**Optimizing productivity and profitability of mungbean (*Vigna radiata L.*) with strategic foliar application of nutrients under hot arid condition of Rajasthan**

**ABSTRACT**

A field experiment was conducted at Agricultural Research Sub-Station, Nagaur, Agriculture University, Jodhpur during (*kharif*) for two consecutive years (2021-2022) to evaluate the impact of foliar nutrient application on the growth, yield, productivity and also combating the dry spell effect during flower initiation and pod formation stage in mung bean. The elven treatments, viz, absolute control (without foliar application); foliar spray of nitrogen urea @ 1% at flowering initiation stage (FI); foliar spray of nitrogen urea @ 1% at FI and Pod formation (PF) stage; foliar spray soluble NPK (19:19:19) @ 1% at FI stage; FS soluble NPK (19:19:19) @ 1% at FI and (PF) stage; foliar spray of soluble KNO3 @ 0.5% at FI stage; foliar spray of soluble KNO3 @ 0.5% at FI and PF stage; foliar spray of borate @ 0.5 % at FI stage; foliar spray of borate @ 0.5 % at FI and PF stage; foliar spray of micronutrient 6’S element (Fe,Zn,Mn,Cu,Mo,B) @ 0.5 % at FI stage and foliar spray of micronutrient 6’S element (Fe,Zn, Mn, and Cu, Mo, B) @ 0.5 % at FI and PF stage was laid out in randomized block design with replicated thrice. Results revealed that foliar application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5 % concentration at flower initiation and pod formation stage exhibited the highest growth and yield attributes of mungbean *viz*., plant height at maturity (78.4 cm), number of branches per plant (8.3), number of active nodules at flowering (24.1), number of pods per plants (61.1), number of seeds per pods (13.6) and 1000-grain weight (43.2 gm) mean grain yield (13.9 q/ha). This treatment also resulted in significant improvement in net returns (₹72,359/ha), B:C ratio (2.25), production efficiency (20.4 kg/ha/day) and monetary efficiency (₹1064/ha/day). However, the lowest value was observed without foliar application. It was concluded that foliar application of micronutrient 6’S element (Fe, Zn, Mn, and Cu, Mo, B) @ 0.5% at flower initiation and pod formation stages exhibited superior growth, yields and returns under the hot arid conditions of Rajasthan (India).

**Key words:** Borate, Foliar spray, growth, micronutrient 6’S element, Production and Monetary efficiency, and Yield

**Introduction**

“Mung bean (*Vigna radiata* L.) alternatively known as green gram, green bean, moong bean, golden gram belongs to the leguminaceae family. It is an important pulse crop in India and believed to be originated from India. It plays an important role as a food security crop because of its nutritional excellence as well as ability to survive in severe environmental conditions such as arid and semiarid lands. They are mainly grown for human food, flour while sprouts and immature pods as a vegetable. The grains contain approximately 25-28% protein, 3.5-4.5% fiber, 4.5-5.5% ash and 60-65% carbohydrates on dry weight. The grains also contain vitamin-A (94 mg), Vitamin-C (8 mg), iron (7.3 mg), calcium (124 mg), magnesium (189 mg), phosphorus (367 mg) and foliate (549 mg)” (Muchomba *et al.* 2023). “Besides presence of a rich source of protein, green gram roots are important sources of soil nitrogen. The roots have the capacity to develop nodules that help in fixing atmospheric nitrogen in the soil through nitro-bacter bacteria through biological nitrogen fixation, the crop has the ability to add about 30-40 kg N/ha in a single season. The vegetative parts, stocks and husks are also useful sources of leguminous fodder for livestock. The crop also serves as an important cover and a rotation crop” (Dhakal *et al*. 2016).

India is the main producer as well as consumer of pulses in the world. Mung bean with 31.94 lakh ha area is the third important pulse crop of India grown in nearly 10 per cent of the total pulses area of the country. In India, total production of mung bean is 15.06 lakh tonnes (Anonymous 2023-24a). Rajasthan is the state having highest area, production and yield of mung bean about 22.12 lakh hectare, 10.56 lakh tonnes, 477 kg/ha, respectively (Anonymous 2023-24b). “The dominant contributors to mungbean cultivation in terms of area and production are Rajasthan (46% and 45% respectively), with Madhya Pradesh (9% and 14%), Maharashtra (9% and 8%), Karnataka (9% and 6%), Odisha (5% and 4%), Bihar (4% and 5%), Tamil Nadu (4% and 3%), Gujarat (3% and 4%), Andhra Pradesh (3% for both), and Telangana (2% for both) also playing significant roles,” (Anonymous, Annual Report, ICAR-IIPR, 2022-23). “In rajasthan, maximum area under mung bean cultivation was covered by Nagaur (27%), followed by Jodhpur (13.57%) and Pali (12.18%) districts of Rajasthan. Nagaur, Jodhpur and Pali, together contribute more than 50% of the total area under mungbean cultivation in Rajasthan” (Sharma et al. 2017).

“Adequate food production and distribution have been severely worried by booming population, climate variability, industrial emissions, and growing fuel and power demands. According to the Food and Agriculture Organization” (*FAO, 2017*), “around 2050, the population of the planet would have surpassed 10 billion, resulting in a 50 percent increase in food requirement, predominantly in developing countries. Worldwide, micronutrient deficiencies impact approximately 38% of pregnant mothers and 43% of preschool-aged children. According to reports, over 30% of people on the planet are anaemic and experiencing hidden hunger” (Dogra et al., 2024). “The worldwide issue to acceptance the approaches for sustainable crop production in the degrading soil health and environment is losses of major as well as micronutrient” (Ram et al., 2022). Indian soils short of micronutrient mainly Zn, Fe, Mn, Cu, B, Mo, and S are 48, 12, 5, 4, 33, 13, and 41 percent, respectively (Boradkar *et al.,* 2022). “Common fertilizer practices comprise only major nutrients applying as nitrogen and phosphorus and mostly the micronutrients are scarce as emerged significant barriers to achieve high crop yields in legumes. Micronutrients like Iron, Zinc, Manganese, Copper, Molybdenum, and Boron are important in increasing legume yield through their effect on the plant itself, nitrogen-fixing symbiotic process, and effective use of major and secondary nutrients. They have a key role in cell division, development of meristematic tissues, photosynthesis, respiration, and acceleration of plant maturity. Currently micronutrient deficiencies are found limiting factors for crop growth and optimum legume yield”. (Basir *et al.,* 2022).

“The hot arid region of western Rajasthan poses a unique challenge for mungbean cultivation due to nutrient deficiencies intensified by limited water availability, prevalence of high temperatures and poor soil conditions, such as salinity or extreme pH, root-based nutrient uptake is impeded, making foliar nutrition an effective approach to overcome fixation and immobilization challenges, enhancing nutrient efficiency, particularly for short-duration crops” (Pochampally *et al.,* 2021: Danga *et al.,* 2020). Keeping the above facts in view, the present study was conducted with the objectives to examine the growth and yield, productivity, profitability and also combating the dry spell effect through foliar application of nutrient at flower initiation and pod formation stage of mungbean under the hot arid conditions of Rajasthan (India).

**Material Methods**

A field experiment was conducted two consecutive seasons during *Kharif* (Rainy) of 2022 and 2023 at the Research farm of Agricultural Research Sub-Station, Nagaur, Agriculture University, Jodhpur, Rajasthan situated at 27° 12' 7.24'' N latitude, 73° 44' 2.18 E longitude, at an altitude of 302 m above the mean sea level. This location falls within agro-climatic zone II A, characterized as arid and semi-arid transitional plain of inland drainage zone in Rajasthan. The climate of this region is distinctly arid and semi- arid marked by significant temperature fluctuations throughout the year. Average annual rainfall of 385 mm, about 80% of which falls during July–September from the southwest monsoon while the rest is more or less equally distributed during the rest of the year. Weather data during the whole experimental period was recorded and presented as per –

List 1 : Weather data during the whole experimental period

|  |  |  |  |
| --- | --- | --- | --- |
| Months  | Mean monthly maximum temperature (˚C) | Mean monthly minimum temperature (˚C) | Total monthly rainfall (mm) |
| 2021 | 2022 | 2023 | 2021 | 2022 | 2023 | 2021 | 2022 | 2023 |
| July  | 37 | 34 | 35 | 29 | 27 | 28 | 130 | 270 | 233 |
| August  | 36 | 33 | 35 | 28 | 26 | 26 | 126 | 216 | 16 |
| September | 33 | 36 | 37 | 26 | 27 | 27 | 175 | 54 | 46 |

 The soil samples were drawn from top 15 cm soil depth. The soil in the experimental field is classified as loamy sand and slightly alkaline in reaction (pH 8.2) and with EC of 0.35 dS/m. The soil was low in organic carbon (0.15%), available N (219 kg/ha), available P2O5 (15 kg/ha) and available K2O (217 kg/ha). Eleven treatments (T1: Absolute control (without foliar application); T2: foliar spray of nitrogen urea @ 1% at flower initiation (FI) stage; T3: foliar spray of nitrogen urea @ 1% at FI and pod formation (PF) stage; T4: foliar spray soluble NPK (19:19:19) @ 1% at FI stage; T5: foliar spray soluble NPK (19:19:19) @ 1% at FI and PF stage; T6: foliar spray of soluble KNO3 @ 0.5% at FI stage; T7: foliar spray of soluble KNO3 @ 0.5% at FI and PF stage; T8: foliar spray of borate @ 0.5 % at FI stage; T9: foliar spray of borate @ 0.5 % at FI and PF stage; T10: foliar spray of micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @ 0.5 % at FI stage and T11: foliar spray of micronutrient 6’S element (Fe, Zn, Mn, and Cu, Mo, B) @ 0.5 % at FS and PF stage was laid out in randomized block design with three replications. Micronutrient mixture 6’S (Six element) was ready mix with grade of Zn:5%, Fe:2%, Mn:2%, Cu:0.5%, B:0.5% and Mo: 0.05%, borate (Di sodium tetra borate penta hydrate:20%), Potassium nitrate 13% nitrate nitrogen and 46% potassium oxide (K2O) and soluble urea nitrogen 46% in available form solubilized in an aqueous medium at the rate of 500-liter water/ha @ 0.5% at flower initiation and pod formation stage using a knapsack sprayer with flat-fan nozzle. Seeds of Mung bean variety “GM-4” were sown manually with 30 x 10 cm planting geometry using seed rate of 15 kg/ha on 08 July and 18 July 2022 and 2023, respectively. The crop was grown under totally rainfed conditions. A recommended dose of fertilizer (40:20 kg NP2O5/ha) was applied as basal application through Urea and Di-ammonium phosphate (DAP) as per package of practices of crop for the area. Cultural practices appropriate for the Agro-climatic zone were applied throughout the mung bean growth cycle, except for the experimental foliar nutrient management technique. Activities such as gap filling, thinning, irrigation, weeding, mulching, and pest control were performed as needed to ensure optimal plant growth and development. Observations on the number of nodules/plants, plant height (cm), number of branches/plants, number of pods/plants, and number of seeds/pods were conducted by randomly selecting five representative plants from each plot within each replication. Additionally, test weight (g) and overall yield were documented. The important growth parameters, yield attributes and yield were recorded as per standard procedures. In order to calculate the net returns for each treatment, total cost of cultivation was subtracted from the gross returns. Total cost of cultivation calculated as per input and labour requirement at the time of experiment conducted. Gross returns were estimated as per the minimum support price of last three years prevailing at the time of conduct of experiment of and benefit-cost ratio was calculated from gross return to cost of cultivation. Harvesting occurred on 1th October 2022 and 5th October 2023~~.~~ Grain and straw yield were recorded from the net plot area of each treatment. Harvest index (HI) was calculated as:

|  |  |  |
| --- | --- | --- |
| HI (%) = [ | Seed yield | ] × 100 |
| Biological yield |

Benefit-cost (B:C) ratio was computed to assess the economic viability of different treatment combinations as:

|  |  |
| --- | --- |
| B:C Ratio =  | Net Returns (₹/ha) |
| Cost of cultivation (₹/ha) |

Production Efficiency was calculated as:

|  |  |
| --- | --- |
| Production efficiency (Kg/ha/day) =  | Mean Yield obtained (t/ha) |
| Number of growing days (Days) |

Monetary Efficiency was calculated as:

|  |  |
| --- | --- |
| Monetary efficiency ((₹/ha/day) =  | Net returns obtained (₹/ha) |
| Number of growing days (Days) |

The experimental data were subjected to statistical analysis employing standard techniques of analysis of variance (ANOVA). Mean analysis of the data was conducted, adhering to the methodology outlined by Gomez and Gomez (1984). Furthermore, mean comparison was carried out based on critical differences at the 5% probability level.

**Results and Discussion**

**Effect of foliar application of nutrients on growth, yield attributes and yield**

Foliar application of different nutrients at flower initiation and pod formation stage significantly influenced the growth, yield attributes and yield parameters of mungbean. Among the various treatments, foliar application of nutrients soluble nitrogen urea, NPK, KNO3,borateand micronutrient 6’s element exhibited the significant enhancement in plant growth, yield attributes and yield parameters, economics, production and monetary efficiency over the absolute control (Table 1). The highest value of plant height at maturity (78.4 cm), number of branches per plant (8.3), number of active nodules at flowering (24.1), number of pods per plants (61.1), number of seeds per pods (13.6) and 1000-grain weight (43.2 gm) was observed when treated with foliar application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5 % concentration at flower initiation and pod formation stage (Table 1). However, the lowest value of plant height (63.7 cm), number of branches per plant (6.8), number of active nodules at flowering (21.3), number of pods per plants (46.0), number of seeds per pods (11.3) and 1000-grain weight (39.9 gm) was observed in mungbean grown without foliar application. This similar result was observed with Shivashankar *et al.* (2023) who displayed that the foliar application of 1%K through KNO3/KCl at flowering and pod development stage recorded significantly higher grain and straw yield than rest of the treatments. This fact can be recognised to the improved availability of both macro and micronutrients to the plants through foliar nutrient application. This enhanced nutrient availability eased early root growth, cell multiplication, and nutrient absorption from deeper soil layers. Thus, these factors part to increased plant height, enhanced food synthesis and better partitioning of resources (Dhaliwal *et al.* 2023). These results were in tune with Zafar et al. (2023), who observed that number of branches, plant height, pods/plant, pod length, seeds/pod, 1000-grain weight and grain yield of mungbean were significantly improved with foliar application of Zn @ 0.3%. Zinc serves a complex role in plant physiology, exerting regulatory control over water uptake and effective utilization by plants (Bahadari *et al.* 2020).

The two-year mean data demonstrated that the application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5 % concentration at flower initiation and pod formation stages registered the highest year wise *kharif* season seed yield 14.6 and 13.2 q/ha during year 2022 and 2023, respectively (Table 1). These treatments also resulted in significant improvement in mean seed yield (13.9 q/ha), straw yield (24.9 q/ha), biological yield (38.8 q/ha) and harvest index (35.8%) followed by foliar application of borate @ 0.5 % at flower initiation and pod formation stages provided the mean seed yield (12.3 q/ha), straw yield (25.1 q/ha), biological yield (37.4 q/ha) and harvest index (32.8%) and whereas, the lowest value of mean seed yield (10.4 q/ha), straw yield (22.5 q/ha), biological yield (32.9 q/ha) and harvest index (31.5%) was recorded of mungbean grown without foliar application of nutrients (Table 1 & 2). The foliar application of micro elements might have increased the plant height, leaf area index, 1000-grain weight, total chlorophyll content, grain protein percentage, proline accumulation and with and without stress condition (Amirani and Kasraei, 2015). Foliar application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5% concentration at flower initiation and pod formation stages exhibited a significant increased number of branches/plant, number of pods/plants, number of seeds/plants, number of active nodules/plants, mean seed yield and harvest index with a notable improvement 22.1%, 32.8%, 20.3%, 13.1%, 33.6%, and 13.6%, respectively, over the without foliar application of nutrients (Fig. 1). The same results were obtained under combined application of ZnSO4.7H2O (0.5%) + FeSO4. 7H2O (0.5%) + borax (0.1%) could be considered the most effective combination for enhancing yield, nutritional quality and economic returns of mungbean(Dhaliwal *et al.,* 2023) and also significant increase in yield and yield attributes due to foliar application of ferrous sulphate, zinc sulphate and borex might be due to increased leaf area (Kumawat *et al*., 2006; Ali *et al*., 2008). The addition of zinc and ferrous to the soil might have also caused higher activation of micronutrients mainly due to its positive effects in mobilizing the native nutrients to increase their availability besides addition of zinc and ferrous to the soil to provide better nutrition over longer time and coactive effect of both nutrients on yield component (Bahadari *et al.* 2020). Such improvement effect might be also attributed to the favorable influence of these nutrients on metabolism and biological activity and stimulatory effect on photosynthetic pigments and enzymatic activity which in turn increase vegetative growth of plants (Thalooth *et al.*, 2006). Similar results showed that foliar fertilization of NPK with Fe, Zn and Mn reflected increases in vegetative growth, yield component and nutrient concentrations by cowpea plant (Ali *et al.,* 2014; Barla *et al.,* 2023)

|  |  |
| --- | --- |
| Fig. 1. Effect of foliar application of nutrients at flower initiation and pod formation stage on seed yield and percent improvement of yield over control | Fig. 2. Effect of foliar application of nutrients at flower initiation and pod formation stage on production and monetary efficiency over control  |

**Effect of foliar spray of nutrients on economics, production and monetary efficiency**

The economic analysis of mung bean cultivation as influenced by foliar application of various soluble nutrients of nitrogen urea, NPK, KNO3,borateand micronutrient 6’s element. The data indicated that the highest cost of cultivation was found for micronutrient 6’s element (₹ 32100/ha) followed by borate application (₹ 31,700/ha), whereas, the minimum cost of cultivation was observed in without foliar application (₹27,500/ha). The highest gross return (₹1,04,459/ha) and net returns (₹72359/ha) was observed with foliar application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5 % concentration at flowering and pod formation stages and least gross return (₹77,780/ha) and net returns (₹50,280/ha) was observed in without foliar application (Table 2). The similar finding was tuned with Diwedi *et al.* (2024). The highest B:C ratio (2.25), production efficiency (20.4 kg/ha/day) and monetary efficiency (₹1064/ha/day) was also obtained under foliar application of micronutrient 6’s element 0.5 % concentration at flowering initiation and pod formation stages followed by foliar application of borate for production efficiency (18.0 kg/ha/day) and monetary efficiency (₹888/ha/day) whereas, the minimum production efficiency (15.2 kg/ha/day) and monetary efficiency (₹739/ha/day) was observed in without foliar application (Fig. 2). The similar results were also reported by Dhaliwal *et al.,* (2023).

**Conclusion**

The study clearly states the importance of foliar application of nutrients during flower initiation and pod formation stage in mungbean for increasing growth, yield and economics. The recommended dose of fertilizers with foliar application of soluble nutrients at flower initiation and pod formation stage of nitrogen urea @ 1%, NPK (19:19:19) @ 1%, KNO3, @ 0.5% borate@0.5% and micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @ 0.5 % exhibited the superior performance of mung bean in terms of growth and yield parameters and monetary returns and production efficiency over control. Thus, application of micronutrient 6’s element (Fe, Zn, Mn, Cu, Mo, B) at 0.5% concentration at flower initiation and pod formation stages could be considered an effective combination for enhancing growth, yield economic returns, production and economic efficiency of mungbean under the hot arid conditions of Rajasthan (India).

**Table 1. Effect of foliar application of nutrients on the growth and yield attributes of mungbean (Mean data of two years)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Plant height at maturity (cm) | Number of branches/plants | Number of active nodules at flowering | Number of pods/plants | Number of seeds/pods. | 1000 -grain weight(gm) | Seed yield (q/ha) | Stalk yield (q/ha) | Biological yield(q/ha) |
| 2021 | 2022 | Mean  |
| Absolute control (Without foliar application) | 63.7 | 6.8 | 21.3 | 46.0 | 11.3 | 39.9 | 10.6 | 10.1 | 10.4 | 22.5 | 32.9 |
| Foliar spray of nitrogen Urea @ 1% at FI stage  | 73.0 | 7.9 | 23.1 | 49.8 | 11.8 | 40.1 | 11.7 | 10.5 | 11.1 | 23.5 | 34.6 |
| Foliar spray of nitrogen Urea @ 1% at FI and PF stage | 73.8 | 8.0 | 23.4 | 50.8 | 12.0 | 41.3 | 11.9 | 10.6 | 11.3 | 23.5 | 34.8 |
| Foliar spray soluble NPK (19:19:19) @ 1% at FI stage  | 73.4 | 8.1 | 23.8 | 49.6 | 12.1 | 41.5 | 12.0 | 10.7 | 11.4 | 24.6 | 36.0 |
| Foliar spray soluble NPK (19:19:19) @ 1% at FI and PF stage | 76.0 | 8.1 | 23.8 | 51.2 | 12.5 | 41.1 | 12.2 | 10.9 | 11.6 | 24.7 | 36.3 |
| Foliar spray of soluble KNO3 @ 0.5% at FI stage | 71.4 | 8.2 | 23.9 | 50.5 | 12.6 | 41.3 | 11.6 | 12.2 | 11.9 | 25.2 | 37.1 |
| Foliar spray of soluble KNO3 @ 0.5% at FI and PF stage | 72.4 | 8.2 | 24 | 52.3 | 12.3 | 41.8 | 12.5 | 12.1 | 12.3 | 24.6 | 36.9 |
| Foliar spray of borate @0.5 % at FI stage  | 74.1 | 8.2 | 24.1 | 52.9 | 12.5 | 43.8 | 11.9 | 12.1 | 12.0 | 25.0 | 37.0 |
| Foliar spray of borate @ 0.5 % at FI and PF stage  | 75.1 | 8.2 | 24.1 | 53.2 | 12.7 | 42.7 | 12.4 | 12.1 | 12.3 | 25.1 | 37.4 |
| Foliar spray of micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @0.5 % at FI stage  | 73.2 | 8.2 | 24.4 | 53.5 | 12.8 | 43.0 | 12.7 | 12.4 | 12.6 | 24.4 | 37.0 |
| Foliar spray of micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @0.5 % at FI and PF stage  | 78.4 | 8.3 | 24.1 | 61.1 | 13.6 | 43.2 | 14.6 | 13.2 | 13.9 | 24.9 | 38.8 |
| SEm± | 2.6 | 0.38 | 0.8 | 2.1 | 0.2 | 0.3 | 0.36 | 0.34 | 0.35 | 0.76 | 0.82 |
| CD (*P*=0.05) | 7.9 | 1.15 | 2.4 | 6.3 | 0.7 | 1.0 | 1.08 | 0.99 | 1.04 | 2.29 | 2.46 |

**Table 2. Effect of foliar application of nutrients on harvest index, economics production and monetary efficiency the yield in mung bean (Mean data of two years)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Harvest index | Cost of cultivation (₹/ha) | Gross returns(₹/ha) | Net returns (₹/ha) | Benefit costratio | Production efficiency (kg/ha/day) | Monetary efficiency (₹/ha/day) |
| Absolute control (Without foliar application) | 29.3 | 27500 | 77780 | 50280 | 1.83 | 15.2 | 739 |
| Foliar spray of nitrogen Urea @ 1% at FI stage  | 32.1 | 29500 | 83417 | 53917 | 1.83 | 16.3 | 793 |
| Foliar spray of nitrogen Urea @ 1% at FI and PF stage | 32.4 | 30500 | 84544 | 54044 | 1.77 | 16.5 | 795 |
| Foliar spray soluble NPK (19:19:19) @ 1% at FI stage  | 31.6 | 29500 | 85295 | 55795 | 1.89 | 16.7 | 821 |
| Foliar spray soluble NPK (19:19:19) @ 1% at FI and PF stage | 31.9 | 30500 | 86798 | 56298 | 1.85 | 17.0 | 828 |
| Foliar spray of soluble KNO3 @ 0.5% at FI stage | 32.1 | 29300 | 89429 | 60129 | 2.05 | 17.5 | 884 |
| Foliar spray of soluble KNO3 @ 0.5% at FI and PF stage | 33.3 | 30400 | 92435 | 62035 | 2.04 | 18.1 | 912 |
| Foliar spray of borate @0.5 % at FI stage  | 32.4 | 29400 | 90180 | 60780 | 2.07 | 17.6 | 894 |
| Foliar spray of borate @ 0.5 % at FI and PF stage  | 32.8 | 31700 | 92059 | 60359 | 1.90 | 18.0 | 888 |
| Foliar spray of micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @0.5 % at FI stage  | 34.0 | 30300 | 94313 | 64013 | 2.11 | 18.5 | 941 |
| Foliar spray of micronutrient 6’S element (Fe, Zn, Mn, Cu, Mo, B) @0.5 % at FI and PF stage  | 35.8 | 32100 | 104459 | 72359 | 2.25 | 20.4 | 1064 |
| SEm± | 0.86 | - | - | - | - | 0.42 | 29.1 |
| CD (*P*=0.05) | 2.59 | - | - | - | - | 1.29 | 87.6 |

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**COMPETING INTERESTS**

Authors have declared that no competing interests exists

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**ETHICS AND CONFLICT OF INTEREST**

This research is conducted ethically and in compliance with relevant guidelines and regulations. We, all the authors have declared that no conflict of interest exists that could have appeared to influence the work reported in this paper.

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