# Physiological responses of osmopriming and hormonal treatments in two contrasting mungbean (*Vigna radiata*) cultivars

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**The present study was conducted to identify the effects of some priming treatments, viz. polyethylene glycol (PEG), indole-acetic acid (IAA), abscissic acid (ABA), PEG + IAA, PEG + ABA on germination and seedling growth in two commonly grown mungbean cultivars, Pratap and IPM99-125 which differed in their response to drought. Primed seeds were further fed for evaluation of different seedling morpho-physiological characteristics. The study confirms the positive effect of priming on germination stage of mungbean, irrespective of the cultivars. Significant differences were noted for the applied treatments in both the cultivars, the best being PEG and PEG + IAA for cultivar Pratap (drought-resistant) and IPM99-125 (drought-susceptible) respectively.**

**Keywords:** Germination, mungbean, morpho-physiological characteristics, priming treatments.

WITH the increasing population and economic development, expansion of agriculture and industry has equally accentuated resulting in higher water demand. Along with the changing climatic conditions, the global rainfall pattern has also changed leading to water scarcity in recent times causing severe drought stress in plants.

Drought is one of the most complex, devastating events that plants encounter which severely affects growth, especially for short-duration crops like mungbean, an essential grain legume. Short-term growth (90–120 days), nitrogen-fixation capability, soil reinforcement and prevention of soil erosion make mungbean even more popular as a crop for farmers. Irregular rainfall pattern and the expanding drought-stressed zones have accentuated, creating it a limiting factor for mungbean growth and production all over the world, including three billion people by 2030 (ref. 1).

Seed invigoration is now a successful method to reduce the germination time and also for better crop establishment. Seed priming is one of the pre-sowing strategies which enhances seedling growth, germination rate and plant performance by regulating key metabolic processes, and thereby combats stress[2]. Seeds are first partially hydrated, while radical protrusion is prevented, and then dried back to the original moisture level[3]. The most important priming treatments include osmopriming, hydropriming and hormone priming. Osmopriming involves special treatment of seeds with low osmotic potential solutes like polyethylene glycol (PEG), mannitol and chemical fertilizers (such as urea and nitrate)[4]. For hydration, seeds are soaked in water and then dried before they are sown[5,6]. Hydropriming is also known to enhance drought tolerance in germination stage[7]. Efficacy of the priming treatment depends upon the duration and osmotic potential of the priming solution[8]. Growth regulators like auxin and abscissic acid (ABA) play a key role in the mechanism of dormancy breaking in seeds of many plant species. However, a paucity of information remains in investigating their combined effects in mungbean. With this background, we studied the effect of PEG, indole-acetic acid (IAA), ABA priming individually as well as in combination and further identified the effective priming treatments on seedling growth of two mungbean cultivars known to differ in their response to drought.

Seeds of two mungbean cultivars, Pratap and IPM99-125, were collected from the Regional Agricultural Research Station (RARS), Nagaon and IPRI, Kanpur respectively and stored at 4° ± 1°C till further use. Moisture content of seeds was determined using an oven at 103°C for 12 h.

Seeds were first surface-sterilized (Figure 1) and then treated with 20% PEG (T1), 1 ppm IAA (T2) and 1 ppm ABA (T3) individually. Combination of treatments was also used, viz. 20% PEG + 1 ppm IAA (T4), 20% PEG + 1 ppm ABA (T5). A control set was simultaneously maintained, where seeds were dipped in double-distilled water after sterilization. Mungbean seeds of both cultivars were subjected to these priming treatments with three replicates for 24 h. Each replicate contained 15 seeds. Mean ± SE values were calculated.

Germination tests were carried out according to standard protocols established by the International Seed Testing

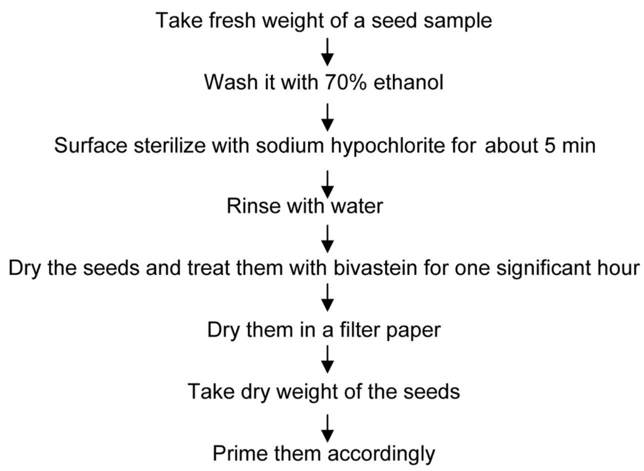


**Figure 1.** Surface sterilization technique used to sterilize mungbean seeds of the two cultivars chosen prior to seed priming.

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Association (ISTA, Switzerland). The experimental units were arranged in a completely randomized design with three replications. Fifteen seeds from each of the priming treatments were placed on moistened filter papers in petri dishes and germinated in an incubator at 20° ± 1°C. Germination of seeds (protrusion of radicle by 2 mm) and root–shoot length were recorded at daily intervals over the course of seven days[9].

The germination index (GI) was calculated as described by the Association of Official Seed Analysts (AOSA)[10] using the formula

GI = Number of germinated seed/days of first count
+ Number of germinated seed/days of final count.

The vigour index (VI) was calculated using the formula

VI = [Seedling length (cm) × germination percentage].

One-way analysis of variance (ANOVA) was used to test the effect of priming treatments with SPSS for Windows 16.0.20. The Duncan multiple range (DMRT) tests were used to assess the differences among the means of three replications at $P < 0.05$. All data obtained were subjected to two-way ANOVA (treatment and cultivar as the main effects) (Table 1).

Priming treatments, both individually and in combination, highly accentuated seedling growth and germination compared to the control, except in treatment T5. Compared to control, significant increase in root and shoot length was recorded in the drought-tolerant cultivar Pratap under all the priming treatments, though no significant differences for root growth were observed between treatments T1 and T4. However, maximum root and shoot length was observed under treatments T2 and T1 respectively. On the other hand, in the drought-sensitive cultivar IPM99-125 maximum root and shoot length was recorded under treatments T1 and T4 respectively. However, no substantial difference for root growth was noted under treatments T3 and T2.

**Table 1.** Two-way ANOVA results demonstrating the mean squares of the priming treatments and the significance ($P \leq 0.05$) between the contrasting mungbean cultivars

| | Mean squares | | | Significance |
|---|---|---|---|---|
| Parameters | Treatment (T) | Variety (V) | T × V | S/NS |
| Root | 1.578 | 3.028 | 0.565 | S |
| Shoot | 9.89 | 9.76 | 3.86 | S |
| GP | 138.32 | 78.05 | 85.43 | S |
| Germination index | 33.17 | 20.41 | 15.43 | S |
| Vigour index | 167697 | 113299 | 59807 | S |
| d*f* | 5 | 1 | 5 | |

S, Significant; NS, Non-significant; GP, Germination percentage.

GI in both the cultivars was also seen to increase under the priming treatments compared to control. However, results demonstrated that treatments T2, T3 and T1, T3 performed similarly in cultivars Pratap and IPM99-125 respectively. T1 was found to be the best treatment to increase GI in cultivar Pratap, and T2 in cultivar IPM99–125. The maintenance of GI and root length for cultivar Pratap even in unprimed seeds further reconfirms its superior varietal performance (Figure 2).

Significant increase in VI was recorded in all the priming treatments, with the highest value in treatment T1 of cultivar Pratap and treatment T4 of cultivar IPM99-125. However, the increase in VI between treatments T2 and T4 was non-significant in cultivar IPM99-125. On comparison, cultivar Pratap recorded 18% higher root length when primed with T1 and T4. It also showed a 33% increase in shoot length and 24% increase in VI under T1.

On the contrary, priming with ABA individually and in combination with PEG did not show significantly better results compared to control.

PEG treatment or osmopriming applied in mungbean showed better responses for root–shoot length, GI and VI in both the cultivars, which could be attributed to the improved seed germination and growth. This is in agreement with the results of Basra *et al.*[11]. The positive effect of osmopriming in seed performance like seedling growth[12], uniformity[13] and seed germination rate[14], can mainly be attributed to the accelerated metabolism and physiological alterations which modify protein expression[15,16], enzyme activity[17], synthesis of DNA[18], and RNA[19]. Reports of successful PEG priming in different agricultural and horticultural crops also indicate its affirmative role in plants[20].

Hormones like ABA, IAA, giberellic acid (GA), ethylene and their essential role in plants are well evidenced by the fact that their concentration changes with the developmental stages of plants and this correlation is further reconfirmed by the hormone–metabolite activity relationship. Though ABA and auxin regulate plant growth and development, they contribute to the same in a contrasting manner[21].

The poor performance of mungbean cultivars undertreatments T3 and T5 might be due to their inhibitory role in seed germination by controlling radical emergence, cell wall loosening and expansion, which also supports the results of other studies[22]. The better response of cultivar Pratap to treatments T3 and T5 for most of the studied parameters can be related to its inherent superior varietal performance.

Better root length in mungbean cultivar Pratap under treatment T2 indicated IAA-induced rapid cell division in the root tips. This is in agreement with other studies[7,23], where the correlation of IAA priming with root growth and development has been strongly elucidated.

On the contrary, in the relatively inferior cultivar IPM99-125, osmopriming in combination with IAA

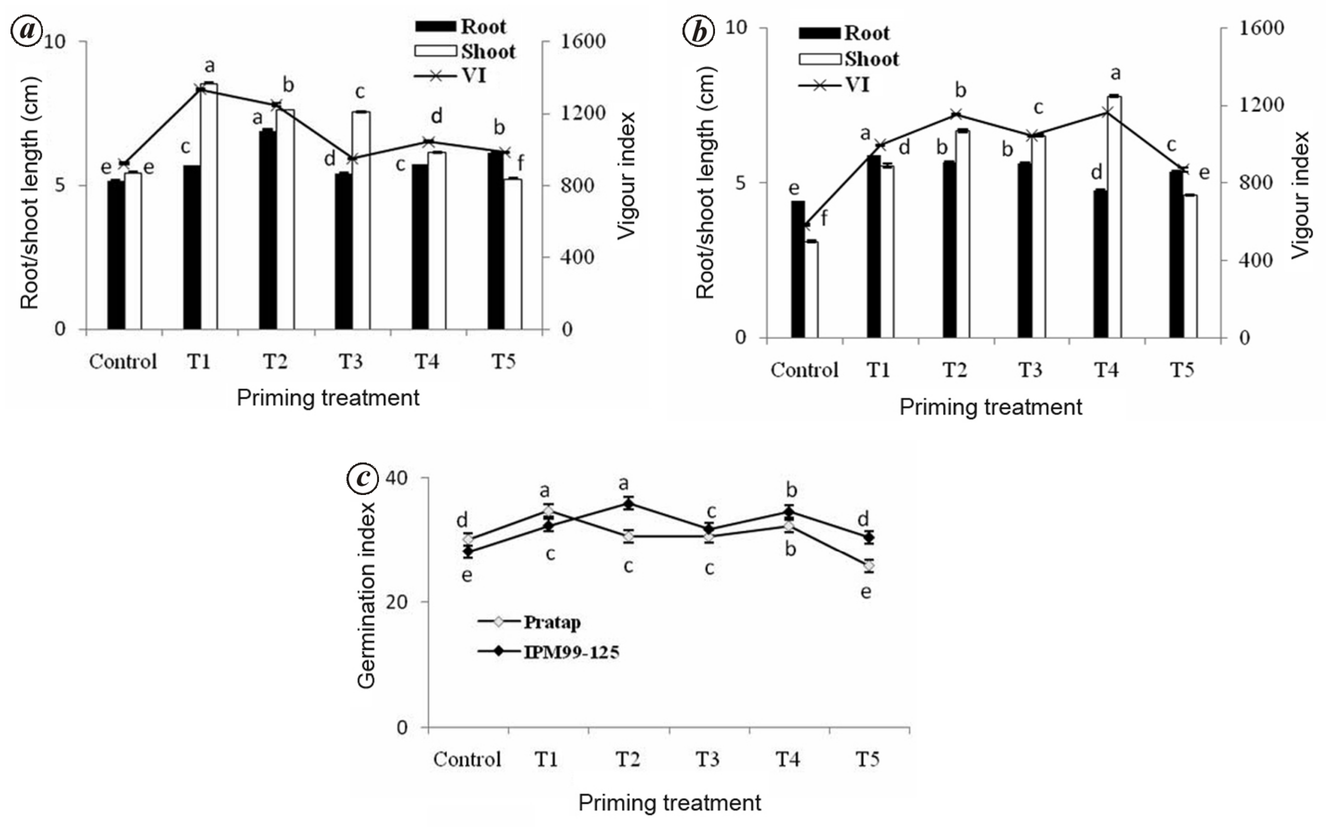


**Figure 2.** Effects of priming treatment on root length, shoot length and vigour index (VI) in mungbean cultivars Pratap (***a***), IPM99-125 (***b***), and on germination index (GI) in both the cultivars (***c***). (Mean ± SE values.)

priming treatment gave better shoot length, GI and VI corresponding to the fact that seed germination and different plant physiological activities are enhanced with the addition of growth regulator IAA[24]. However the higher GI and VI might be due to the enhanced activities of various enzymes like alfa amylase, accentuated DNA–RNA production, and improved ATP synthesis by increased mitochondrial activity and efficiency[25].

Thus, the priming treatments considered here performed well for both the cultivars, though cultivar Pratap gave better results. Osmopriming alone performed well for superior mungbean cultivar Pratap. On the other hand, better GI, VI and plant seedling establishment could be only reached in the comparatively inferior mungbean cultivar, IPM99-125 when osmopriming was supported with IAA hormonal treatment. The study therefore provides clear evidence on the positive role of priming in germination stage, irrespective of the mungbean cultivars considered.


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# Improvement in productivity and economics of major food production systems of India through balanced dose of nutrients

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**Increasing the nutrient use efficiency in major food production systems has always been a major concern because of escalating costs of production of crops, especially with regard to nutrient management. 'Researcher-designed farmer managed trials' were conducted during 2013–14 through farmer participatory research covering the major food production systems in India. A total of 144 trials in rice–rice, 156 in rice–wheat, 48 in rice–green gram and 60 in maize–wheat systems were conducted with 7 treatments. Across the various National Agricultural Research Project zones and cropping systems, farmers applied 29%, 25%, 71% and 100% lower level of N, $P_2O_5$, $K_2O$ and micronutrients respectively, than the recommended dose. Application of recommended dose of NPK + deficient micronutrients in all the systems recorded higher yield over farmer package. Balanced application of recommended NPK + deficit micronutrients gave additional yield. The increase in agronomic efficiency (AE) of nitrogen (two times on an average), phosphorus (45%) and potassium (60%), partial factor productivity and relative response was also observed with the balanced application compared to N, NP and NK alone. Higher increase of AE of N and P was observed in rice–rice system while AE of K was observed in rice–wheat system. Increase in net returns was found to be 24.9%, 63.3%, 27.4% and 92.2% with the application of NPK + deficient micronutrients over farmer practice in rice–rice, rice–wheat, rice–green gram and maize–wheat systems respectively, whereas the increase in cost of cultivation due to addition of P, K and micronutrients was found to be only 4.8%, 7.3%, 13.0% and 17.9% for the respective systems.**

**Keywords:** Agronomic efficiency, food systems, nutrient application, partial factor productivity, productivity and economics.

RICE, wheat and maize crops supply about two-thirds of the energy requirement in human diets. The four key cropping systems of India, namely rice–rice (5.89 m ha), rice–wheat (10.50 m ha), rice-green gram (0.59 m ha) and maize–wheat (1.86 m ha) occupy more than 18 million ha and greatly influence food production in the country.

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