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RESEARCH PAPER

Effect of seed priming and seed dressing on germination and growth of cotton (*Gossypium hirsutum* L.)

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Key Message: The results of this study demonstrate that the coating and application of bio-fertilizers on cotton seeds enhances the seed germination and evidently early growth of seedlings, particularly in loamy soil.

Abstract

This research is conducted to examine the impacts of several seed treatments such as scaling of seed on early growth and other developmental parameters of cotton (*Gossypium hirsutum* L.) crop. The vigorous seeds of cotton genotype "GH-Uhad" were sown in different growth media including loamy soil, brick red soil, ash, press mud, bio-fertilizer and in control zone after treatment with amino acids, potash, sugar, moringa leaf extract, and water. Results showed that only 2.5 days were taken to exhibit the shortest mean emergence time with ash and bio-fertilizer treatment and the longest time with 5.2-5.23 days were required with loam and press mud. For growth parameters, the tallest cotton plants (47 cm) were measured with highest fresh shoot (43.5 g) and fresh root (4.3 g) weight with loam and PGR (plant growth regulator) Treatment in comparison of press mud treatment with shortest plant height (33.5 cm), lowest weight of fresh shoot (14.4 g) and fresh root (1.5 g). In case of dry root weight, loam and PGR treatments displayed the highest weight (1.34 g), while the press mud had the lowest (0.39 g). In addition, the longest root length (21 cm) was recorded with the treatments of loam and PGR however the brick red Treatment had the shortest root length (11.75 cm). Overall, the results demonstrate that seed dressing with bio-fertilizers, especially in loam soil, can significantly enhance cotton germination and early growth, suggesting its potential for improving cotton crop performance in arid regions.

Keywords: Biofertilizers, *Gossypium hirsutum*, Growth parameters, Moringa leaf extract, Seed priming

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Introduction

Cotton (*Gossypium hirsutum*) is widely recognized as 'white gold' and serves as a crucial non-food cash crop, playing a critical role in the national economy (Ali et al., 2012). It stands as a primary source of raw material for the textile sector, which is the largest agro-based industry (Zia et al., 2018a, b; Shoukat et al., 2020; Shaukat et al., 2021). Pakistan holds a prominent position in the global cotton industry, ranking as the 4th largest producer, consumer, and exporter of yarn, and the 3rd largest exporter of raw cotton (Zia et al., 2015). The significance of cotton in Pakistan extends beyond production and export figures. Approximately 45 percent of the workforce is employed in the cotton industry, contributing significantly to the country's economic activity (Nawaz et al., 2021). Moreover, cotton contributes to 60% of foreign exchange earnings (Rana et al., 2020). This vital crop serves as a means of livelihood for over 1.5 million farming families, further boosting the economy in term of export covering a wide range of products and by-products (Economic Survey of Pakistan, 2012-13). Considering as a lifeline of Pakistan's economy, the cotton crop holds a share of 0.8% in GDP and 4.1% to the overall value addition in agriculture (Rana et al., 2020). Besides all, this sector encounters substantial challenges as compare to other crops. For Pakistan, the climate change, insect pests attack, diseases and poor quality seed are major challenges for cotton production (Rauf et al., 2019).

During 2019-2020, the cultivation of cotton crop increased by 6.5% (2,527000 hectares) in comparison with previous years of cultivation (2,373000 hectares) (Dawn, 2020). Despite this expansion, cotton production faced a decline of 6.9% (approximately 9.178 million bales) in the year 2019-2020 as compared to 2018-2019 where cotton produce was 9.861 million bales (Global Agricultural Information Network, 2021). Several factors contributed to the suboptimal performance, including adverse weather conditions and limited water availability during crucial stages of plant development. Pest attacks including infestations of whitefly, pink bollworm, and other pests and insects further increased the challenges adversely impacting crop output.

The cultivation of cotton requires proper protection from threats like chewing insects and borers. It requires a significant amount of fertilizers and pesticides for efficient production (Deguine et al., 2008). In Pakistan, Punjab and Sindh have honored to grow cotton on a large scale, while in regions of

KPK and Baluchistan, it is cultivated on a smaller scale. Punjab is the main and specialized sector for cotton cultivation, with notable districts including Jhang, Raheem Yar Khan, Bahawalnagar, Bahawalpur, Vehari, Khanewal, Multan, Rajanpur, Muzzafarabad, Lodhran and Faisalabad. North-Eastern parts of Sindh (Ghotki, Nawabshah, Kazi Ahmed, Nausheroferoz & Khairpur) are also famous to cultivate cotton crop (Shuli et al., 2018).

Besides of providing fiber to clothing and home textile, cotton is also serving as the source of high quality feed for animals (Narain et al., 1960). Moreover, food and beauty industries are also relying on cotton seed oil for their several products (Mirpoor et al., 2021). Similarly, applications of long fiber linters are found in medical supplies and short fiber linters are practicing in weapons and arms technology. Even though, the waste parts of cotton crop utilize to make evocative designs and eco-friendly packing (Barnes, 2011). Soil erosion, one of the major agriculture constrains, can be controlled by mulching of ginning by-products. Various cotton by-products can be found in a wide range of products, from hot dog casings and baseballs to ice creams and home furnishings, as well as everyday items like cotton swabs and wipes (Blake, 2013).

Seed imbibition plays a crucial role in the germination of cotton crops. Some cotton approaches may result in the formation of dormant seeds, which, when dried, become water-resistant, leading to delayed germination. Priming, a technique enhancing emergence and early growth in drying soils, has shown promise in laboratory settings. On-farm seed priming can partially offset the challenges posed by large aggregates size and ability of soil to hold water help in crop establishment (Farooq et al., 2019). The widespread use of agrochemicals has contributed to yield stagnation, with fertilizers holding a crucial position among them. Synthetic fertilizers have no effective substitutes, and cotton production relies on inorganic fertilizers for nutrient supplementation (Mehasen et al., 2012). Various factors, including insufficient spraying practices and excessive chemical use, have led to pest resistance to available insecticides. Farmers, grappling with bollworm infestations and seeking to recover losses, resort to more expensive and toxic chemicals with diminishing effectiveness (Klümper & Qaim, 2014). Insects, having developed familiarity with harmful chemicals, survive exposure to insecticides. This continuous use of insecticides accumulates, significantly impacting the economics of cotton production (Rehman et al., 2017). The pressing need for advancements in production research is hindered by the challenge of maintaining current yield levels. The cost of production has risen to unsustainable levels in many countries, posing a threat to the economic viability of cotton production (Kooistra et al., 2006). Therefore, this research study was conducted to ease the seed planting by improving the germination process through plant growth regulators.

Materials and Methods

Plant material

3 Kg of sound and vigorous cotton seed of variety/genotype "GH-Uhad" were brought from the Pakistan Agricultural Research Council (PARC) AZRC (Arid Zone Research Center), Dera Ismail Khan, KPK, Pakistan during 2020. Total six treatments were taken. The seeds of each treatment were treated in 20cc amino acid 10%, 10cc Potash (K_2O) 30% , 2cc MLE 3% (Moringa leaf extract), 500 ml Water and 50 grams of sugar .The solution that we prepared was used for seed dressing. We took six pots for each replication then we took 1kg of each loam (T1), Brick red (T2), Ash (T3), Bio-fertilizer (T4), Press mud (T5) and Control (T6). The seed dressing was done to improve the germination.

Preparation of soil

The experiment was managed on clayey soil having good water retention capacity. Irrigation was done before 15 days of seed sowing. After that ploughing was done to the soil with rotavator for removal of weeds and breakage of soil aggregates. At the time of sowing, nitrogen and phosphorus based fertilizer (DAP) applied @ 50 kg/acre.

Experimental design

To evaluate the growth parameters of cotton crop, the experiment was carried out at field station Arid Zone Research Center, D. I. Khan, KPK, Pakistan in kharif, 2020. The research was conducted in a split plot design of about 80*100 square feet by applying RCBD (Randomized Complete Block Design). There were total six treatments: T1 = Loam + Plant growth regulators (PGR); T2 = Brick red + PGR; T3 = Ash + PGR; T4 = Bio-fertilizer + PGR; T5 = Press mud + PGR; T6 = Control. On 12th June,2020 dibbling method was used to sow the seeds with row to row distance of 75 cm and plant to plant distance was 24cm. Thinning was done to remove the weaker plants after seed germination.

Parameters studied

Time to start emergence (days)

Germinated seeds were calculated and noted on regular basis for each treatment from sowing date.

Mean emergence time (days)

$$\text{Mean emergence time (days) (\%)} = \frac{\sum Dn}{\sum n}$$

(D indicates the days and n is the number of emerged seedlings)

Root length (cm)

Length of roots is measured after 50 days of seed germination and record was maintained.

Plant height (cm)

Height of cotton plant in each treatment was measured 50 days after emergence and the data was recorded.

Root fresh weight (g)

Fresh root weight of cotton seedlings in each Treatment is recorded 50 days after emergence with the help of electronic balance.

Root dry weight (g)

Dry root weight of cotton seedlings in each Treatment is recorded 50 days after emergence with the help of electronic balance.

Shoot fresh weight (g)

Shoot fresh weight of cotton seedlings in each Treatment is recorded 50 days after emergence with the help of electronic balance.

Shoot dry weight (g)

Shoot dry weight of cotton seedlings in each Treatment is recorded 50 days after emergence with the help of electronic balance.

Results

Time starts to emergence (Days)

The results presented in Table 1 highlight the varying times required for seed emergence under different treatments. Bio-fertilizer treatment demonstrated the shortest time to maximum emergence, taking only 2.2 days. In contrast, the control treatment displayed a comparatively prolonged germination period, necessitating 3.8 days for the seeds to emerge. The remaining treatments including Loam, Brick Red, Ash and Press Mud also demonstrated distinct germination times contributing to a comprehensive understanding of the temporal dynamics associated with each Treatment. Days for emergence of cotton seedlings with various treatments.

Table 1 Days for emergence of cotton seedlings with various treatments

Treatments	Days for germination
Loam	2.6
Brick red	2.8
Ash	3.6
Biofertilizer	2.2
Press Mud	3.2
Control	3.8

Mean emergence time (MET)

Table 2 represents the mean emergence time (MET) of cotton from day 2-6 with different treatments. The results revealed that in treatment T3, an earlier development took place with shortest time of emergence (2.5 days) while Treatment T1 and T5 took longest period of time (5.2 days). These findings provide the sequential features of growth and also insightful dynamics of crop performance in context of the studied treatments over specified time.

Table 2 Days of Mean Emergence time (MET) in context of various treatments

Treatment	2nd day	3rd day	4th day	5th day	6th Day	MET (Days)
T1	2	2	2	3	4	5.2
T2	1	3	4	4	4	3.4
T3	4	4	4	4	4	2.5
T4	1	2	3	4	4	4.1
T5	2	3	3	4	4	5.23
T6	3	3	4	4	4	4.6

Weight of fresh shoots (g)

A significant variation is to be seen in the performance of different treatments for fresh shoot weight. Notably, the maximum fresh shoot weight (43.5 g) had been borne in treatment T1 whereas treatment T5 indicated the minimum shoot weight (14.5 g) (Table 3). These outcomes highlight the significant impact and efficacy of each treatment on the growth and development of fresh shoot weight.

Weight of dry shoots (g)

In Table 4, the maximum dry shoot weight (7.315 g) was recorded in the Treatment T1, while the least favorable outcome was obtained from Treatment T5 with dry shoot weight (3.89 g).These outcomes put emphasis on the substantial impact of the particular Treatment on the growth of dry shoot weight and an indicate of optimizing conditions to enhance the plant biomass. The findings in Table 4 demonstrate the effectiveness of various treatments that offer strategies to improve the overall plant health.

Table 3 Weight of fresh shoots (g) of cotton crop under different treatments

Treatments	Weight of fresh shoots (g)		Average
	Shoot 1	Shoot 2	
T1	34.11	53	43.555
T2	26	34	30
T3	18	22	20
T4	42	32	37
T5	14	15	14.5
T6	26	24	25

Table 4 weight of dry shoots (g) of cotton plant under different treatments

Treatment	Dry shoot weight (g)		Average
	P1	P2	
T1	3.88	10.75	7.315
T2	5.91	4.35	5.13
T3	4.26	6.24	4.25
T4	3.77	5.31	4.54
T5	4.78	4	3.89
T6	4.12	4.32	4.72

Weight of fresh root (g)

Table 5 illustrates the impact of various treatments on the development of fresh root weight. Treatment T1 performs the most influencing results in the form of highest fresh root weight (4.384). In contrast, treatment T5 yielded lowest root weight (1.52 g). These observations highlight the significance of specific treatment on fresh root weight and provide a crucial element for plant nutrition. It also plays a part in stimulating the plant productivity.

Weight of dry root (g)

The results presented in Table 6 illuminates the importance of applying different treatments on cotton crop. Treatment T1 induced the maximum dry root weight (1.34 g) and treatment T5 provided the minimum dry root weight (0.39 g) (Table 6). These findings emphasize on the potential to increase dry root weight, nutrient uptake and plant stability. The presented data in Table 6 also offers a vision to influence the dry root weight of cotton plants by applying different treatments.

Table 5 Weight of fresh roots (g) of cotton plant on various treatments

Treatment	Weight of fresh roots (g)		Average
	R1	R2	
T1	3.498	5.27	4.384
T2	1.52	3.29	2.405
T3	3.02	4.13	3.575
T4	2.59	2.35	2.47
T5	1.15	1.85	1.52
T6	3.42	2.85	3.135

Table 6 Effect of various treatments on dry root weight (g) in cotton

Treatment	Weight of dry root (g)		Average
	R1	R2	
T1	1.68	1	1.34
T2	0.65	0.25	0.45
T3	0.51	0.62	0.565
T4	0.51	0.47	0.49
T5	0.58	0.2	0.39
T6	0.34	0.58	0.46

Height of plants (cm) and length of roots (cm)

Influence of various treatments on plant height and length of roots of cotton plant presented in Table 7. The highest cotton plant (47 cm) with the longest root length (21 cm) obtained from treatment T1. In the contrary, Treatment T5 showed the smallest plant height (33.5 cm) along with the shortest root length (11.75 cm). The experimental differences in plant height and root length among treatments imply significant influences on the growth and development of cotton plants. These findings underscore the importance of the specific treatments in influencing both above-ground and below-ground growth parameters, providing valuable insights for optimizing conditions to enhance plant height and root development in cotton cultivation.

Table 7 Effect of various treatments on plant height (cm) and root length (cm) in cotton

Treatment	Plant height (cm)	Root length (cm)
T1	47	21
T2	39	11.75
T3	45	17
T4	42	15
T5	33.5	13.25
T6	43	15.75

Discussion

Salinity is a significant challenge for crop production in dry regions. The stages of seed sprouting and growth of seedlings are particularly vulnerable to salt stress, causing negative physiological and biochemical effects on germinating seeds. Salinity hinders germination by reducing water availability, altering the use of stored reserves, and impacting protein structure. Techniques like seed priming, where seeds are exposed to stress beforehand, enhance resistance to salinity. Priming of seed activates progressions in metabolism, preparing the seed for germination, improving antioxidant activity, and repairing membranes. This paper aims to review recent literature on how plants respond to seed priming under salinity stress, discussing the mechanisms affecting seed germination and summarizing the seed priming process. The review covers physiological, biochemical, and molecular changes induced by priming that enhance seed performance. There is limited information for many crops; further research is needed to explore their responses under salinity stress towards priming of seeds.

An investigation was carried out by Basara et al. (2003) on the impact of priming of seed on the production of canola and its and its constituents. They explored that freshly osmoprimed seeds for eight hours had more positive impact on the number of branches/plant statistically comparable to previously osmoprimed seeds for 4 hours. However the maximum no. of pods was obtained by the four hours osmoprimed seed. Also, the total dry matter, the highest grain weight and seed yield noted for seeds formerly osmoprimed for 4 hours. Arif (2005) analyzed that the priming of seeds induced earlier growth and higher development in contrast to non-primed seed. Compared to non-primed seed, primed seed bared more dense and taller plants and higher yield of grain. Besides this, priming of seed for longer duration delay seed germination and increase maturity of cotton crop along with decline in produce and dry matter of crop plant. Furthermore, Increase in the concentration of plant growth regulators by 300 g/L of water increase the dry matter and grain/pod but responsible for decline in emergence/m^2, flowering and maturity period.

Rashid et al. (2004) found that the seed priming had direct effect on mungbean yield. They observed an average increase in grain yield of mungbean by only 30% of seed priming across 39 trials during their 4 years study period. Seed priming was not only connected with rapid growth and development but also had a positive impact on germination and emergence, improved crop stand and produce more productive plants. The researcher recommended the use of seed priming to the mungbean growers due to its beneficial attributes towards crop productivity.

Hofmann et al. (1992) examined that the emergence of seedlings in grain crops such as wheat (*Triticum aestivum* L.) and oat (*Avena sativa* L.) was gently stimulated by applying an aerobic pre-sowing treatment regardless of higher or lower quality seeds. For both species and qualities, a significant improvement saw in the field emergence percentage. In a two-year study, Giri & Schillinger (2003) explored the effect of seed priming on the germination and yield of winter wheat involving laboratory, greenhouse, and field components. They used two cultivars with moderate (Madsen) and strong (Edwin) emergence capabilities. Field and greenhouse experiments proved to be most favorable. For Madsen's emergence, seed priming with KCL, PEG and water worked well but not for Edwin's emergence. In the field, Edwin showed greater rate and extent of seedling emergence in ¾ sowings, regardless of the priming media. However, none of the seed priming media benefited field emergence or subsequent grain yield in either cultivar compared to checks. Overall, the results suggested that seed priming had limited practical value for enhancing emergence and yield of winter wheat planted deep into summer fallow.

Chojnowski et al. (1997) found that sunflower (*Helianthus annuus* L.) seeds exhibited higher germination rates at high temperatures (25-30 °C) compared to temperatures below 20 °C. They discovered that osmopriming Mirasol seeds with polyethylene glycol-6000 for 3-5 days at 15 °C significantly increased germination at suboptimal temperatures. This positive effect of priming persisted even after seed re-drying and during subsequent storage at 20 °C (55% RH) for at least 14 weeks. However, during accelerated aging (45 °C, 100% RH), primed seeds deteriorated faster than untreated seeds. The longer the priming treatment, the higher the germination rate, but this practice increases the sensitivity of seeds to accelerate aging. Priming enhanced the respiratory activity of seeds when transferred to water and their ability to convert laminocyclopropane-l-carboxylic acid (ACC) to ethylene. These effects were retained in the course of dry storage then vanished on later stages. The findings of this research proposed that ethylene-produced-ACC might be accountable for seed strength, expanding the duration of priming and responsible for decline in seed viability significantly. As ACC oxidase activity depends on membrane properties so the reduction in conversion of ACC into ethylene shows a potential association with membrane deterioration. Nevertheless, in aging process, no electrolyte linkage was detected.

Chiu et al. (2002) stated that seed priming enhances the growth and development of crop on one side but it also decreases the longevity of seed. The plausible reasons of the deterioration of primed seed are still not found. They had done their research on finding the impacts of priming and storage temperature by using the shrunken-2(sh-2) gene on emergence and anti-oxidative activity of sweet corn (*Zea mays* L.) Seeds were stored at 25 °C, 10 °C and -80 °C for up to 365 days. The technique of solid matrix priming helped to improve growth, increased metabolic activities and reduced lipid peroxidation but the longevity of seed declined at 20 °C. Higher viability and vigor was attained with primed seeds at 10 & 15 °C. Primed seeds stored at 20 °C were enhanced the peroxidation activities but at 10 °C and -80 °C extend the storability. In addition, Sh-2 primed seeds at 10 °C and or 15 °C storage retained the viability for about 12 months.

Hussain et al. (2015) explored the impact of prolonged storage on the viability of primed rice seeds and its implications for commercial use. They conducted experiments on rice, focusing on three key aspects: (1) the influence of extended storage (210 days) at 25 °C or -4 °C on the viability of primed and non-primed rice seeds, (2) the duration of viability for primed rice seeds when stored at 25 °C, and (3) whether post-storage treatments such as re-priming or heating could restore the viability of stored primed seeds. Using two rice cultivars and three priming agents, the study revealed that prolonged storage at 25 °C significantly decreased the germination (>90 %) and growth attributes (>80 %) of primed rice seeds compared to un-stored primed seeds. However, no such negative effects were observed in primed seeds stored at -4 °C. The positive effects of seed priming persisted for only 15 days of storage at 25 °C, beyond which the performance of primed seeds deteriorated even more than non-primed seeds. The decline in performance at 25 °C was linked to hindered starch metabolism in primed rice seeds. Despite attempts with post-storage treatments like re-priming or heating, none could restore the lost viability of primed seeds. This suggests that extended post-priming storage at 25 °C renders seeds unviable, highlighting a limitation to the application of seed priming in commercial practices.

Brar et al. (2019) analyzing the physiological aspects of naturally aged onion (*Allium cepa* L.) seeds under six priming treatments i.e. biofertilizer (Azobactarial), dry dressing with Thiram (2 g/kg), hydration with GA_3 (50 ppm), hydration with KNO_3 (0.5 % solution), hydration with KH_2PO_4 (0.5 % solution) and control. The goal was to identify the most effective priming Treatment. The researchers observed a significant decrease in standard seed germination, seedling length, seedling dry weight, seed vigor indices I & II, and viability (Tz test), while electrical conductivity increased as the aging period progressed. In summary, the study indicated that onion seeds lose their viability rapidly under typical storage conditions. Therefore, the use of GA_3 at 50 ppm and bio-fertilizer (Azotobacter) as priming treatments can effectively enhance the vigor and viability of onion seeds. These priming treatments have the potential to improve the seed quality when stored for up to one year.

Conclusion

The present study concludes that the seed priming and seed dressing have positive effects on the germination of cotton. From the whole treatments we have concluded that the seed pelleted with "Loam" performed best in each parameter except days to start germination and MET. Having highest plant height, fresh shoot weigh, dry shoot weight, and root weight it is concluded that seed dressing is an effective, practical and facile technique to enhance rapid and uniform emergence, high seedling vigor, and better yields in many field crops particularly under unfavorable environmental conditions.

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