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Research Article

First Report on Nitrogen's Role in Vivipary Suppression in Late-Maturing Mango cv. Sufaid Chaunsa

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ABSTRACT

Punjab is the major mango producing region in Pakistan whereas Pakistan is fifth in the globe in mango production. Among the late season varieties with an 18 % share in Punjab's mango area, the premium Sufaid Chaunsa variety has an exponential share of export but suffers postharvest losses due to a disorder known as vivipary, which causes seeds to germinate too early. The objective of this study was to assess the influence of different doses of nitrogen supplied at flowering and fruit setting stages on vivipary incidence in Sufaid Chaunsa. Experiment was conducted under randomized complete block design with four nitrogen treatments (0 g, 200 g, 300 g, and 500 g per tree), and three replications. Data were collected when fruit get ripened after fruit harvest. Results showed that with an increase in the nitrogen doses manifested an increase in the vivipary expression. In the case of 500 g nitrogen treatment (T_3), the percentage of viviparous seeds (100%) and pulp vivipary (45.45%) was the highest while the lowest among all were in control (T_0 - 65.15% and 1.51%, respectively). Antioxidant capacities and phenolic contents increased with higher nitrogen application, and root length of germinating seed (vivipary) increased as well, which indexing a more general correlation between nitrogen induced metabolic changes and vivipary expression. Vivipary in mango, as of now, is reported for the first time, focusing on the mechanism of the phenomenon and its practice in late maturing varieties. These findings indicate that nitrogen management strategies to reduce vivipary while maintaining fruit quality are needed in mangoes. Research on the effects of growth regulators and irrigation practices on vivipary suppression is also recommended.

Keywords: Vivipary, Nitrogen, hormones, phenolics, antioxidants.

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INTRODUCTION

Mango (*Mangifera indica* L.) is one of the fruit crops, affected by vivipary, or pre-harvest seed germination. Currently Pakistan is producing 1.8 metric tons of mango annually from an area of 168.6 thousand hectare (Grewal et al., 2024). Vivipary situation happens when the seed starts to germinate in the fruit while it is still attached to the tree causing structural damage, fruit damage and reducing its commercial value. One of the most cultivated late season mango cultivar Sufaid Chaunsa is very prone to vivipary and is a valuable threat for the growers residing in the areas where mango is a backbone source of economic growth (Singh et al., 2018). Factors including genetic susceptibility, environmental stress, hormonal imbalance, over irrigation and excessive application of nitrogen fertilizer contribute to the prevalence of vivipary in mango (Luo et al., 2020). Although vivipary has important implications in agriculture and economics, little research has been performed in regard to successful methods for combatting vivipary in the mango production industry.

Nitrogen fertilization is one of the key agronomic factors which largely affect seed dormancy and germination behavior. Nitrogen is a macronutrient necessary for plant growth and metabolism but nitrogen applied in excess during flowering and fruit setting stages in mango, has been known to increase the incidence of vivipary. In mango orchard, to optimize tree growth and fruit production, nitrogen application is done in two intervals. Nitrogen dose in the first 70% is supplied after fruit harvest to support vegetative growth and the remaining 30% at flowering and fruit set to help fruit development. (Anonymous, 2025). Sufaid Chaunsa is late season mango variety and it's harvesting time starts from mid of August. To produce at an optimum, a fully-grown mango tree (10 years old) needs about 1500 g of nitrogen matter annually. Appropriate timing and dosage of nitrogen has to be applied to avoid the adverse effects on fruit quality and physiological disorders viz., vivipary in the late season maturing mango cultivars like Sufaid Chaunsa. Higher levels of nitrogen can alter hormonal regulation (reducing abscisic acid (ABA) necessary for maintaining seed dormancy while promoting gibberellin (GA) biosynthesis for seed germination. (Shah et al., 2019). Furthermore, nitrogen meditated metabolic shifts cause oxidative stress which in turn induces early embryo development and seedling emergence within the fruit (Zhang et al., 2017). Therefore, understanding the relationship of vivipary and nitrogen supply is crucial in developing solid nutrient management strategies for possible optimal fruit production and reduced preharvest seed germination.

The biochemical effects of vivipary play an important role in regulating the quality of fruits. Early embryo growth correlates with heightened antioxidant capacities together with elevated phenolic compound levels altering the entire fruit biological state (Kumar et al., 2021). Vacuum stress elevations within the system increase antioxidant concentration levels while damaging tissues and weakening seed dormancy functions so vivipary develops more intensely (Luo et al., 2020). An increase in total phenolic content of fruits leads to diminished market competitiveness along with decreased fruit flavor and texture and shortened postharvest period and consumer satisfaction (Shah et al., 2019). First-order importance exists for investigating the impacts of nitrogen on vivipary-related biochemical and physiological transformations for abnormal vivipary interventions in mango orchard management.

This investigation examined how different nitrogen treatments during mango blossoming and fruit formation phases influence the development of vivipary in Sufaid Chaunsa mango. The study examines two main physiological characteristics associated with viviparous seed production together with root development and with selected biochemical measurements of antioxidant capacity and total phenolic content. This research has developed a measurable relationship between nitrogen application and vivipary appearance because it aims to create efficient fertilizer strategies and minimize plant embryo sprouting before harvest in commercial mango farming.

MATERIALS AND METHODS

The experiment was conducted on Muzaffar Nagar Farm, Multan-Pakistan (30°07'07.5"N, 71°32'04.9"E) in 2023 and 2024 to evaluate the effect of different nitrogen doses on the incidence of vivipary in mango (*Mangifera indica* L.) cv. Sufaid Chaunsa. A total of twelve healthy and uniform-sized plants were selected for the study, which was laid out in a Randomized Complete Block Design (RCBD) with four nitrogen treatments and three replications. The treatments included T_0 (0 g, control), T_1 (200 g), T_2 (300 g), and T_3 (500 g) of nitrogen, which were applied using the soil dressing method during the flowering and fruit-setting stage in March. To maintain a balanced nutrient supply, phosphorus (P) and potassium (K) were applied at recommended doses, with a full dose of phosphorus (1000 g) and half of the potassium (500 g) provided after fruit harvest, while the remaining half of the potassium (500 g) was applied at flowering and fruit-setting.

For data collection, 25 fruits per replication were harvested from each plant, ensuring equal sampling from all four directions at shoulder height. The recorded parameters included viviparous seed percentage, vivipary in pulp percentage, root length (vivipary), antioxidant activity, and total phenolic content. The number of affected fruits in each treatment was also assessed in order to determine the percentage of viviparous seeds and pulp vivipary. We measured root length from seeds located inside the fruits after germination. The Total Phenolic Contents (TPC) of mango pulp was measured by modifying Folin-Ciocalteu (FC) method according to Razzaq et al. (2013). A mixture composed of 300 µL supernatant and 600 µL 10% FC reagent was followed by the addition of 2.4 mL 700 mM Na_2CO_3 solution in an Eppendorf tube. After mixing together the sample was placed in the dark environment and incubated at room temperature for thirty minutes. The Epoch ELISA reader measured the absorbance at 765 nm before reporting the

TPC results as mg GAE 100 g^{-1}. The determination of total antioxidants contents in mango pulp occurred through DPPH analysis following Razzaq et al. (2013). The DPPH solution received 50 µL supernatant while the mixture reacted at room temperature for thirty minutes. An Epoch ELISA reader determined the 517 nm absorbance of the solution. The formula for calculating antioxidant activity as % inhibition was:

$$\text{Total antioxidant (\% Inhibition)} = \frac{(\text{A blank} - \text{A sample})}{\text{A blank}} X\ 100$$

Analysis of Variance (ANOVA) was carried out for the collected data, treatment means were compared using Least Significant Difference (LSD) test at 5% level of probability to determine significant differences between treatments (Steel et al., 1997). All analyses were performed by using Statistix® 8.1 software (Tallahassee, Florida, USA).

RESULTS

The application of different nitrogen doses had a significant impact on vivipary incidence in mango cv. Sufaid Chaunsa. The percentage of viviparous seeds were lowest in the control treatment (T_0), with 65.15%, while it increased significantly with nitrogen application. The highest vivipary incidence was recorded in T_2 (100%) and T_3 (98.48%), whereas T_1 showed a moderate increase (81.81%). A similar trend was observed in vivipary within the pulp, where T_0 and T_1 exhibited the lowest values (1.51%), while a substantial rise was observed in T_2 (30.30%) and T_3 (45.45%).

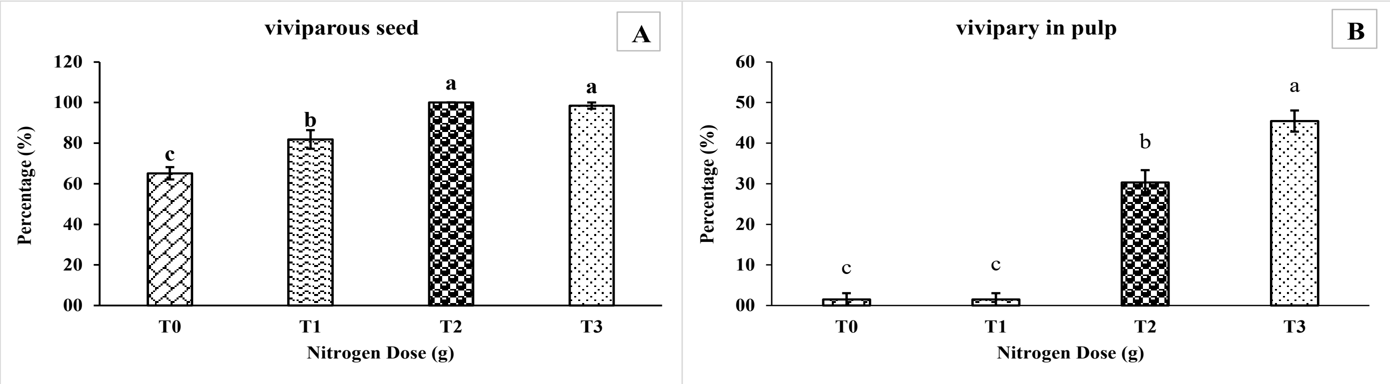

Figure 1. Effect of various nitrogen doses on viviparous seed (A) and vivipary in pulp (B). The significant difference is indicated by letters at *P* ≤ 0.05. Vertical bars indicate ± S.E & means and are invisible when the values are negligibly small.

Root length of germinating seed (vivipary) varied significantly among treatments, with the longest root length observed in T_3 (4.73 cm), followed by T_2 (3.37 cm), while no root emergence was recorded in T_1. The control treatment had the shortest root length (0.53 cm).

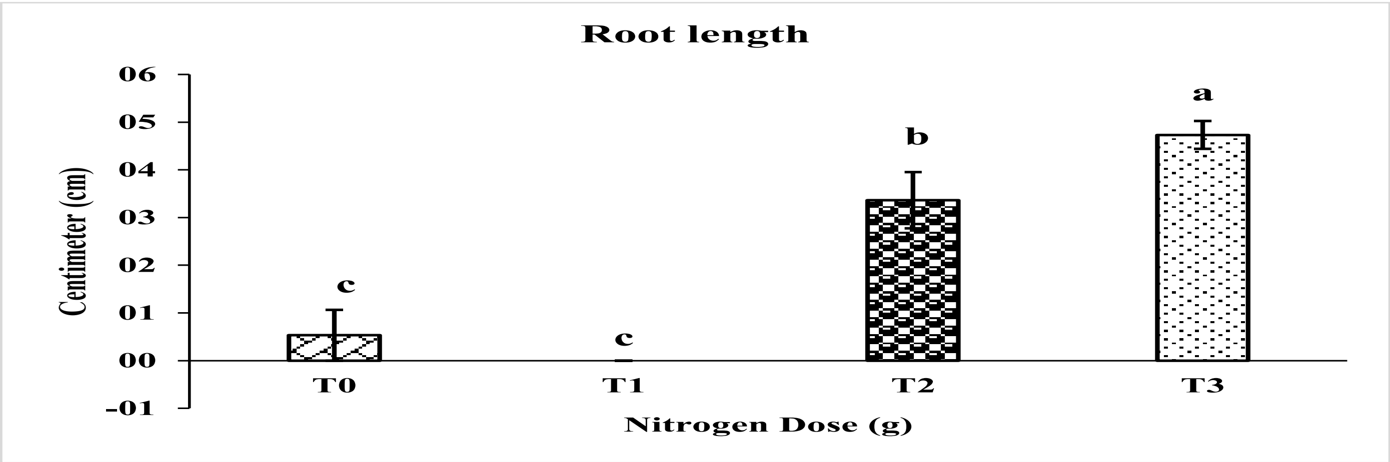

Figure 2. Effect of various nitrogen doses on root length of viviparous seed. The significant difference is indicated by letters at P ≤ 0.05. Vertical bars indicate ± S.E & means and are invisible when the values are negligibly small.

Antioxidant activity also increased with higher nitrogen levels, with the maximum value recorded in T_3 (87.26), followed by T_2 (69.75), while T_0 and T_1 showed lower activity at 55.50 and 60.67, respectively. Similarly, total phenolic content was significantly influenced by nitrogen application, with T_3 exhibiting the highest phenolic content (39.00), followed by T_2 (29.01). Phenolic content of T_0 was found to be lowest (16.39) whereas T_1 possessed moderate increase (22.98).

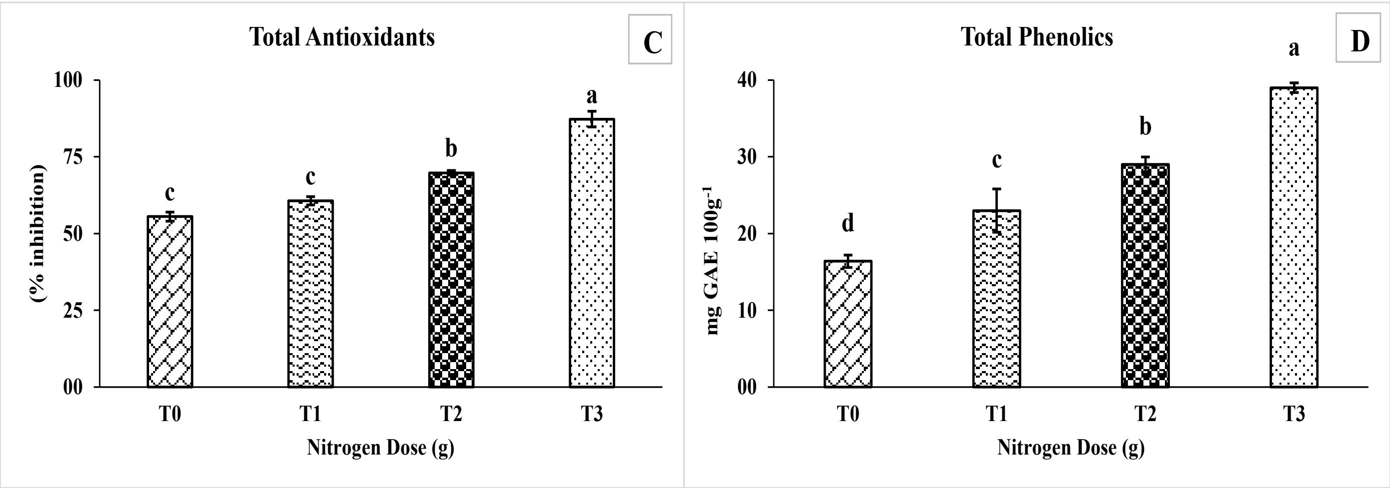

Figure 3. Effect of various nitrogen doses on total antioxidant (C) and total phenolics (D). The significant difference is indicated by letters at P ≤ 0.05. Vertical bars indicate ± S.E & means and are invisible when the values are negligibly small.

Results indicate that mango fruit increased antioxidant activity and phenolic content and vivipary incidence was enhanced due to high nitrogen application during flowering and fruit setting stage.

DISCUSSION

This study revealed that nitrogen application has a major role in increasing incidence of vivipary in Sufaid Chaunsa mango. The raising of nitrogen levels on T2 and T3 resulted in a sharp rise in viviparous seed formation and pulp vivipary. T2 (100%) and T3 (98.48%) showed the highest vivipary rates, and therefore, application of high dose of nitrogen has been found to break seed dormancy causing premature germination within the fruit. According to hormonal imbalances, mainly a decrease in ABA and an increase in gibberellins (GA), which support early seedling growth (Luo et al., 2020), this can be attributed. Similar findings have been reported in previous studies, which also showed that nitrogen induced suppression of ABA, caused seed dormancy breakdown by inducing viviparous germination on several fruit crops (Shah et al., 2019).

Furthermore, root elongation in viviparous seeds was also appeared to be influenced by nitrogen availability. In T2 and T3 (where highest nitrogen application was), root length was significantly higher. Nitrogen results in an increase in root growth which implies that it enhances metabolic activity within the seed and enhances embryo elongation as well as seedling formation even before fruit detachment (Singh et al., 2018). With low nitrogen, no or minimal root growth was seen in T0 and T1, however, via controlled nitrogen application, it has been seen that seed dormancy can be maintained and vivipary can be avoided. Increased root length in nitrogen enriched treatments could also be related to higher gibberellin synthesis and this hormone is known to promote cell elongation and root growth in germinating embryos (Zhang et al., 2017).

Biochemical analysis furthermore corroborates the physiological effects of nitrogen in regulation of vivipary. Treatments with high levels of nitrogen contained higher antioxidant activity and total phenolic content. Activation of the antioxidant response in T2 and T3 indicates the contribution of oxidative stress to the vivipary syndrome. Reactive Oxygen Species (ROS) are reported to break seed dormancy, and excessive nitrogen application may have caused the imbalance in oxidative metabolism for encouraging vivipary occurrence (Kumar et al., 2021). Furthermore, treatment with higher nitrogen also correlated to a higher phenolic content which also indicates a stress induced metabolic shift (as phenolic compounds are secondary metabolites associated with plant defense mechanisms (Shah et al., 2019) Nevertheless, too high phenolic accumulation can lead to undesirable fruit flavor, texture and astringency, which may affect its acceptability by consumers and thus limit its marketability.

Overall, the results indicate that nitrogen management in respect to mango orchards should be carefully conducted, especially during flowering and fruit setting periods. Nitrogen is required for fruit growth and development but afterwards its excess application seems to be the most important factor responsible for inducing vivipary in Sufaid Chaunsa. High nitrogen levels induce hormonal and biochemical shifts resulting in viviparous fruits deteriorating more rapidly because of increased fruit respiration and susceptibility to microbial growth (Luo et al., 2020). The implications of these findings are that optimization of nitrogen application can, in part, reduce vivipary incidence without scarification of fruit quality.

CONCLUSION

The experiment showed that, vivipary incidence in mango cv. Sufaid Chaunsa was affected severely by higher doses of nitrogen at flowering and fruit setting stages. Excessive application of nitrogen (High N, 500 g) resulted in highest vivipary and lowest was observed in control treatment. Nutrient dose elevated phenolic content and antioxidant activity, and there was a possible correlation between nitrogen metabolism and vivipary expression with increased dose. The growers in South Punjab, Pakistan are advised to apply a maximum of 200 g of nitrogen per plant at flowering and fruit setting stage. Further studies should investigate the effect of growth hormones and irrigation on vivipary expression in late maturing varieties of mango.

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AUTHOR CONTRIBUTION

All authors contributed equally to this research.

CONFLICT OF INTEREST

No conflicts of interest have been disclosed by the authors.

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