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Foliar Application of Cow Urine Enhances Morphological Traits and Yield in Mungbean (*Vigna radiata* L.) Cultivars under Drought Stress

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ABSTRACT

Background: Drought is water deficient unfavorable environmental condition that impacts agricultural production globally. The foliar application of cow urine plays a key role in enhancing plant tolerance to both biotic and abiotic stresses in mungbean. The present study focuses on evaluating the potential of cow urine in alleviating the adverse effects of drought stress in mungbean plants.

Methods: In this study, four mungbean cultivars were grown in pots, namely V1: RMG-62, V2: RMG-344, V3: RMG-492 and V4: RMG-975. The foliar application of cow urine treatment (T2:5%, T3:10% and T4:15%) under normal irrigation and drought conditions, together with the withdrawal of irrigation at 25 and 50 days after sowing (DAS), induced the drought stress. At 35 and 60 DAS, observations were taken of growth and yield parameters.

Result: Plant height, number of pods plant^{-1}, number of grains pod^{-1}, biological yield plant^{-1} and test weight were all higher with foliar application of cow urine (T3:10%) among the treatments. It was also shown to improve specific leaf weight and leaf area (T4:15%) and harvest index. Variety (V4; RMG-975) showed highest growth and yield parameters among other varieties. However, V3 showed a higher specific leaf weight and V1: RMG-62 had maximum test weight. A significant decrease in each parameter related with growth and yield under drought condition was observed. So, on the basis of findings, it is concluded that cow urine @ 10% may reduce adverse effect of drought in mungbean plant.

Key words: Cowurine, Drought, Mungbean, Specific leaf weight.

INTRODUCTION

In the world's subtropical regions, mungbean is one of the most significant pulse crops for a protein supplement. In India, it ranks third among the most important pulse crops, behind pigeon pea and chickpea. The nutritional composition of mungbean includes 51% carbohydrates, 24-66% protein, 4% minerals and 3% vitamins. It is an essential, short-duration, diploid legume crop that fixes nitrogen and has great nutritional benefits. It is a leguminous food grain that is sustainable and an excellent source of vitamins, minerals and proteins for dryland agriculture (Ketinge *et al.,* 2011). It has the remarkable capacity to assist the symbiotic root rhizobia in fixing atmospheric nitrogen, which enhances soil fertility, in addition to providing protein for the diet (Anjum *et al*., 2006). Abiotic stressors such as drought are among the most common and can severely reduce crop yields and productivity globally by as much as 65% (Thakur *et al.,* 2010 and Akram *et al.,* 2013). Drought stress is intensifying with each passing day and by 2025 it is projected to reduce global agricultural production by as much as 30% relative to present yield levels. Water stress, or drought conditions, mainly affect basic metabolism and regulate crop development, quality and production (Begg and Tuener, 1976). Drought stress affects plant water relations and diminishes water-use efficiency (Reddy *et al.,* 2004). Water stress lowers mungbean crop growth and yield, as well as the fresh and dry weight of plants (Tawfik, 2008). The dry matter accumulation of the plant, average seed yield, number of pods plant^{-1}, number of seeds pod^{-1} and plant height were all greatly decreased by drought stress (Muna *et al.,* 2013). The fermentation of cow urine produces organic nutrients that improve soil fertility. It can also be made into a liquid fertilizer and crop insecticide. Urine's uric acid functions as both a hormone and a fertilizer. Cow urine is the most effective animal secretion with a wide range of medicinal uses because of its antifungal,

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antibacterial and antiviral properties. It also improves soil fertility and purifies the environment. But cow urine can be used as a biofertilizer and has significant manorial value (Ledgard *et al.,* 1982). According to Bhadauria (2002), cow urine is composed of 95% water, 2.5% urea, 24 different types of salts, hormones, 2.5% enzymes and organic substances such as amino acids, carbonic acid, uric acid, cytokinin, lactose and crucial minerals including phosphorus, calcium, sulfur, iron and manganese. Nutrients including 1% N, 1.9% K_2O and traces of P_2O_5 are found in cow urine (Tamhane *et al.,* 1965). Although cow urine is high in minerals, particularly potassium and nitrogen, it is typically excreted as waste. Since it is organic, using it in crops won't harm the environment or people's health (Rajanna *et al.,* 2012 and Singh *et al.,* 2012). Additionally, it has been observed that fresh cow urine contains 20-200 µg of corticosteroids/100 ml, 0.05-0.15 mg of 17-ketosteroids/100 ml and 50-100 mg of oestrogens per 100 ml. Application of cow urine positively affects wheat, rice, maize and lab beans (Gopakkali *et al*., 2012; Rajanna *et al*., 2012; Maheswari *et al*., 2017; Devakumar *et al*., 2014). In wheat, cow urine seed treatment improved dry matter, plant height, tiller number and LAI (Shivamurthy, 2005), while foliar spray enhanced black gram harvest index (Ingle, 2007). The objective of current study is (1) To determine the optimum concentration of cow urine for enhancing growth, morphological traits and yield performance of four mungbean cultivars under both normal irrigation and drought stress conditions. (2) To assess the differential varietal responses of mungbean cultivars to foliar application of cow urine.

MATERIALS AND METHODS

Location and climate of the experimental site

The experiment was conducted at Jobner, situated 427 meters above sea level at 75°28′E longitude and 26°06′N latitude. During summer, the maximum temperature ranges from 36°C to 45°C, while in winter it may fall as low as -3°C (Fig 1). The area receives an average annual rainfall of about 500 mm.

Soil and pot preparation

The experimental pots were filled with loamy sand soil, having a particle density of 2.65 Mg m^{-3} and a bulk density of 1.50 Mg m^{-3}. The soil was moderately alkaline with a pH of 8.20 and an electrical conductivity (ECe) of 1.10 dS m^{-1} at 25°C. A total of ninety-six ceramic pots, each with an internal diameter of 20 cm and a height of 25 cm, were used for the experiment. Each pot was filled with approximately 10 kg of a well-mixed soil and farmyard manure (FYM) mixture in a 4:1 ratio (soil to cow dung). Prior to filling, broken stone fragments were placed over the drainage hole at the bottom of each pot to ensure unrestricted water drainage.

Collection of cow urine

A Gir breed of cow was used to collect fresh cow urine in a sterile container (Department of Livestock Production Management (LPM), SKN College of Agriculture, SKNAU, Jobner.). Before being used, the urine was kept in an airtight container at 4°C after being filtered through Whatman No. 1 filter paper to remove debris and precipitated material.

Experimental details

During the summer of 2020-21 (one season), a pot experiment was conducted in the cage house at the S.K.N. College of Agriculture, Jobner, in the Department of Plant Physiology. There are four different mung bean varieties: V1: RMG-62, V2: RMG-344, V3: RMG-492 and V4: RMG-975. There are also two different drought levels: I0: Normal irrigation and I1: stress produced by withholding irrigation (At 25 DAS and 50 DAS). T1: Control, T2: Cow urine (5%), T3: Cow urine (10%) and T4: Cow urine (15%) are also applied topically. 25 and 50 days after sowing (DAS) were used to spray the various concentrations of cow urine and 35 and 60 DAS (ten days after the spraying of cow urine) were used for observations. With three replications in each factorial arrangement, the trial was set up in a Factorial Completely Randomized Design. On July 21, 2020, ten different mungbean varieties seeds were sown in each pot. After five days of seeding, seedlings emerged and six healthy plants in pot^{-1} were then allowed to grow rapidly. Hand weeding was done as normal management

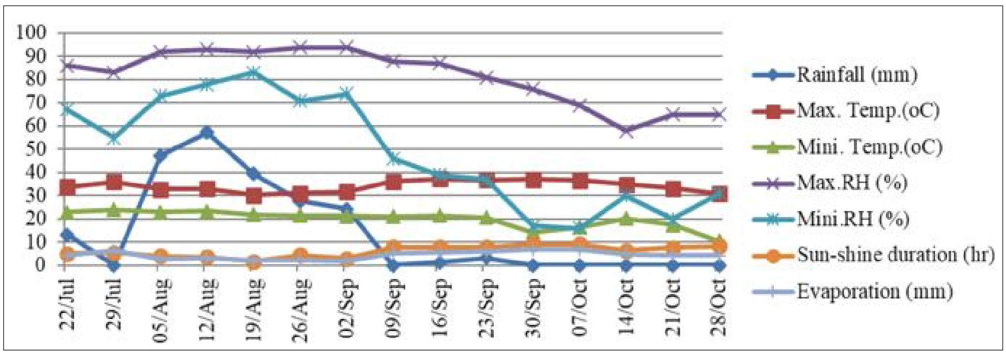


Fig 1: The average weekly weather data for the years 2020-21 that were collected at the Meteorological Observatory, Department of Agronomy, SKN College of Agriculture, SKNAU, Jobner.

practices Depending on the level of soil moisture in each treatment; a drought treatment was imposed at 25 and 50 days after sowing. A tensiometer was used to measure the irrigation needs.

Statistical analysis

The statistical analysis of the raw data was conducted using the methodology drawn by Gomez and Gomez (1976). The standard error of the mean was used to calculate the mean values from three replicates. An investigation of the relationships between various qualities was done using a correlation analysis. Origin Pro 2024 Dark Mode can be used for creating heat maps, graphs, correlation coefficients and principal compound analyses.

Observations recorded

Plant height (cm) was recorded using a meter scale, while leaf area per plant was estimated by the graph paper method described by Jenkins (1959). Specific leaf weight (mg cm{ ²) was determined following the method of Barnes *et al*. (1969) and calculated as the ratio of leaf dry weight (mg) to leaf area (cm^2), *i.e*., SLW = dry weight/area. These growth parameters were measured at 35 and 60 days after sowing. At harvest, yield attributes were recorded for each treatment. While the number of seeds per pod was taken from the pods of three randomly selected plants and the mean was determined, the number of pods per plant was counted by counting all of the pods from randomly selected plants. Grain yield per plant (g) was measured after air-drying the harvested plants and test weight (g) was recorded by weighing 1000 grains. Biological yield (g/plant) was assessed as the total above-ground biomass, including both grain and straw yield, from three selected plants. The harvest index (HI) was then calculated following Donald (1965) as the ratio of economic yield to biological yield, expressed as a percentage.

RESULTS AND DISCUSSION

Plant height (cm)

The data presented in Fig 2 (A) depicts the effect of foliar application of cow urine at 25 and 50 DAS on plant height of mungbean varieties grown under irrigated and drought condition. Plant height was recorded significantly higher with treatment T3 *i.e*. (cow urine 10%) 43.56 cm in V4; RMG-975 variety under normal irrigated condition (I_0) and minimum (32.66cm) plant height obtained under control condition in V1; RMG-62 variety under drought stress condition (I_1) at 35 DAS respectively. At 60 DAS, treatment T3 (52.68cm) in V4; RMG-975 variety under normal irrigated condition (I_0) exhibited higher plant over other treatments, which was significantly superior and minimum (39.9 cm) plant height obtained under control condition in V1; RMG-62 variety under drought stress condition (I_1). Plant height (cm) was found to increase (20% and 17%) with foliar application of cow urine (T3; 10%) in comparison to control at both days of observations respectively in the V4 variety under normal conditions. but under drought conditions, T4; 15% cow urine foliar application shows the best result compared to other treatments with V4 variety on both days of observation (Fig 2). Similar results were reported by Diatta *et al*. (2023). Saha *et al.* (2025) reported a reduction in plant height under drought stress, while Xu *et al.* (2025) observed significant decreases in germination-related traits, indicating the broad negative impact of drought on plant growth and early development.

Leaf area (cm^2 $plant^{-1}$)

Leaf area $plant^{-1}$ taken at 30 DAS and 60 DAS is depicted in the Fig 2B. Leaf area was increase with treatment T4 *i.e.* cow urine 15% (232.89 and 238.29 cm^2) in V4; RMG-975 variety under normal irrigated condition (I_0), which was significantly superior over other treatments *i.e.* T3, T2 and T1 (control) at 35 and 60 DAS respectively. Leaf area was found to significantly increase with treatment T4 in comparison to control at both days of observations respectively. The highest leaf area was recorded with variety V4 *i.e.* RMG975 was 232.89 and 238.29 cm^2, whereas in case of drought condition (I1), it was reduced (170.5 and 175.9 cm^2) in comparison to irrigated condition (I0) at 35 and 60 DAS respectively in V4 variety (RMG 975). Several studies have highlighted the positive impact of cow urine on growth parameters across various crops (Verma *et al*., 2018; Singh *et al*., 2018; Sadhukhan *et al*., 2018; Karale *et al.,* 2020). Similarly, numerous reports have addressed the negative effects of drought on plant growth (Dutta *et al.,* 2008; Eman *et al*., 2010; Ranawake *et al*., 2011; Siddiqui *et al*., 2015; Ndiso *et al*., 2016; Moonmoon and Islam, 2017; Kareem *et al*., 2017).

Specific leaf weight (mg cm^2)

A reference to data presented in Fig 2C showed the effect of foliar application of cow urine on specific leaf weight (SLW) at 35 and 60 days *i.e*. 10 days after foliar application of cow urine under irrigation and drought condition. The treatment T4 (cow urine 15%) showed highest SLW among treatments was 7.699 mg cm^2 in V3; RMG-492 variety under normal irrigation condition at 35 DAS. Additionally, a highly significant increase in specific leaf weight was observed in variety V4; RMG-975 (6.71 mg cm^2) with foliar spray of T3; 10% cow urine under normal irrigation condition (I_0). After 35 days of observation, specific leaf weight (mg cm^2) in the V3 variety increased (17%) after treatment T3 compared to control. Conversely, there was no rise at 60 DAS. A number of reports are noted to educate about the positive role of cow urine on specific leaf weight in various crops (Patil *et al.,* 2012; Singh *et al.,* 2014; Jandaik *et al.,* 2015; Tamarkar, 2016; Jayanta *et al.,* 2017).

Number of pods $plant^{-1}$

Number of pods $plant^{-1}$ has been presented in Fig 2D, Whereas, the T3; 10% cow urine (17.33) was noted with number of pods $plant^{-1}$ highest other treatments under normal irrigation in V4 variety. Foliar application of cow urine

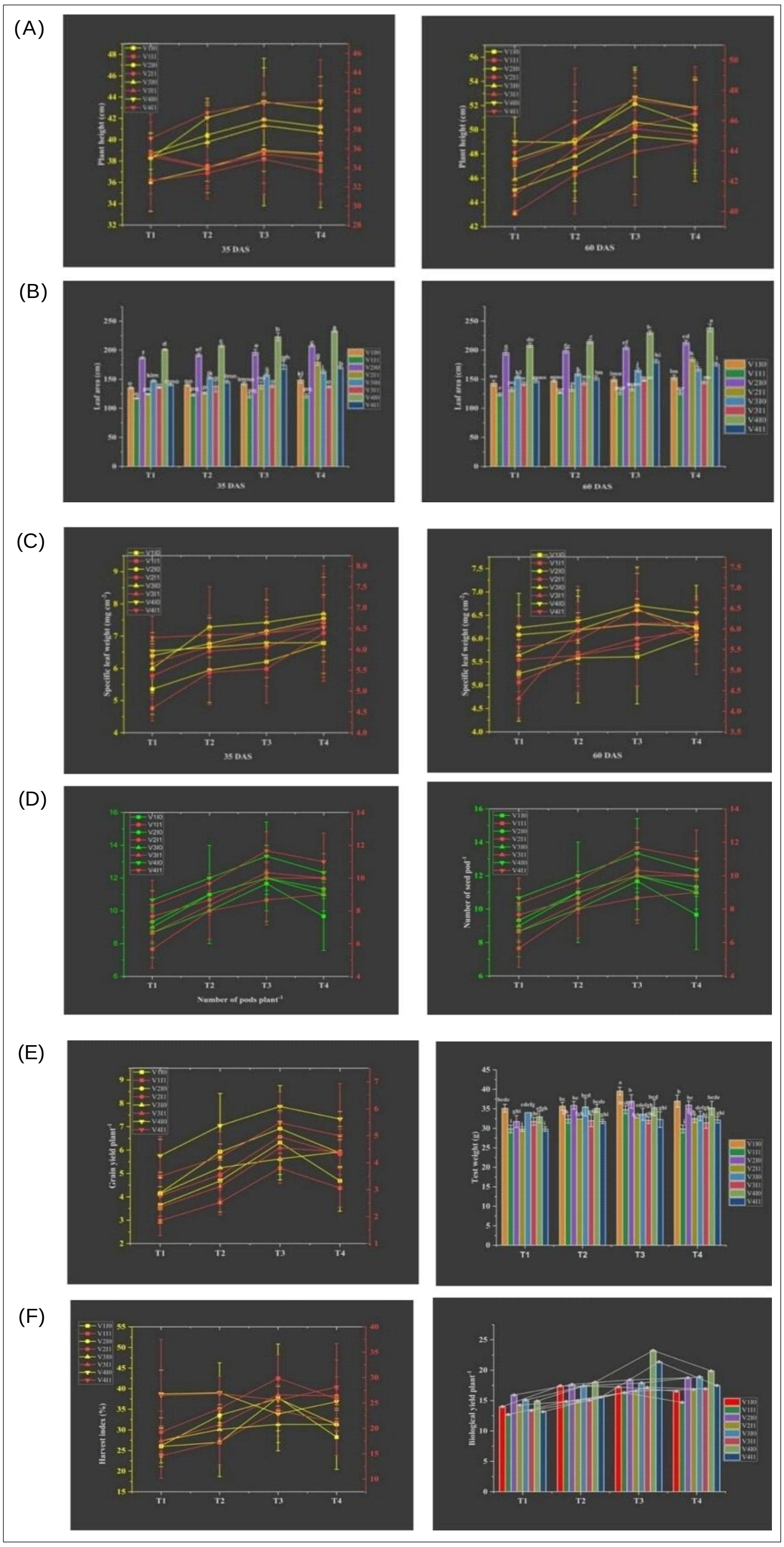


Fig 2: (A) Plant height (cm) at 35 and 60 DAS (B) Leaf area plant^{-1} at 35 and 60 DAS. (C) Specific leaf weight ((mg cm^{-2}) at 35 and 60 DAS. (D) Number of pods plant^{-1} and Number of seeds pod^{-1} (E) Grain yield plant^{-1} (g) and Test weight (g). (F) Harvest index (%) and Biological yield (g/plant) at harvesting stage.

T3 (foliar spray of 10% cow urine) was found to significantly increase for number of pods plant^{-1} (6.12%) with comparison to control at harvest in V4 variety under normal condition. (Fig 2). A number of investigators observed that drought reduces number of pods (Tawfik, 2008; Asaduzzaman *et al.,* 2008; Pervez *et al.,* 2009; Zare *et al.,* 2013).

Number of grains pod^{-1}

Number of grains pod^{-1} has been depicted in Fig 2D. Among foliar application of treatments T3; (cow urine 10%) was recorded with highest (13.33) number of grains pod^{-1} (11.21) in V4 variety under normal irrigation condition (I_0). The application of cow urine T3 was increase number of grains pod^{-1} (24.92%) with comparison to control at harvest in V4 variety under normal condition. (Fig 2). similar result reported that drought conditions lead to a reduction in grain count and grain size (Muna *et al*., 2013; Yagoob *et al*., 2014; Fooladivanda *et al*., 2014).

Grain yield plant^{-1} (g)

The impact of foliar applications of cow urine treatment and drought conditions on grain yield per plant of mungbean varieties has been presented in Fig 2E. Among treatments T3; cow urine 10% recorded with significantly higher grain yield (7.86 g) in V4 variety (RMG-975) under normal irrigation (I_0) which was observed 38.13% higher to T1 (control). Grain yield plant^{-1} was found to significantly increase (36.70%) with foliar application of cow urine (T3) in comparison to control in V4 variety under normal condition. Variety RMG-975 (V4) was recorded with maximum grain yield plant^{-1} and it was 7.86 g, whereas drought stress (I_1) was reduced (5.74 g) in comparison to irrigated condition (I_0). Ahmad *et al.* (2015); Moonmoon and Islam (2017); Kareem *et al.* (2017); Satyavathi *et al.* (2018); Diatta *et al.* (2023) and Alghabari and Ihsan (2018) have all highlighted the negative impact of drought on crop production, specifically in terms of reducing grain yield. Yadav *et al*. (2025) showed that FYM or vermicompost at 5 t ha^{-1} significantly improves crop growth, yield and grain protein content in drought-prone Bundelkhand chickpea systems. Under stress conditions, grain yield exhibited strong positive associations with selected growth traits and yield components. The correlation coefficients and cluster heat map (Fig 3) clearly demonstrated the interdependence of these traits in determining yield performance in *Vigna radiata*.

Test weight (g)

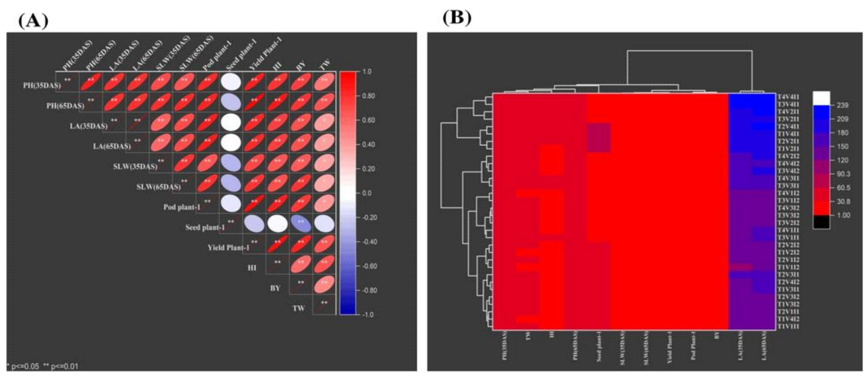
Fig 2E showed the effect of cow urine on test weight of mungbean varieties under irrigated and drought condition. It was maximum in plants treated with T3; cow urine 10% (39.56g) as compared to other treatments under in V1 variety under normal irrigation condition. Whereas the combined effect of treatment x variety was found significant. In case of drought condition (I_1), it was reduced (13.80%) in comparison to irrigated condition (I0) at harvest in V1 variety with T3 (10% cow urine). According to Kumar *et al.,* 2025, 100-seed weight had positive correlation with seed yield and directly contributed towards seed yield.

Harvest index (%)

The impact of foliar application of cow urine, varieties and drought on harvest index has been presented in Fig 2F. Harvest index significantly differed in relation to treatment, varieties and drought condition. Among treatments T2; (cow urine 5%) recorded with highest harvest index (39.04%) in V4 variety under normal irrigation condition (I_0).

Biological yield plant^{-1} (g)

Biological yield per plant was presented in Fig 2F revealed that it was significantly differed in respect to treatments, varieties and drought conditions. Whereas T3 (23.25 g) found significantly superior over rest of the treatments for maximum biological yield per plant in V4 variety under normal irrigation condition. The foliar application of cow urine at the T3 level significantly enhanced the biological yield per plant in the V4 variety under normal conditions; showing increases of 55.83% compared to the control at harvest (Fig 2). According to Ukwu *et al*., 2024 reported that



In a microarray heat map, the columns (or rows) stand for parameters, while the rows (or columns) indicate treatment combinations (T: treatment, V: verities and I: drought level).

Fig 3: (A) Grain yield correlation coefficients on growth traits and yield components in V. radiate (B) Cluster heat map, where pixels are squared by adjusting the aspect ratio.

drought stress reduced grain yield, leaf area, 100-seed weight, number of seed per pod *etc*.

CONCLUSION

Drought is an adverse environmental phenomenon that affects agricultural production worldwide and is characterized by a lack of water. Based on the above-mentioned findings, which include observations from the growth stage to yield, it is possible to draw the conclusion that foliar application of 10% cow urine at 25 and 50 days after sowing is the most effective way to achieve vigorous vegetative growth and increased yield of mungbean crop under both irrigated and drought conditions. It can also potentially mitigate the negative effects of drought by causing mungbean plants to develop resistance or tolerance.

Author contributions

Manju Jat: writing-original draft preparation, Conceptualization; Manoj Kumar Sharma: methodology, investigation, validation, supervision; Manoj Kumar Sharma: data curation, formal analysis, supervision; Basant Kumar Dadrwal: review and editing.

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Disclaimers

The opinions and findings discussed in this article are entirely those of the authors and may not reflect the positions of their respective institutions. Although the authors have ensured the accuracy and completeness of the information presented, they are not liable for any direct or indirect damages that may arise from the use of this material.

Informed consent

Plant seed collection was conducted at the Rajasthan Agricultural Research Institute (RARI), Durgapura.

Conflict of interest

The authors declare that none of their personal relationships or competing financial interests could have an impact on the work presented here.

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