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Breaking Seed Dormancy in Some Selected Sunflower Accession using Pre-Germination Techniques

F. Garba, R.A*. Sami, H. Abubakar and M. Usman
Department Of Plant Science, institute for Agricultural Research, Ahmadu Bello University, Zaria
*Correspondence E-mail: rukkysami@gmail.com

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Abstract
Pre-germination techniques are essential for breaking seed dormancy in sunflower accessions. This study focuses on the use of indole-3-acetic acid (IAA), gibberellic acid (GA), hot water treatment, and potassium nitrate (KNO_3). These techniques have been extensively studied and proven effective in promoting germination in dormant sunflower seeds. IAA and GA, as exogenous plant growth regulators which plays a vital role in stimulating the synthesis of germination-related enzymes, thus breaking seed dormancy. Hot water treatment involves subjecting the seeds to specific temperature regimes, leading to the weakening of the seed coat thereby facilitating germination. Additionally, potassium nitrate treatment enhances seed germination by promoting water uptake and activating germination enzymes. The results revealed significant differences among genotypes and treatments for most parameters studied, highlighting the genotype-specific nature of dormancy treatment responses. Treatment of the SAMSUN I genotype with potassium nitrate yielded the highest germination percentage of about 98%, while the SAMSUN 3 genotype without seed coat showed the lowest percentage of about 77%. The hot water treatment emerged as the most effective method for breaking sunflower seed dormancy, followed by GA treatment. KNO_3 treatment showed moderate effectiveness, while IAA treatment had limited impact. Seed coat removal exhibited mixed results. Based on the findings mechanical scarification and auxins indole-3 acetic acid soaking were found to be effective in overcoming seed dormancy, while seed coat removal did not yield satisfactory results. These findings provide valuable insights into selecting appropriate methods to break dormancy in sunflower seeds, thus facilitating enhanced agricultural productivity.
Keywords: Sunflower, seed, dormancy, potassium nitrate, scarification, germination,

Introduction

Sunflower (Helianthus annuus L.) is a globally important oilseed crop, cultivated for its high-quality oil and nutritional value [1]. Seed dormancy is considered to be a serious constraint in sunflower seed production. Viable seeds sometimes do not germinate even in the presence of favorable environmental conditions. Such seeds are suspected to be dormant [2]. Dormancy can be defined as a condition in which there is a hindrance to germination as a result some inherent inadequacy of the mature embryo. Sunflower exhibits seed dormancy, which refers to its ability to resist germination under favorable conditions. This dormancy can be categorized into primary dormancy after harvesting and secondary dormancy induced by unfavorable environmental factors [3]. However, sunflower seed remains dormant for more than 40 days after harvest. Some dormancy causing agents are hard seed coat and enclosing tissues as well as genotypic variability which exists [4, 5]. Several techniques have been adopted with little success to break dormancy some of which includes hot water treatment and the use of phytohormones. A simple technique of hydro-priming to break seed dormancy was effectively utilized to break seed dormancy in sunflower genotypes has also been reported [6]. Various chemicals including growth regulators (gibberellic acid) have also been used to break seed dormancy in sunflower which has shown to double germination percentage over a non-treated control [7]. Studies have also showed that dormancy can also be broken down by ethylene and its precursors [8-10]. Ethrel is the most effective and also an expensive technique which is been commercially used to break seed dormancy in sunflower [11]. Soaking seeds in hot water and using chemicals has been shown to be effective also in converting the seed from dormant to non-dormant state [2]. Several techniques have been evaluated using treatments such as growth regulators, ethrel, hydro-priming, acetone and potassium nitrate which were found to be effective in breaking seed dormancy in sunflower [12]. Seed dormancy in sunflower poses a huge challenge to growers by reducing germination percentage. Dormancy mechanisms in sunflower seeds can vary,

including physical, physiological, and morphological barriers to germination [3]. The precise mechanisms responsible for seed dormancy in sunflowers are not fully understood, but one hypothesis suggests that the accumulation of abscisic acid during seed ripening may play a role. Other factors such as seed coat thickness, permeability, and genetic differences among sunflower varieties can also contribute to seed dormancy. It was once believed that temperature primarily regulated dormancy and germination in sunflower seeds, with light playing a secondary role. However, recent studies have shown that light also significantly influences seed dormancy. Therefore, it is now recognized that both temperature and light can impact the dormancy and germination of sunflower seeds [13]. Sunflower is one of the sources of high quality edible oil. Therefore, there is a need to increase its productivity [14]. Seed production and vigor are highly influenced by environmental factors such as temperature, water stress and depth of sowing seed. The seed shape and size also affect seedling emergence [15, 16]. During the process of germination, sunflower faces the problem of seed dormancy which is one of the most important constraints to its production. Such seeds do not germinate until some particular requirement (either endogenous or exogenous) is satisfied.

It is well known that seed dormancy after harvest delays sowing of the crop immediately. The sowing date has to be adjusted by the farmers to avail them enough time to break seed dormancy under natural growing conditions. As such there is a need for evaluation of the various dormancy breaking techniques as well as genotypic response to those techniques in order to minimize the period of seed dormancy favoring maximum seed production in the earliest possible time. The purpose of the study was to evaluate the most effective treatment for breaking seed dormancy using physical and chemical methods.

Materials and Methods

The experiment was conducted at the Institute for Agricultural Research (IAR) of Ahmadu Bello University (ABU), Zaria. The Sunflower seeds used for this study were gotten from the Sunflower unit at IAR. The experiment was conducted in a Completely Randomized Design (CRD) with four replicates per treatment. River sand was used for soil preparation, and the soil was washed thoroughly to remove any nutrients before being placed in plastic containers. The untreated seeds served as the control, while physical, and chemical methods were used to break seed dormancy. other treatments included scarification by removal of seed coat, soaking in hot water at 80°C for 15 minutes followed by air drying, and soaking in chemicals such as potassium nitrate (0.2% KNO3), gibberellic acid (GA-0.05%), and auxins indole-3 acetic acid (IAA-50ppm) for 15 minutes each. Planting was done in the laboratory with twenty-five healthy seeds sown in each container after creating twenty-five shallow holes on July 25th, 2023. Germination tests were carried out immediately after treatment by sowing seeds in plastic containers 2cm deep at a temperature of 28°C for a photoperiod of 12 hours. Data collected include: First day count Germination Index (GI), Mean germination Time (MGT), Germination percentage (last day count), Mean daily germination (MDG),Peak Value (PV) ,Germination Value (GV) and last day count which was done after fourteen days. The data collected on the last day include normal germination, abnormal germination, decayed seeds and fresh seeds which were each expressed as a percentage of the total number of seeds Sown in each plastic container. The germination percentage was calculated and the germination data were subjected to statistical analysis (ANOVA).

Results and Discussion

The results showed significant differences among genotypes and treatments for most parameters studied, highlighting the genotype-specific nature of dormancy treatment responses. Treatment with potassium nitrate yielded the highest germination percentage, while seed coat removal exhibited mixed results. Mechanical scarification and auxins indole-3 acetic acid soaking were found to be effective in overcoming seed dormancy. These findings provide valuable insights into selecting appropriate methods to break dormancy in sunflower seeds, thus facilitating enhanced agricultural productivity for this important crop. Furthermore, the mean of accession and treatment for mean decayed seeds, peak value and germination value from the analysis conducted showed that peak value and germination value were significant while decayed value was not significant as shown on table below.

Table 1: Mean of accession and treatment for mean decayed seeds, peak value and germination value

Accessions	DS	DSSQRT	PKV	GMV
SAMSUN 1	0.79b	0.89	4.96a	8.71a
SAMSUN 2	1.88a	1.37	4.00b	6.65b
SAMSUN 3	1.88a	1.37	3.65b	6.11b
SAMSUN 4	1.79a	1.34	3.60b	6.01b
Mean	1.58	1.26	4.05	6.87
SE	0.34	0.58	0.23	0.41
Treatments				
Control	1.19b	1.09	4.03	6.93ab
Seed Coat Removal	3.69a	1.92	3.73a	5.90b
Gibberellic acid	1.38b	1.17	4.30a	7.41a
Auxins indole-3 acetic acid	0.94b	0.97	4.03a	6.94ab
Potassium nitrate	1.44b	1.20	3.88a	6.58ab
Hot water (80°C)	0.88b	0.93	4.36a	7.47a
Mean	1.58	1.26	4.05	6.87
SE	0.41	0.58	0.28	0.50
Interaction	NS	NS	0.04*	0.03*

DCS - Decayed seeds, SQRT- Square root, PKV - Peak value, GMV – Germination value, SE- Standard error, NS- Not significant, *- Significant

The mean squares from the analysis of variance for replications were highly significant ($p<0.01$) for normal germination, abnormal germination and germination index indicating that these variables were greatly influenced by the pre-germination techniques employed. On the other hand, no significance ($p>0.05$) were observed for decayed seed, first day count, mean germination time, mean daily germination, peak value and germination value.

Furthermore, the mean squares from the analysis of variance for accessions were highly significant ($p<0.01$) for normal germination, decayed seeds, first day count, final day count and mean daily germination indicating that the genotype of the sunflower has a significant impact on these variables studied. However, abnormal germination, germination speed index, mean germination time, peak value and germination value showed no significance ($p>0.05$).

The mean squares from analysis of variance for treatments showed highly significant ($p<0.01$) for normal germination, abnormal germination, final day count, germination speed index, mean germination time, mean daily germination, peak value and germination value. Conversely, there was no significance ($p>0.05$) for decayed seed and first day count. Considering both the mean squares from analysis of variance for accessions and treatments, normal germination, peak value and germination value showed highly significant ($p<0.01$) indicating that both factors played a significant role in promoting normal germination. However, there was no significant effect ($p>0.05$) observed for abnormal germination, decayed seeds, final day count, germination speed index, mean germination time and mean daily germination (Table 1).

Table 2: Analysis Of Variance for Traits of Sunflower Evaluated At Samaru in 2023

Source of variation	DF	NGE	ABG	DSC	FDC	LDC	GSI	MGT	MDG	PKV	GMV
Replications	3	202.2**	188.7**	3.8	0.93	2.26	7.21**	0.3	0.01	1.67	4.2
Treatments	5	62.3**	20.6	17.8**	2.04**	14.21**	2.3	1.79	0.07**	0.95	5.3
Accessions	3	279.9**	200.9**	6.7	0.26	10.12**	12.79**	6.33**	0.05**	9.58**	38.1**
T×A	15	10.8**	10.1	1.67	0.26	2.19	1.82	1.07	0.01	2.33*	7.9*
Error	69	12.3	11.1	2.69	0.47	2.36	1.29	1.14	0.01	1.27	4.05

DF- Degree of freedom, FDC- First day count, LDC- Last day count, NGE- Normal germination, ABG- Abnormal germination, DCS- Decayed seeds, GSI- Germination speed index, MGT- Mean germination time, MDG- Mean daily germination, PKV- Peak value, GMV- Germination value**- highly significant, *- significant

Discussion

The results of the experiment revealed significant differences among genotypes and treatments for most of the studied parameters, with the exception of peak value, and germination value, which were found to be statistically significant and decayed seed was not significant. When examining germination percentage, treatment of the SAMSUN 1 genotype with potassium nitrate resulted in the highest value, while the SAMSUN 3 genotype without seed coat had the lowest percentage, although not significantly different from the former when the seed coat was removed. These findings suggest that the response to dormancy treatments is genotype-specific. Success has been reported in breaking seed dormancy using potassium nitrate [6]. Treatment of dormant seeds with certain nitrogenous compounds such as potassium nitrate results in turn improved seed vigor [17]. Hot water treatment affects the status of the cell membrane thus resulting in increased membrane permeability which allows solutes and growth inhibitors to come out from the cells (18). These plant growth regulators are effective in little quantities for breaking seed dormancy. Their excessive use is not recommended as it may likely bring about toxicity which will in turn produces negative effects on breaking dormancy. The consistent results have shown that the application of indole-3-acetic acid (IAA), gibberellic acid (GA), hot water treatment, and potassium nitrate (KNO_3) can effectively overcome seed dormancy. Treatment of seeds with hot water (80°C) has been proven to be highly effective in breaking seed dormancy [2] These techniques stimulate the synthesis of germination-related enzymes, weaken the seed coat, enhance water uptake, and activate germination enzymes, ultimately improving germination rates. Some of the genotypes responded negatively to one or more dormancy breaking treatments showing that germination response is genotypic dependent. Low to high level of variability were observed among the genotypes as confirmed by the co-efficient of variation. Genotypes exhibited variations in germination response upon chemical treatments for breaking seed dormancy, which may be due to difference in their genetic make-up. Other factors which may be involved in controlling dormancy are accumulation of growth inhibitors such as Abscisic acid which occurs at maturity [17] and hard seed coat [10]. At present a little success has been achieved in breaking seed dormancy since it is genotype dependent and the exact role of the dormancy breaking agents is not fully understood. Seed dormancy breaking treatments are confined up to seed germination level. Once the seed dormancy is released naturally or by pre-germination treatments (In vitro), the seedling can established itself into a new plant. However, it is obvious that an understanding of the mechanism of seed dormancy and role of the factors/agents responsible for the release of dormancy may be helpful in minimizing the period of seed dormancy in sunflower after harvest.

Conclusion

In conclusion, this study emphasizes the importance of considering genotype-specific responses to dormancy treatments in sunflowers. For SAMSUN 1, potassium nitrate treatment was found to be effective, while for SAMSUN 3, indole-3-acetic acid treatment showed positive results in breaking down seed dormancy and promoting faster germination. Mechanical scarification was also found to be successful, while seed coat removal did not yield satisfactory results. Based on these findings, recommendations are made to conduct additional research and experimentation to optimize the application methods and concentrations of pre-germination techniques for different sunflower accessions. It is important to consider environmental factors such as temperature, humidity, and light conditions. Tailoring the application of techniques to each specific sunflower accession and exploring the combination of pre-germination techniques with other seed treatment methods may enhance their effectiveness. Field trials are also necessary to validate the findings of laboratory-based studies and understand the practical application of these techniques in real agricultural settings. It is also suggested to increase the number of accessions in further research to determine the potential of other accessions in terms of seed dormancy and their reaction to various treatments. It is recommended to further research and experiment to optimize the application methods and concentrations of these substances for different sunflower accessions and environmental conditions.

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