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Influence of Seed Priming on Morphological Parameters in Groundnut (*Arachis hypogea* L.)

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ABSTRACT

Background: A study comprising laboratory and field research studies were conducted at the Department of Seed Science and Technology, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be) University, Bhubaneswar in 2022-23 to evaluate the relative effectiveness of different seed priming treatments and soaking duration enhancement to improve groundnut seed production and quality maintenance. The field study was set up using randomized block design (RBD) with three replications and eight priming treatments. For the experiment, groundnut seeds of the Devi variety were procured from a self-help group (SHG) located in the region of Pipili, Puri, Odisha.

Methods: Different priming treatments were applied to the seeds, including; Untreated (control, T_1), hydro priming (4 hours, T_2), 1% Na_2HPO_4 (4 hours, T_3), 1% $CaCl_2$ (4 hours, T_4), 1% KCL (4 hours, T_5), 0.5% Borax (4 hours, T_6), 25 ppm Gibberellic acid (4 hours, T_7), 0.5% KNO_3 (4 hours, T_8). The treatments mentioned above were used for seed priming and seeds were then dried back until their moisture content was the same as before.

Result: Plant growth parameters showed that seeds primed with 1% $CaCl_2$ had earlier 50% flowering and maturity, while seeds primed with 25 ppm GA_3 had the maximum plant height. Additionally, seeds primed with $CaCl_2$ showed an increase in yield attributing parameters, such as the number of pods per plant, pod weight, number of seeds per pod and test weight of seeds, which increased the yield per plant and per hectare.

Key words: $CaCl_2$, Groundnut, KCL, Plant growth parameters, Seed priming.

INTRODUCTION

The groundnut crop (*Arachis hypogaea* L.), cultivated over a hundred countries is the fourth-largest oilseed crop in the world. The seeds of groundnut are not only consumed raw but are also used as a vegetable oil in baking and cooking (Sepehri and Rouhi, 2017). The most important legume crop is groundnut because it fixes nitrogen into the soil without affecting the sensitive ecological balance (Khan *et al*., 2009). The term *Arachis* comes from Greek words "arachos" (mean weed) and "hypogaea" (mean underground chamber). According to all India *rabi* crop coverage report, Government of India, as on 5th January 2024, groundnut was sown in around 3.73 lakh hectares as compared to last year (4.62 lakh hectares). Among the states, Karnataka stood first in area coverage with 1.08 lakh ha followed by Tamil Nadu (0.76 lakh ha), Telangana (0.74 lakh ha), Odisha (0.59 lakh ha) and Andhra Pradesh (0.42 lakh ha) (Groundnut Outlook, January 2024).

In Odisha, the groundnut crop is produced in large amounts during the *rabi* season and in significantly smaller amounts during the *kharif* season. The state does not produce enough seed to fulfil the demand for seeds during the *rabi* season since it produces little seed during the *kharif* season (Das and Mohanty, 2018). The seeds from the previous *rabi* season are not good to utilize as seed for the current year because of their low storability. It is needed for the government to get seeds from other states, such as

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Karnataka and Andhra Pradesh and farmers often receive their seeds too late. Farmers depend on their own conserved seeds since government or public sector certified seeds (CS) or truthfully labelled seeds (TLS) are hard to come by or arrive late.

The performance of the above-mentioned crop is influenced by the use of poor-quality seeds and by adverse climatic conditions throughout the crop growth and crop-growing seasons. The combination of all these factors results in low agricultural productivity in the state. A technique called priming is applied to partially damaged seeds to improve their performance. It is known that seed priming is an essential strategy for enhancing seed tolerance oxidative degradation (Ashraf and Foolad, 2005; Jisha *et al*., 2013; Yan, 2015). The term "seed priming" refers to a pre-sowing treatment in water or an osmotic solution that prevents radicle emergence through the seed coat while allowing the seed to imbibe water to move on to the first stage of germination. Appearance of radicle through the seed coat is prohibited, in this process the seeds enter the lag phase but before radicle emergence get desiccated back to the initial moisture content (Arun *et al*., 2017). Seed priming results in improved seed germination, enhanced flowering, increase seed resistance to unfavorable environmental condition, its advantages have been seen for numerous field crops, resulting in a uniform and earlier plant stand along with yield related benefits in various field crops and oilseeds (Harris *et al*., 2007; Rehman *et al*., 2011; Diya *et al*., 2024, Das and Jana, 2016). Enhancement in seedling performance and crop establishment was found by using different priming treatments in groundnut (Dhedhi *et al*., 2007), soybean (Miladinov *et al*., 2020) and cowpea (Nabi *et al*., 2020).

MATERIALS AND METHODS

The freshly harvested seeds of groundnut variety 'Devi' were obtained from the groundnut breeder (SHG) situated at Pipili, Puri, Odisha. Various hydration treatments were used to soak seeds, followed by dehydration to obtain their original moisture content. Along with that, a set of unprimed seeds was maintained.

Eight clean beakers were filled with about 1 kg of groundnut seeds, to which chemical solutions and water in the appropriate quantities were added. Four hours of treatment duration was standardized for various priming treatments of groundnut variety used.

Different priming treatments used in the study are as follows, Control (T_1), Hydropriming (T_2), 1% Na_2HPO_4 (T_3), 1% $CaCl_2$ (T_4), 1% KCL (T_5), 0.5% Borax (T_6), 25 ppm GA_3 (T_7), 0.5% KNO_3 (T_8). The groundnut seeds were soaked in various treatments for four hours. The primed seeds for each treatment along with the unprimed seeds were line-sown at 15 × 30 cm, between plants and between rows on January 9th, 2023. The field was evenly distributed with 8.3 kg/plot of farmyard manure (FYM). Urea, MOP and DAP fertilizers were applied at a ratio of 0.6:1.2:1.2 kg ha^{-1} during sowing. At regular intervals, the intercultural operations and weeding were completed. Throughout the crop growing phase, the experimental plot was maintained clean. If necessary, irrigation was applied to the plots. The plants were harvested at physiological maturity stage, they were uprooted from each plot separately. The harvested pods were left in the field for seven days to dry in the sun after discarding contaminants such as, immature pods and soil clods on the pods. The dried pod yield (kg/plot) was recorded after drying. Evaluation of the impact of priming treatments on groundnut field performance involved recording observations on field emergence percentage, plant growth parameters, yield attributing traits and seed yield parameters. To facilitate additional biometric observations, five healthy plants were haphazardly opted out from individual plot and tagged separately.

Observations recorded during the field experiment

50 per cent flowering (Days)

For 50% of the plant population in each plot, from sowing to flowering arrival the total number of days was noted.

Plant height (cm)

Five plants were chosen at random and their heights were noted from the foundation to the growing point at harvest. The average plant height was measured in cm.

Maturity (Days)

It was noted as total number of days to reach physiological maturity taken from the date of sowing. Rough shell surface, prominent net venation and dark brown color are indications of physiological maturity.

Mature pods per plant (Number)

The pods considered as mature when they displayed prominent veins on surface of the shell and felt hard to the touch when pressed with the fingertips.

Seed yield /plant (g)

The pod yield per plant was determined and reported in grams after weighing each dried mature pod from the sample plants in each plot.

Seed yield /plot (kg)

The dry pod yield per plot was computed after the pods from each plot were weighed and sun-dried.

Laboratory observations

Test weight of seeds (g)

One hundred seeds were randomly collected from each replication. In this investigation total three replication data was used and the mean test seed weight was noted in grams.

Fresh weight of pods (g)

The pods are carefully cleaned and removed from the plants once the plants are harvested.

The pods of five observation plants are removed from each treatment of each replication and the weight of the pods is measured.

Seeds per pod (Number)

The seeds of each pod are taken out and the quantity of seeds in each pod is recorded once the pods are separated from the plants.

Pod length (cm)

The length of each pod was determined using a measuring scale of the sample plants and the average length was noted in cm.

Pod breadth (cm)

A measuring scale was used to determine the width of each pod on the sample plants and the average length was noted in cm.

Statistical analysis

The research data was assessed using the Analysis of Variance (ANOVA) techniques developed by Panse and Sukhatme (1985), Cochran and Cax (1967) and Gomez and Gomez (1984) to determine the effects of different treatments. The field observations were analyzed using randomized block design (RBD) and Laboratory observation was analyzed using completely randomized design (CRD).

RESULTS AND DISCUSSION

Although the flowering behavior of crops is greatly influenced by genotype and environmental conditions, it is also related to the vigor of the plants. The flowering behavior of the crops ultimately determines the potential yield since it influences seed development and maturity. In the current study, the flowering behavior of groundnut was examined in terms of 50% flowering in the plants. Significant differences were found between the treatments for this flowering behaviour according to the analysis of variance (Fig 1). With an overall mean value of 45.33 days, the mean days to 50% flowering varied from 41.0 (T_4) to 50.0 (T_8) days. When calcium was applied to the seed as a priming agent, it induced early flowering in T_4, but all other treatments observed flowering delays of up to one week. The current results corroborated those of previous studies by Jahangir *et al*. (2008) and Babu *et al*. (2018), which noted that seed primed with calcium chloride was shown to flower earlier.

In the current research, significant differences were seen between the treatments when the days to maturity were measured during the *rabi* season. The average number of days needed for maturity was 122.2 days, with a range of 121.7 days (T_4) to 122.7 days (T_6 and T_7) (Fig 1). Similar to flowering, T_4 showed early maturity, however all other priming treatments showed later maturity compared to the control. The early maturity in T_4 was induced by early flowering. The time to maturity decreased for plants primed with $CaCl_2$ as they began branching and flowering earlier. The preceding publications by Rehman *et al*. (2014) in Linola and Babu *et al*. (2018) in Groundnut support these findings.

The height of the plant is a crucial factor in determining its canopy development and photosynthetic efficiency. In the current investigation, the height of the sample plants in every plot were measured after the crop reached maturity. An ANOVA showed significant differences existed across the treatments (Fig 1). With an overall mean value of 38.66 cm, the mean values of the different treatments varied from 34.8 cm (T_1) to 42.9 cm (T_7). Due to the strong relationship between the duration of the vegetative phase and the daily average temperature during crop growth, shorter plants developed during the winter months due to the low minimum temperature (Bhaumik *et al*., 2007). The current conclusion is consistent with previous groundnut studies by Hasan and Ismail (2018) and Vardhini and Singh (2021). The utilization of GA_3 may have improved plant development, which can be linked to cell division and elongation. GA_3 stimulates the mobility of starch particles in the cotyledons and affects the activity of several enzymes, including amylase, which in turn promotes development.

Yield attributes

An important crop production parameter is the number of mature pods per plant. In this study, the number of mature pods at the maturity stage was counted in the plants of various treatments (Table 1). The seeds primed with $CaCl_2$ (T_4) had the significantly largest number of pods per plant

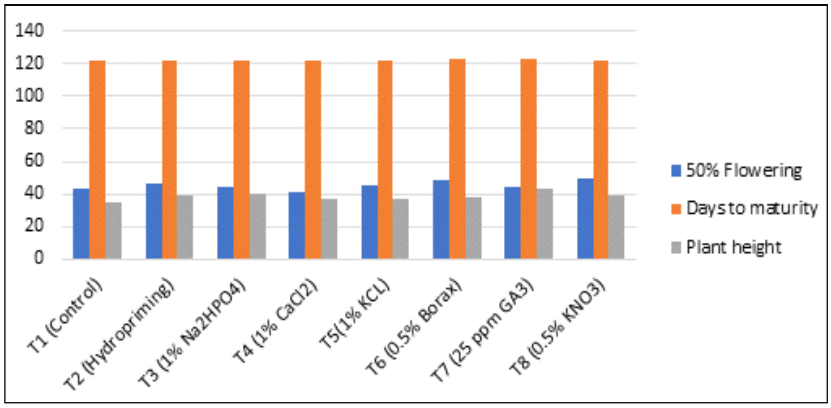


Fig 1: View of graph of plant growth parameters.

(22.1), followed by the seeds treated with KCL (T_5) (22.0), while the untreated seeds (T_1) had the lowest number of pods per plant (28.50). The current result was consistent with previous studies by Jahangir *et al*. (2008) and Babu *et al*. (2018), which found that groundnut seeds primed with $CaCl_2$ produced more pods per plant. In seed priming with $CaCl_2$, there are more pods per plant; this might be because the calcium improves groundnut pod filling, leading to a higher number of filled pods per plant.

The amount and size of the seeds within the fruit may be determined by weighing the pods. The total amount of dry matter collected, or fresh pod weight, indicates the level of seed development. A higher seed yield is frequently correlated with a larger fruit weight. A significant yield parameter of the crop is the weight of mature pods on a plant. In the current study, the weight of the mature pods in the plants undergoing various treatments was calculated. Based on the analysis of variance, it was shown that there was significant variation in this attribute between the treatments (Table 1). With an overall mean of 37.1 g, the differences across the treatments ranged from 27.6 g (T_1) to 43.6 g (T_4). The largest weight was observed in T_4 (43.6 g), followed by T_5 (39.9 g). This is because each plant produces a higher number of pods. In groundnut seeds primed with calcium chloride ($CaCl_2$), the fresh weight of pods per plant is greater. This might be because the calcium improves pod filling, leading to more pods per plant.

The quantity of seeds in the fruit or capsule at harvest time is also indicated by the size of the capsules at crop maturity, which ultimately establishes the potential yield of the crop. The quantity of seeds within a fruit or pod is determined by its length, which is an essential yield characteristic. After harvest, the pod length of sample plants from various treatments was calculated for the current study. Regarding this trait, the ANOVA showed that there was no significant difference across the treatments (Table 1). With an overall mean value of 1.9 cm, the mean values of the various treatments varied from 2.1 cm (T_4) to 1.8 cm (T_1). The largest pod was observed in T_4 (2.1 cm), followed by T_5 (2.0 cm). With an overall mean value of 3.7 cm, all priming treatments had a positive impact on this trait. The mean values of pod breadth for the various treatments varied from 3.2 cm (T_1) to 3.8 cm (T_2, T_3, T_4 and T_5). The mean pod breadth of the treatments was greater than that of the control; T_2, T_3, T_4 and T_5 had the largest pod breadth (3.8 cm), followed by T_7 and T_8 (3.7 cm).

Another essential yield attribute of agricultural plants is the number of seeds per capsule. An increase in the number of seeds per fruit is an indication of improved growth circumstances for the seed crop, especially during the reproductive phase. Any factor that affects pollen viability and pollination has an adverse effect on this trait. The amount of pollination and fertilization, as well as the process of seed development that produces mature seeds, determine how many seeds reside in a fruit (pod). The number of pods per plant and seed per pod determines the crop yield. Thus, this trait is regarded as one of the crucial yield attributes. The number of mature pods and seeds on the sample plants at the maturity stage were counted in the current study. For this character, the analysis of variance showed that there were significant variations between the treatments (Table 1). The average values of the different priming treatments varied from 1.8 (T_1 and T_3) to 1.9 (T_2, T_4, T_5, T_6, T_7 and T_8). A smaller number of seeds in the capsules may have formed because of the poor weather, especially the low temperatures that are typical during the *rabi* season.

Seed weight is one of the most important parameters that influences yield. It is believed that more photosynthates or assimilates will be mobilized by vigorous plants into the developing seeds, resulting in the development of bold and heavy seeds. According to the ANOVA, the mean values of the different treatment varied from 50.7 g (T_1) to 56.4 g (T_4) with an overall mean value of 53.4 g. When compared to the control, it was discovered that all the priming treatments were effective to improving seed weight to some extent. The use of $CaCl_2$ (T_4) as a priming treatment for four hours produced the highest test weight of seed (56.4 g) of

Table 1: Outcome of priming of seed technique on yield attributing parameters.

Treatments	No of pods /plant	Fresh wt. of pod (g)	Pod length (cm)	Pod breadth (cm)	No. of seeds / pod	Test weight (g)	Seed yield / plant (g)	Seed yield /hectare (Kg)
T_1 (Control)	17.9	27.6	1.8	3.2	1.8	50.7	15.5	3695.3
T_2 (Hydropriming)	19.1	38.4	1.9	3.8	1.9	50.8	17.1	4505.5
T_3 (1% Na_2HPO_4)	18.3	34.8	1.9	3.8	1.8	55.6	15.8	4344.9
T_4 (1% $CaCl_2$)	22.1	43.6	2.1	3.8	1.9	56.4	21.7	4606.9
T_5 (1% KCL)	22.0	39.9	2.0	3.8	1.9	55.6	20.8	4602.6
T_6 (0.5% Borax)	18.7	38.8	1.9	3.6	1.9	53.7	17.5	4594.5
T_7 (25 ppm GA_3)	19.3	38.0	1.9	3.7	1.9	52.7	16.7	4437.4
T_8 (0.5% KNO_3)	21.1	35.5	1.9	3.7	1.9	51.7	16.4	4432.6
Mean	19.8	37.1	1.9	3.7	1.9	53.4	17.7	4402.5
SEm (±)	1.74	4.72	0.11	0.09	0.02	0.84	1.32	84.71
CD (5%)	4.88	13.21	0.30	0.25	0.06	2.35	3.69	237.21

the treatments evaluated followed by T_5 and T_3 (55.6 g) with a 9.66% higher over the untreated control. The increased vigor of the plant resulted in the development of bold and heavy seeds. Increased photosynthate synthesis might result in the production of bolder, heavier seeds by mobilizing more photosynthates to the developing seed. Previous research on groundnut by Babu *et al*. (2018) has shown a significant increase in seed weight.

Any research related to the commercial cultivation and seed production of a crop must take seed yield into consideration. In the present investigation, the yield potential of the groundnut variety was assessed only on a per-plant basis. The no. of mature pods on a plant, the no. of seeds in each pod and the average seed weight are all factors that affect the quantity of seeds produced per plant and are therefore regarded as essential yield components. There was significant variation between the treatments this is what the results of the analysis of variance of these two yield parameters showed (Table 1).

Mean value for the seed yield values of the various treatments was between 15.5 g (T_1) and 21.7 g (T_4). Out of all the treatments studied, T_4 had the highest yield value (21.7 g), followed by T_5 (20.8 g). The formation of bolder and heavier seeds and the production of more mature pods/ plant and ature seeds per pod are responsible for the rise in seed output. This might be the result of increase in more seed germination, vigour and mature pods in each plant kernel, yield per plant and 100 seed weight. This result was supported by the findings of Moharana *et al*. (2023) in groundnut and Golezami *et al*. (2014) in mung bean. The seed yield was increased may be due to increase in germination enzyme activity in primed seed as compared to unprimed seed. This supported the research given by Tiwari *et al*. (2018) in pigeon pea, where germination enzymes, alpha-amylase and protease enzyme activity was increased in seeds primed with GA_3 as compared to others. With an overall mean of 4402.5 kg, the mean values of seed production per hectare for the various treatments varied from 3695.3 kg (T_1) to 4606.9 kg (T_4). The T_4 had the greatest yield value (4606.9 kg) that the study's result indicated, followed by T_5 (4602.6 kg) among the treatments. There is an increase in yield attributing parameters such as number of pods/plants, weight of the pod, number of seeds/pods and test weight of seeds in seeds primed with $CaCl_2$, which leads to an increase in per plant and per hectare yield. A higher seed output for each plant and for each hectare has been seen when calcium is added to the fruiting medium. This helps to create full fruits and promotes the development.

CONCLUSION

Compared to the control, 50% more flowering was observed after the priming treatments. In 1% $CaCl_2$, the days to 50% flowering (T_4) were earlier. When compared to control there was a noticeable increase in early flowering (2.0 days). In priming treatments height of the plant was also increased. The highest height of the plant was observed in 25 ppm GA_3 *i.e.*, 42.9 cm (T_7). An enhancement of 23% height of the plant was observed in comparison to the control. Observations was recorded on yield attributes namely, length of the pod, breadth of pod, no. of mature pods, fresh weight of the pods, no. of seeds per pod, test weight, seed yield characteristics namely, seed yield/plant and seed yield/hectare. Thus, based on the findings, it was concluded that groundnuts seeds if primmed with $CaCl_2$ for 4 hours may enhance the morphological parameters and may results in increasing the yield which can be beneficial to the farmers.

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Conflict of interest

As declared by the authors of the manuscript no conflict of interest is present.

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