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Efficacy of seed pre-treatments on seed vigour index with exogenous jasmonic acid and salicylic acid to mitigate pathogen -induced stress in mungbean selected genotypes in India

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Abstract

Our agriculture is threatened by resource depletion, biodiversity loss, and climate change. A new agricultural revolution is necessary to increase crop productivity and sustainably ensure food quality and safety. SA and JA were used to prime seeds, which can assist in assuring the long-term viability of agriculture. Seed elicitor priming is a potent method for altering the metabolic and signalling pathways in seeds, which impacts the whole plant life cycle, not only germination and seedling establishment. A few advantages include higher nutritional quality of food, greater output and improved plant growth and development. The effects of elicitor priming on metabolic pathways and the balance of reactive oxygen species and plant growth hormones increase stress and disease tolerance while lowering the need for pesticides and fertilizers. To evaluate seed vigour, shoot weight, shoot height and germination % were employed. Indicating that pre-sowing treatments can have either positive or negative effects on seed vigour depending on the treatment dose, the use of SA and JA in combination as an elicitor had a marginally advantageous impact on seed vigour. More studies are required to determine their effects and the ideal seed priming dosage.

Keywords

JA; *M. phaseolina;* mungbean; pre-sowing seed treatment; SA; seedling vigour

Introduction

The widely farmed mung bean (*Vigna radiata* L.) is a seed legume crop mainly used as a source of digestible protein for people and animals (24-27 %). Due to their high protein content, mungbean seeds are a great addition to most cereal-based diets that lack lysine (1). It can boost soil fertility and bio-stabilize atmospheric nitrogen, among other things. Mung beans (*Vigna radiata* L.), a widely cultivated seed legume, are principally utilized as a source of digestible protein for people and animals (24-27 %). Due to their high lysine content, mungbean seeds are a fantastic addition to most cereal-based diets (2). It can boost soil fertility and bio-stabilize atmospheric nitrogen, among other things.

It belongs to the Leguminoseae plant family's Papilinoidae subfamily. Even though it is primarily cultivated in Asia, it has recently expanded to Africa and the Americas. Mungbean is a beneficial crop typically grown in dry and semiarid regions due to its early maturity and ability to restore soil nutrients. This important crop is being destroyed by the soil-borne plant disease *M. phaseolina*, which produces charcoal rot (3). This widespread fungal disease affects 500 plant species in the tropics and subtropics, including angiosperms and conifers (4).

Compared to unprimed seed, seed priming procedures like hydro priming, hormone priming, or nutrient priming have increased the seed germination rate, speed, uniformity, percentage and seedling vigour (5). This technique allows the seed to retain as much stored, saved nutrients as possible while preventing damage to the seed cell membrane during the imbibition phase, the most critical germination stage. In the field, seed priming techniques improve seed resistance to abiotic stress (6)

In contrast to previous treatments, (7) found that priming mung bean seeds with phosphorus at a concentration of 0.6% for five hours boosted germination speed, radicle length, seedling vigour index and seedling dry weight (distilled water, salicylic acid and dry seeds). By radicle and branch length, seedling dry weight and seedling vigour index measurements, (8) discovered that soaking mung bean seeds in 10 and 20 mg L^{-1} salicylic acid for 4 and 5 hours increased seedling vigour. Furthermore, (9) found that, compared to dry seeds treatment, soaking mung bean seeds in distilled water for 4 hours significantly increased germination ratio, radicle and stalk length, seedling dry weight and vigour index. This study aims to investigate how successful elicitor pre-treated procedures are in terms of seedling vigour in mung bean seeds.

Plant roots stems, branches, petioles, leaves, pods and seeds are all consumed by *Macrophomina phaseolina*. *Macrophomina phaseolina* seed infection also lowers urdbean protein content by 12.3% and diminishes grain yield by 10.8%. (10). Mature plants experience the development of reddish to brown lesions on their roots and stems from *Macrophomina phaseolina*. Black microsclerotia and dark mycelia made plants wilt and lose their leaves (11)

Salicylic acid was discovered in 1979 by White, who asserts that SA contributes to the disease resistance of tobacco plants (12). Since then, much research has been conducted to show how important SA is for plant defence against biotic and abiotic stresses. SA levels are known to increase in a number of pathosystems following infection with viruses, fungi, insects or bacteria (13) and exogenous SA treatment boosts the host's defence mechanism (14). In plants that overexpress NahG, a salicylate hydroxylase that breaks down SA, the inability to manufacture SA in response to pathogen infection weakens systemic acquired resistance (SAR), a broad-spectrum systemic resistance acquired after primary infection (15). Even though SA is necessary for SAR, it is unlikely that a mobile signal will be needed. Pipecolic acid and SA collaborate to synchronize SAR (16). Resistance genes are primarily expressed in plants through JAs and SA-mediated signalling pathways in response to pathogen infection, environmental damage (mechanical, herbivore and insect) and both. Plant hormones are significant in forming signalling networks that regulate plant growth and stress responses.

The endogenous growth-regulating compound jasmonic acid (3-oxo-2'-cis-pentenyl-cyclopentane-1-acetic acid, also known as JA) is present in higher plants. Jasmonates, a family of fatty acid derivatives, include JA, its methyl ester (MeJA) and the conjugate of isoleucine (JA-Ile) (JAs). Vital growth and developmental processes are regulated by JAs (17).

Materials and Methods

In the experiment, two genotypes of mungbean-Bireshwar and Samrat, which are resistant and sensitive, were employed. After being surface sterilized, these genotypes were treated post-seed with various elicitors at variable doses. Grown plants were sprayed with distilled water as a control. The lab tested treated and untreated seeds, as well as infected and untreated seeds, to evaluate the vigour of the seeds. The 35 seeds passed through the final count phase of the mungbean, which lasted eight days at 25°C, after receiving control media and observed every 24 hours. Fifteen seedlings were observed and their roots and shoots were measured in each Petri dish to determine their vigour. Seedling vigour results from seeds growing in various biotic and abiotic environments.

Details of Treatment

Treatment 1: Salicylic acid along with infected seedlings

Treatment 2: Salicylic acid without infected seedlings

Treatment 3: Jasmonic acid with infected seedlings

Treatment 4: Jasmonic acid without infected seedlings

Treatment 5: Water priming

Seed Germination Test

Calculating seedling vigour involves combining a variety of growth indices, such as seedling length, fresh seedling weight and seedling dry weight.

1. Germination Percentage

= total number of seeds multiplied by the number of seeds germinated

Seedling Vigour Index

Three identical Petri dishes containing 25 seeds of each kind were subjected to different elicitors at different dosages. The (18) method was used to construct the vigour index.

Vigour index =

(mean root length + mean shoot length) x Germination percentage

Results

Utilizing the seedling vigour index, the efficacy of elicitors in Bireshwar (resistant genotype) and Samrat (sensitive genotype) against *M. phaseolina* Charcoal rot was evaluated. Elictors reduced disease occurrence and demonstrated a substantial difference between several defence-related molecules at various dosages (Table 1 to 4 and Fig 1. and 2.) (19). This was also the goal of my experiment, which is not included in this study, which showed an increase in the concentrations of defence-related chemicals in both pathogen and non-pathogen inoculation plants. The

Table 1. Vigour index of mungbean to SA and JA on (Bireshwar)

Elicitors	C1	C2	C3
SA	31.065	31.172	30.882
JA	31.287	30.136	29.267
SA+P	30.680	30.788	30.680
JA+P	30.904	29.739	28.857
CONTROL		27.617	

SA (C1,C2 and C3)= 0.5 mM, 1 mM, 2 mM; JA (C1,C2 and C3)= 1mM, 2.5 mM, 4 mM

Table 3. Vigour index of mungbean to SA and JA on (Samrat)

INDUCERS	C1	C2	C3
SA	26.23	26.35	26.01
JA	26.49	25.12	24.07
SA +P	25.77	25.90	25.55
JA+P	26.04	24.64	23.57
Control		22.03	

SA (C1,C2 and C3)= 0.5 mM, 1 mM, 2 mM; JA (C1,C2 and C3)= 1mM, 2.5 mM, 4 mM

Table 2. Various Elicitors and their interaction with different concentrations (Bireshwar)

	Elicitors	Concentrations	I × C	Check vs Others	
SEm±	34.52	34.51	34.51549	37.57277	34.51549
CD (P≤0.05)	99.36	99.36677	99.36677	108.1684	99.36677
CV %			121.7298		

Table 4. Various Elicitors and their interaction with different concentrations (Samrat)

	Inducer	Concentrations	I × C	Check vs Others
SEm±	34.51	34.51	34.51	37.57
CD (P≤0.05)	99.36	99.36	99.36	108.16
CV %		314.39		

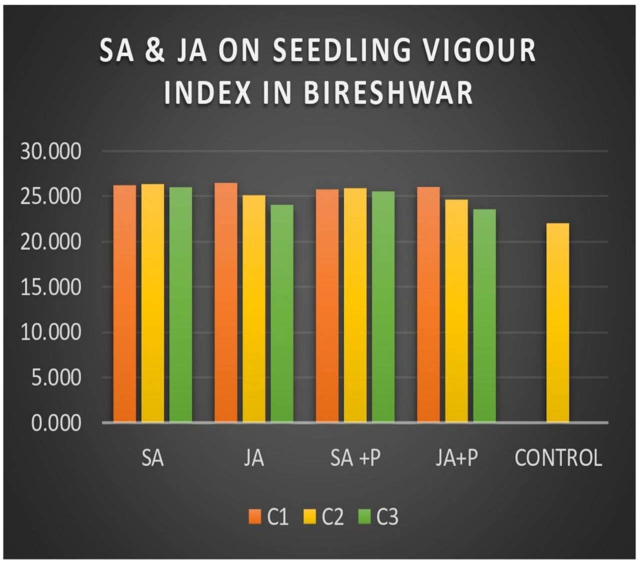

Fig. 1. Graph depicting the effect of elicitors on seedling vigour in the Bireshwar mungbean genotype

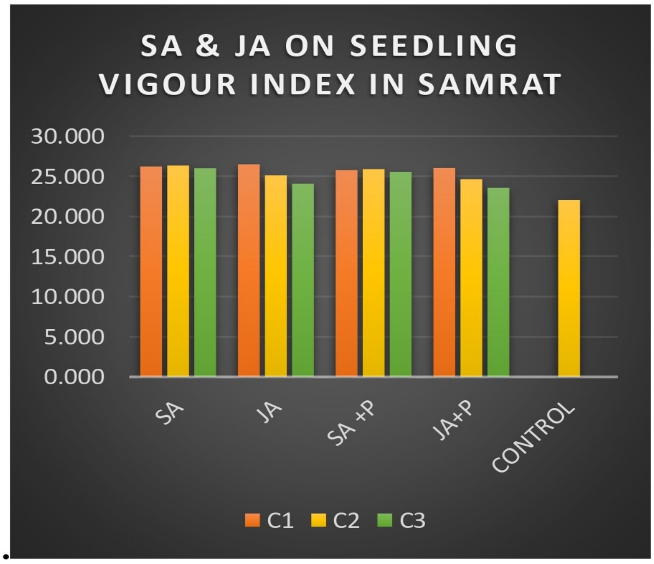

Fig. 2. Graph depicting the effect of elicitors on seedling vigour in the Samrat mungbean genotype

Bireshwar mungbean genotype recorded the highest seeding vigour index at 0.02 percent chitosan elicitor concentration (24.513), followed by 0.05 percent yeast-treated mungbean seeds (24.366). Its vigour index increased significantly compared to control plants and was higher than infected plants of the samrat type. However, the effectiveness of the 0.02 percent chitosan elicitor content exhibited a similar pattern as the other two genotypes. Elicitor effectiveness was displayed on the graph for both genotypes, damaged seeds and healthy seeds.

Discussion

The efficacy of elicitors in enhancing seedling vigour and resistance against *M. phaseolina* in two mungbean genotypes: Bireshwar (resistant) and Samrat (susceptible). The study aimed to evaluate the impact of different elicitor concentrations on disease occurrence, defence-related molecules and seedling vigour index (20).

The authors referred to previous studies by (19), which demonstrated the effectiveness of elicitors in reducing disease occurrence and modulating defence-related molecules. Building on this foundation, the current experiment sought to expand understanding by investigating the response of Bireshwar and Samrat genotypes to elicitor treatments. Results indicated that elicitors led to a significant increase in defence-related chemicals in both pathogen-infected and non-infected plants, which was supported by the findings of (21). This finding suggests a potential priming effect, where the plant's defence mechanisms are activated in anticipation of a pathogen attack. Moreover, the study observed that Bireshwar exhibited a higher seedling vigour index than Samrat, indicating its superior resistance to *M. phaseolina* (22). Specifically, the highest seedling vigour index was recorded in Bireshwar, treated with 0.02% chitosan elicitor concentration, followed by 0.05% yeast-treated mungbean seeds. These results suggest that chitosan and yeast elicitors effectively enhance seedling vigour, potentially by activating defence mechanisms (23).

Interestingly, the vigour index of Bireshwar treated with 0.02% chitosan was significantly higher than control plants and even exceeded that of infected Samrat plants. This highlights the robustness of the Bireshwar genotype in response to elicitor treatments. Graphical representation of elicitor effectiveness illustrated a clear pattern for both genotypes, demonstrating the impact on damaged and healthy seeds. This suggests that elicitors consistently affect seedling vigour across different seed conditions and genotypes (24).

Overall, the study provides valuable insights into the potential of elicitors in enhancing plant resistance to charcoal rot in mungbean. By elucidating the mechanisms underlying elicitor-induced resistance, this research contributes to the development of sustainable strategies for disease management in agricultural systems (25).

Conclusion

In conclusion, the agricultural sector faces formidable challenges, including resource depletion, biodiversity loss and climate change, all threatening food security. Addressing these challenges demands a paradigm shift towards a new agricultural revolution. Seed elicitor priming, particularly with substances like salicylic acid (SA) and jasmonic acid (JA), emerges as a promising strategy to enhance crop productivity and sustainably ensure food quality and safety. Seed elicitor priming offers multifaceted benefits by altering metabolic and signalling pathways in seeds, thereby influencing the entire plant life cycle beyond just germination and seedling establishment. This approach has shown potential in enhancing food nutritional quality, increasing yield and promoting overall plant growth and development. Moreover, it enhances stress and disease tolerance while reducing the reliance on pesticides and fertilizers, thus aligning with sustainable agricultural practices. However, the efficacy of seed elicitor priming depends on various factors, such as the dosage and combination of elicitors used. While studies have shown marginally advantageous effects of SA and JA combination on seed vigour, further research is warranted to evaluate their impacts and determine optimal priming dosages comprehensively. By continuing to explore and refine seed elicitor priming techniques, we can pave the way for a resilient and sustainable agricultural future, safeguarding food production and environmental integrity.

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Authors' contributions

PR and DSV carried out the research and compiled the manuscript. PR analyzed and interpreted the data. SM and SD read and reviewed the manuscript conceived of the study and participated in its design and coordination. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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