L_2T_3	1513.52	40.13	22.03
L_2T_4	1639.13	42.99	23.88
L_2T_5	1616.84	40.40	22.58
L_2T_6	1492.06	41.84	23.70
Mean	1697.39	43.93	24.04
SEm ±	66.02	1.23	0.64
CD @ 5 %	192.82	3.61	1.88
CV (%)	6.74	4.88	4.62

90.86% in fresh seeds), plant stand (up to 90.11%), and plant height (up to 159.02 cm at 60 DAS), particularly in fresh seed lots with higher vigour. Hydropriming also resulted in earlier flowering, with fewer days to first flowering and 50% flowering compared to untreated seeds. Additionally, it increased capitulum diameter (up to 23.53 cm), the total number of achenes per capitulum (up to 1995.75), yield per plant (up to 50.00 g), and yield per hectare (up to 27.12 q/ha), outperforming all other treatments including priming with 2% KNOƒ .

These improvements are likely due to enhanced and synchronized germination, better seedling emergence, improved root development, and increased water and nutrient uptake—leading to improved photosynthesis, enzymatic activity, and plant metabolism. Moreover, hydropriming is a simple, cost-effective, and eco-friendly technique that does not require any chemical inputs.

Therefore, hydropriming for 18 hours can be recommended as an efficient pre-sowing treatment to enhance sunflower seed performance, especially under varying seed vigour conditions, and to ensure optimal crop establishment, growth, and yield in field conditions.

REFERENCES

1. DE CASTRO RD, AA VAN LAMMEREN, SP GROOT, RJ BINO AND HW HILHORST (2000). Cell division and subsequent radicle protrusion in tomato seeds are inhibited by osmotic stress but DNA synthesis and formation of microtubular cytoskeleton are not. *Plant physiol.*, **122(2)**: 327-336.

2. KIBITES AND KN HARKER(1991). Effects of seed hydration on agronomic performance of wheat, barley and oats in central Alberta. *Canadian J. Plant Sci.*, **71(2)**: 515-518.

3. MOGHANIBASHI M, H KARIMMOJENI, P NIKNESHANAND D BEHROZI (2012). Effect of hydropriming on seed germination indices of sunflower (*Helianthus annuus* L.) under salt and drought conditions. *Plant Knowledge J.*, **1(1)**: 10-15.

4. GHASSEMI-GOLEZANIK, AAALILOO, M VALIZADEH ANDM MOGHADDAM (2008). Effects of hydro and osmo-priming on seed germination and field emergence of lentil (*Lens culinaris*Medik.*). NotulaeBotanicaeHortiAgrobotanici Cluj-Napoca*, **36(1)**: 29-33.

5. TABASSUM T, M FAROOQ, R AHMAD, A ZOHAIB, A WAHIDAND M SHAHID (2018). Terminal drought and seed priming improves drought tolerance in wheat. *Physiol Molecular Biol. Plants*, **24(5)**: 845-856.

6. TESTER M AND R DAVENPORT (2003). Na+ tolerance and Na+ transport in higher plants. *Annals Bot.*, **91(5)**: 503-527.

7. SHANTHAMALLAIAH NR, G PUSHPA, N VENUGOPAL AND NM PATIL (1976). Effect of pre-soaking of sunflower seeds in water on the growth and yield of sunflower. *Mysore J. Agric. Sci.*, **10**: 34-37.

8. FAROOQ M, SMA BASRA, I AFZAL AND A KHALIQ (2006). Optimization of hydropriming techniques for rice seed invigoration. *Seed Sci. Technol.*, **34**(2): 507-512.

9. BASTIA DK, AK RAUT, SK MOHANTYAND AM PRUSTY (1999). Effect of sowing date, sowing methods and seed soaking on yield and oil content of rainfed safflower grown in Kalahandi, Orissa. *Indian J. Agron.*, **44(3)**: 621 623.

10. HUSSAIN, MUBSHAR, M FAROOQ, SM BASRAAND N AHMAD (2006) Influence of seed priming techniques on the seedling establishment, yield and quality of hybrid sunflower. *Int. J. Agric. Biol.*, **8(1)**: 14-18.

11. RAKSHITHA HN, PARASHIVAMURTHY AND MS HARISH (2022). Influence of seed priming techniques for enhancing seed quality in sunflower (*Helianthus annuus* L.). *Seed Research,* **50(1)**: 21-27.

12. VIDYA CJ AND N NETHRA (2022). Seed deterioration: An overview. *Seed Research,* **50(2)**: 87-90.

13. KAYA MD AND S GÜL (2024). Seed priming as a method of preservation and restoration of sunflower seeds. *OCL - Oilseeds and fats, Crops and Lipids*, **31(1)**: 1–9. https://doi.org/10.1051/ocl/2024001

14. KURDIKERI MB, MN MERWADE AND CHANNAVEERASWAMY (2000). Maintenance of viability in different crop species under ambient storage. *Seed Research,* **28(1):** 109-110.

15. PALLAVI M, SK SUDHEER, KS DANGI AND AV REDDY (2003). Effect of seed ageing on physiological, biochemical and yield attributes in sunflower (*Helianthus annus* L.) cv. Morden. *Seed Research***, 31(2)**: 161-168.

16. BASAVEGOWDA, ENAYAT, SEEMA BEEDI, SANGEETHA MACHA, UMESH HIREMATH AND MS HARISH **(**2019). Studies on enhancing seed performance of kabuli chickpea. *Int. J. Curr. Microbiol. App. Science, **8(4)**: 507-512*.

17. VYAKARANAHAL BS, M SHEKHARGOUDA, AS PRABHAKAR, SA PATIL AND SD SHASHIDHARA (2002). Studies on improvement of seed yield and quality in sunflower restorer lines. *Seed Research***, 30(1)**: 18-24

18. SGHAIER AH, H KHAEIM, Á TARNAWA, GP KOVÁCS, C GYURICZAAND Z KENDE (2023). Germination and seedling development responses of sunflower (*Helianthus annuus* L.) seeds to temperature and different levels of water availability. *Agriculture*, **13(3)**: 608. https://doi.org/10.3390/agriculture13030608