Effect of combined use of nutrition and weed management practices on the weed studies,seed yield and microbial counts of soil in blackgram (*Vigna mungo* (L.) Hepper)

Abstract

A study was conducted at NEBCrop Research Center, G.B.Pant University of Aagriculture &Technology, Pantnagar, to evaluate the effect of combined use of weed and nutrition management through seed inoculation, foliar application and weed management practices on the weed studies (weed count weed dry weight and weed control efficiency) and seed yield parameters of blackgram. The experiment was laid out in the factorial randomized block design with 3 factors, which 2 factors were about nutrient management i.e., seed inoculation (Rhizobium+ PSB &Rhizobium sp.+PGPR), and foliar nutrition (water spray, Nano urea @0.25 &18:18:18 NPK @2%), and one was about weed management(weedy check, Propaquizafop + Imazethapyr & Fomesafen% + Fluazifop-p-butyl). Results showed that among seed inoculation treatments, Rhizobium sp.+PGPR performs better in terms of total weed count, weed dry biomass, seed yield and microbial count (actinomycetes and bacteria) in soil whereas seed inoculation did not influence the weed control index, initial and final plant population and fungi count. After Weed-free treatment, Fomesafen% + Fluazifop-p-butyl gave minimum weed count, weed dry weight, maximum yield and microbial count (actinomycetes and bacteria) among weed management treatments. However, among foliar nutrition, 18:18:18 NPK @2% treatment gave maximum weed dry biomass and maximum seed yield, with microbial count in soil whereas foliar nutrition did not exert an effect on weed count, weed control index, plant initial and final plant population and fungi count. These findings highlight the importance of nutrient management through seed inoculation and foliar nutrition with weed management practices in addressing productivity issues with sustainability improving returns for black gram farmers.

Keywords: blackgram, microbes, seed inoculation, weed management, foliar nutrition

Introduction

Blackgram (*Vigna mungo* L. Hepper), commonly known as urdbean and black lentils, is one of India's most important pulse crops grown in tropical and subtropical regions and many parts of Southeast Asia. It is a highly nutritious crop, rich in protein (20-25%), essential amino acids, vitamins, and minerals, and forms a significant part of the vegetarian diet. Moreover, blackgram plays a vital role in sustainable agriculture due to its ability to fix atmospheric nitrogen through symbiotic associations with *Rhizobium* bacteria.Blackgram is widely cultivated under rainfed and marginal environments where it serves as an essential food legume, fodder, and green manure crop. It is a short-duration crop (70-90 days) that fits well into various cropping systems, including rice-fallow, cereal-pulse, and intercropping systems. Its ability to improve soil health through biological nitrogen fixation makes it an integral part of sustainable farming practices, particularly in resource-constrained farming systems.

Despite its importance in pulse production, soil fertility enhancement ecological and economic significance, blackgram productivity remains relatively low due to several constraints, such as poor weed and nutrition management.

Weed infestation is one of the major biotic stresses that significantly limits blackgram production and productivity. According to **Mansoori *et al.* (2015),** uncontrolled weed growth can cause yield losses of up to 70%, depending on factors such as weed density, type, and the duration of weed-crop competition. The first 3-5 weeks after sowing are considered the critical weed competition period, during which effective weed management is essential for ensuring optimal crop growth and yield (Singh *et al.*, 2014).Although manual weeding is effective, it is labor-intensive, time-consuming, and costly, making it impractical for large-scale cultivation. As an alternative, the adoption of herbicide-based weed control methods has shown promising results. The combined use of pre- and post-emergence herbicides, supplemented with manual weeding, proves to be more efficient than relying on a single herbicide, as the latter often fails to achieve broad-spectrum weed control. Additionally, the use of mixed herbicides can save time and enhance overall weed management efficiency.Post-emergence herbicides, such as imazethapyr and quizalofop-p-ethyl, have been particularly effective in controlling weeds without causing harm to crop growth. These herbicides not only minimize labor requirements but also effectively manage the second flush of weeds, a common challenge in pulse crops. However, careful selection and proper application of herbicides are crucial to avoid issues such as herbicide injury to crops and residue accumulation in the soil. By implementing integrated weed management practices, blackgram farmers can effectively tackle weed infestations and achieve higher productivity.

Nutrient management is a crucial factor that significantly influences blackgram growth, productivity, and soil fertility. As a leguminous crop, blackgram has relatively low external nutrient requirements compared to cereals. However, ensuring an adequate supply of essential nutrients remains vital for achieving optimal growth and yield.To enhance early vegetative growth and promote vigorous crop establishment while minimizing external fertilizer inputs, microbial seed inoculation emerges as an effective strategy. Blackgram has the unique ability to attract beneficial microorganisms and establish a synergistic relationship with them. This interaction enhances root development and canopy establishment, ultimately contributing to improved crop growth and productivity. Microbes produce the plant growth hormones that increase phosphorous, potassium, and other micronutrients available to the host plant (**Zahir *et al.*, 2004**). While microbial inoculation supports nutrient availability during the early stages, its efficiency often declines during the critical flowering and pod-filling phases due to environmental and physiological stress. During these stages, foliar nutrient application could be essential as it ensures quick and efficient nutrient uptake, addressing deficiencies and preventing yield reduction. The combined use of seed inoculation and foliar application thus offers a balanced approach to meet the crop's nutrient demands throughout its lifecycle, leading to improved yield and quality.

To address this problem, foliar application ensures the quick and efficient uptake of nutrients during these critical growth stages, helping to overcome nutrient limitations and improve crop yield and quality.

Adopting an integrated approach to weed and nutrient management is essential to maximize blackgram productivity in a sustainable manner. Combining pre-emergence and post-emergence herbicides with cultural practices such as crop rotation, mulching, and intercropping can effectively control weeds while reducing dependency on manual labor. Similarly, integrated nutrient management through the application of biofertilizers (e.g., *Rhizobium* inoculation), and balanced fertilizers ensures a steady nutrient supply while maintaining soil fertility.

Material and methods

Field experiment design and location

A field experiment was conducted during the *kharif* seasons of 2022 and 2023 at the N.E. BorlaugCrop Research CentreGB Pant University of Agriculture and Technology,Pantnagar Uttarakhand, India, located at 29.015° N-latitude and 79°48' E-longitude, with an altitude of 243.84 m above mean sea level in the foothills of the Shivalik mountain range. During the 2022 and 2023 crop growth period maximum temp goes 35 to 26 ^{o}C . during both years crop received 820 and 704 mm of rainfall, respectively.

The experimental field soil was silty clay loam in texture, neutral in pH (7.25), with an organic carbon content of 0.79%. The available nutrient status of the soil was low in nitrogen (250.2 kg ha^{-1}), medium in phosphorus (22.3 kg ha^{-1}), and potassium (150 kg ha^{-1}).

The experiment was laid out in a factorial randomized block design (FRBD) with 3 factors, which 2 factors were about nutrient management i.e., seed inoculation (I_1: Rhizobium+ PSB & I_2: Rhizobium sp.+PGPR), and foliar nutrition (water spray, Nano urea @0.25 &18:18:18 NPK @2%), and one was about weed management. The weed management treatments included W_1, where no weed control was carried out throughout the cropping period; W_2, where Propaquizafop 2.50% + Imazethapyr 3.75% ME @ 125 g ha^{-1} was applied at 20 DAS; W_3, where Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 220 g ha^{-1} was applied at 20 DAS; and W_4, where the field was kept weed-free throughout the cropping period. The foliar spray treatments consisted of F_1, where 500 l of water was sprayed at the flowering and pod-filling stages; F_2, where nano urea @ 2.5 ml L^{-1} was applied at the flowering and pod-filling stages; and F_3, where 18:18:18 NPK was sprayed at 2% concentration during the flowering and pod-filling stages.

Crop cultivation and management

Land preparation involved a single pass with a disc plough, followed by one pass with a cultivator, and a final pass with a rotavator to achieve a fine tilth. The field was divided into small plots with designated beds and channels. Gross plots measuring 6.3 × 5 m were laid out, while the net plot size was maintained at 4.5 × 4 m. The experiment used a high-yielding blackgram variety, Pant urd 9, known for its resistance to Mung bean Yellow Mosaic Virus and Powdery mildews.

Blackgram seeds were sown at a rate of 15 kg ha^{-1} after being treated with a Mancozeb 75% WP @ 3 g a.i. kg^{-1} of seeds followed by total seed quantity was equally separated into two parts and then 1 part was treated with Rhizobium + PSB and another part was treated with Rhizobium sp.+PGPR as per treatment @ 20 g kg^{-1} of seeds. Seeds were inoculated by coating them with a powdered microbial formulation containing respective treatments, using a 10% gum arabic solution as an adhesive. The treated seeds were then shade-dried for 30 minutes before sowing. Seeds were drilled in furrows in the well-prepared field at a spacing of 30 × 10 cm between rows and plants, respectively. Sowing was carried out on August 8, 2022, and August1, 2023, while harvests occurred on Nov 15, 2022, and Nov7, 2023, respectively. To maintain soil fertility and support better crop growth and yield, 18::48: 24 kg N, P_2O_5 K_2Orespectively was applied through NPK mixture. Maximum water requirement of the crop was fulfil by rainfall and 1 irrigation was done during both the year at pod filling stage.

At harvestable maturity, the crop was manually harvested according to treatment. The harvested produce was placed on the threshing floor, sun-dried, manually threshed, and further dried to achieve a moisture content of 12%. The cleaned blackgram seeds were weighed and recorded as per the respective treatments.

Data collection

In each plot, the totalweed count was recorded at the harvest stage. For estimating weed density, a quadrate (1 m^2) was placed randomly in the weed observation area in each plot. Total weeds were counted taken and expressed as counts m^{-2}. Similarly, the dry biomass of the weed was recorded at the harvest stage. All the weeds falling within quadrate were cut close to the ground and after the counting weeds were filled in paper bags, for sun and oven drying at 65±5 ^{o}C till constantly weighed. After oven drying samples were weighed to record the dry matter of weeds.

The weed control index was calculated at the harvest. weed control index of each treatment was computed by using the following formula suggested by **Mishra and Tosh, 1979.**

$$\text{WCI\%} = \frac{\text{Weed dry weight in weedy check (g)} - \text{weed dry weight in treatment (g)}}{\text{Weed dry weight in weedy check (g)}} \text{X100}$$

For the plant population,the number of plants that emerged in the second row from both north and south, sides in 4 m row length were counted at 25 DAS and at harvest stage.

The total pods of the five tagged plants were threshed and grains were separated. The weight of grains was recorded and the mean grain yield per plant was worked out by dividing the total grain yield by five to express the grain yield per plan

Soil samples from surface depth (0-15 cm) were taken in small polythene bags from each plot by core sampler after each crop harvest. These moist samples were used for the analysis of microbial counts. Specific agar media brought from Himedia were used for individual microbial counts (Bacteria - Nutrient agar, Fungi- Potato dextrose agar & Actinomycetes -Actinomycetes isolation agar). The number of colony-forming cells of bacteria, fungi, and actinomycetes, was determined by serial dilution pour plate method (Subbarao, 1986) and expressed in colony-forming units (CFU) g^{-1} dry soil.

Statistical analysis

The data obtained from various observations were statistically analysed as per the procedure of randomized block design by using the standard techniques of Analysis of Variance (ANOVA) with the help of a computer software program, as described by Indian Agricultural Statistics Research Institute (IASRI)

Result and Discussion

Total weed count m $^{-2}$

At harvest stages, seed inoculation and weed management practices significantly influenced total weed density during both the years of experimentation (Table 1). Whereas foliar nutrition did not have significant effect on the total weed count m^{-2}.Among seed inoculation, treatments with Rhizobium sp.+PGPR consistently recorded the lowest total weed populations compared to Rhizobium + PSB, a pattern observed during both the 2022 and 2023 seasons. The vigorous growth observed in plots treated with seed inoculation using Rhizobium sp. with PGPR (Plant Growth-Promoting Rhizobacteria) may be attributed to their significant role in enhancing plant growth and vigor. This enhanced plant vigor effectively suppresses weed growth and inhibits the germination of new weeds (**Yadav and Verma, (2014**).Weed management practices significantly affected total weed density at all crop growth stages. At the harvest stage, significant differences appeared, with the weed-free treatment maintaining the lowest weed densities, followed by Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 220 g/ha applied at 20 DAS. The weedy check had the highest weed density throughout both seasons. The results conformed with the findings of **Singh *et al*(2014)** and **Shah and Pramanik (2020)**. The interaction between seed inoculation weed management and foliar nutrition practices did not significantly influence total weed counts atthe harvest stage.

weed dry matter harvest

weed and nutrition management significantly influence the weed dry matter at the harvest stage (Table 1). Among seed inoculation, Seed inoculation with Rhizobium sp. + PGPRconsistently resulted in significantly lower total weed biomass compared to Rhizobium +PSB inoculations across both years. This result could be attributed to the early growth and development of the crop, which might have been enhanced by seed inoculation. Seed inoculation promotes root growth by providing essential hormones and nutrients, thereby supporting better plant development.Weed management practices greatly influenced total weed biomass at the harvest stage. The weed-free treatment recorded the lowest total weed biomass, followed by Fomesafen+ Fluazifop-p-butyl, which significantly reduced weed biomass compared to other treatments. The unweeded plots consistently recorded the highest total weed biomass during both crop seasons. This outcome could be attributed to the herbicidal action of Fomesafen, which suppresses weeds by targeting the protoporphyrinogen oxidase (PPO) enzyme in plants, and Fluazifop-p-butyl, which interferes with lipid synthesis by inhibiting CoA carboxylase in susceptible species. These mechanisms may have effectively reduced weed density and biomass, as suggested by**Székács, (2021)**. Foliar nutrient management practices exhibited a significant effect on total weed biomass atthe harvest stage during 2022-23 and 2023-24. Maximum weed biomass has been reported in the 18: 18: 18 NPK @ 2% (flower initiation and pod initiation) applied treatment whereas minimum weed biomass was reported in the water spray treatment. Foliar application of nutrient feeding to crops along with weed. In comparison to nonfoliar application treatment weed has much more growth might be due to weedstakingnutrients and use in their growth and development. The interaction between seed inoculation weed management and foliar nutrition practices did not significantly influence total weed dry biomass at the harvest stage.

Weed control index

Seed inoculation and foliar nutrition did not show any significant effect on weed control index during both the years of study (Table 1). However, weed management practices show a significant impact on the weed control index. After weed free plot, among herbicide treatment maximum weed control index was observed in the Fomesafen + Fluazifop-p-butyl (67 & 60% respectively during 2022-23 and 2023-24) compared to the Propaquizafop + Imazethapyr combination of treatments. This outcome might be due to Fomesafen + fluazifop-p-butyl control all types of weed i.e., grasses, broadleaf and sedge.**Singh *et al*(2014)** also reported similar findings.

Plant population – initial and final

The effect of weed and nutrition management on the Plant population (number of plants m^{-2}) of blackgram at 25 DAS and harvest stages during 2022-23 and 2023-24 (Table 2). The results indicate that seed inoculation, weed management, and foliar nutrition had no significant effect on the plant population of the blackgram during both the years of experimentation. However, a slight reduction in the number of plants per square meter was observed at the harvest stage during both the years, likely due to plant mortality caused by insect pest attacks.

Grain Yield

Seed inoculation, weed management, and foliar nutrition had a profound impact on grain yield during both years (Table 3). The higher grain yield was recorded for the seed treatment with Rhizobium sp.+PGPR indicating the effectiveness of the inoculated seeds in enhancing productivity. It was significantly superior to the yield obtained by Rhizobium + PSB during both years of study. Seed yield enhancement with Rhizobium sp.+PGPR seed inoculation might be due to the roles of Rhizobium sp.+PGPR. The microbial consortium of Rhizobium sp+ PGPR offers a multifaceted approach to plant growth promotion.Both species produce phytohormones such as indole-3-acetic acid (IAA), which stimulate root growth and nutrient absorption, leading to better resource utilization and ultimately higher grain weight (**Kumar *et al* 2023**). As well as microbial consortia*also* play a critical role in nutrient availability in the soil by solubilizing phosphate and producing siderophores, which chelate iron, making it available to plants. **Priyanka and Mohan *et al.* (2010)** and **Khanna *et al* (2011)** reported similar results. Weed management significantly influenced grain yield. The weed-free treatment (W_4) achieved the maximum grain yield due to effective weed suppression, which minimized competition for nutrients, water, and light. This treatment was found statistically at par with Fomesafen + Fluazifop-p-butyltreatment. Conversely, the lowest grain yield was noted in the weedy check treatment (W_1), whereas unchecked weed growth severely impacted resource availability and hindered crop development. These results corroborated with the findings of **Singh *et al*., 2014**, **Khot *et a*l. (2015)**, **Harisha et al (2021)** and **Patidar *et al*., 2023.**

Foliar nutrition treatments significantly affected the grain yield of the blackgram. The 18 : 18 : 18 NPK @ 2% (flower initiation and pod initiation) treatment (F_3) was recorded as significantly superior to the rest of the treatment during 2023. whereas during 2022, the F_3 treatment was found at par with the F_2 treatment. This outcome highlights the role of major nutrient, foliar application of phosphorus (P) and potassium (K) directly supplies nutrients to leaves, overcoming soil-related limitations and ensuring efficient uptake. Phosphorus enhances energy transfer, nodulation, and seed development, while potassium improves photosynthesis, grain filling, and stress tolerance. Together, they boost flowering, pod formation, and overall plant vigor. This results in enhanced growth parameters, better resource use efficiency, and higher grain yield of blackgram. A similar observation was also reported by **Khan *et al.*, (2018)** and **Aziz and Zarar, (2021)**

The interaction between seed inoculation weed management and foliar nutrition practices did not significantly influence grain yield.

Microbial count

Data on soil microbial count (actinomycetes, bacterial, and fungi population) at the harvest stage of blackgramrevealed that seed inoculation and weed management practices have a significant impact on the actinomycetes, and bacterial population in the rhizosphere of the blackgram during both the years while foliar application affects the actinomycetes, and bacteria count during 2023-24 but during 2022-23 foliar nutrition did not affect on the microbial count. Whereas, nutrition and weed management did not show any influence on fungi count (Table 4).

Seed inoculation significantly influenced the microbial count(actinomycetesand bacterial) during both years. Seed inoculation with Rhizobium sp.+PGPR treatment produced a significantly higher microbial count compared to the seed inoculation with Rhizobium + PSB treatment. The higher population of microbial count in Rhizobium sp.+PGPR treatment is due to enhanced microbial diversity, improved soil health, and favorable root zone conditions. These treatments create an environment that promotes the growth of actinomycetes by providing nutrients, stimulating beneficial microbial interactions, and suppressing competing microorganisms.

Among weed management practices, a maximum of microbial count was reported in weed-free treatment and this treatment was found at par with the Fomesafen + Fluazifop-p-butyl. whereas the minimum microbial population was reported in the weedy check plot during both years. In weed-free conditions, microbial populations increase due to reduced competition for nutrients and space, improved resource availability, and enhanced soil health. The absence of weeds creates a favourable environment for these beneficial microbes to thrive.

Foliar nutrition affects the microbial count and 18 : 18 : 18 NPK @ 2% (flower initiation and pod initiation) treatment (F_3) was recorded as significantly superior to the rest of the treatment during 2023.

Interactions between seed inoculation weed management and foliar application were found non-significant.

Conclusion

The combined use of effective weed and nutrition management practices significantly influences weed dynamics, seed yield, and soil microbial properties in blackgram cultivation. Approaches like seed inoculation, weed management and foliar nutrition reduce weed competition, enhance crop productivity, and sustain soil health. Optimizing nutrient availability through seed inoculation and foliar nutrition supports vigorous crop growth, indirectly suppressing weeds, while targeted weed management minimizes weed infestation without adverse effects on beneficial soil microorganisms. This synergistic strategy ensures a balance between productivity and environmental sustainability, providing a viable approach for enhancing the profitability and ecological health of blackgram-based cropping systems. Future studies may explore the long-term impacts of these integrated practices under varying agro-climatic conditions

Table: 1 Effect of weed and nutrition management on weed studies at the harvest stage of blackgram during 2022-23 and 2023-24.

Treatment	Weed count m^{-2}		Weed dry matter (g) m^{-2}		Weed control index (%)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Factor A: Seed Inoculation						
$I_{1:}$ Rhizobium +PSB	87	106	351	367	48	44
I_2: Rhizobium sp. +PGPR	81	95	295	310	50	47
SEm±	2	3	10	9	1	2
C.D. (p=0.05)	7	10	29	25	NS	NS
Factor B: Weed Management						
W_1: Weedy check	165	186	622	647	0	0
W_2: Propaquizafop + Imazethapyr	117	142	440	476	28	22
W_3: Fomesafen + Fluazifop-p-butyl	54	74	231	231	67	60
W_4: Weed-free	0	0	0	0	100	100
SEm±	3	5	14	13	2	2
C.D. (p=0.05)	9	14	41	36	6	7
Factor C: Foliar nutrition						
F_1: Water spray (500 L ha^{-1})	89	105	291	316	46	44
F_2: Nano urea (0.25%)	83	98	318	333	48	45
F_3: 18 : 18 : 18 NPK (2%)	80	97	359	367	52	48
SEm±	3	6	12	11	2	2
C.D. (p=0.05)	NS	NS	35	31	NS	NS

Table: 2 Effect of weed and nutrition management on plant population at the 25 DAS and at the harvest stage of blackgram during 2022-23 and 2023-24

Treatment	Plant population m^{-2} at 25 DAS		Final plant population m^{-2} at harvest stage	
	2022-23	2023-24	2022-23	2023-24
Factor A: Seed Inoculation				
$I_{1:}$ Rhizobium +PSB	32	31	28	29
I_2: Rhizobium sp. +PGPR	31	32	28	30
SEm±	1	0.5	1	1
C.D. (p=0.05)	NS	NS	NS	NS
Factor B: Weed Management				
W_1: Weedy check	33	32	28	30
W_2: Propaquizafop + Imazethapyr	31	31	27	29
W_3: Fomesafen + Fluazifop-p-butyl	31	31	29	28
W_4: Weed-free	32	32	29	30
SEm±	1	0.7	1	1
C.D. (p=0.05)	NS	NS	NS	NS
Factor C: Foliar nutrition				
F_1: Water spray (500 L ha^{-1})	31	32	28	28
F_2: Nano urea (0.25%)	32	31	28	29
F_3: 18 : 18 : 18 NPK (2%)	31	32	28	30
SEm±	1	0.6	1	1
C.D. (p=0.05)	NS	NS	NS	NS

Table: 3 Effect of weed and nutrition management on grain yield (g m^{-2}) of blackgram during 2022-23 and 2023-24

Treatment	Seed yield (g m^{-2})	
	2022-23	2023-24
Factor A: Seed Inoculation		
$I_{1:}$ Rhizobium +PSB	385	401
I_2: Rhizobium sp. +PGPR	424	457
SEm±	10	13
C.D. (p=0.05)	29	36
Factor B: Weed Management		
W_1: Weedy check	338	361
W_2: Propaquizafop + Imazethapyr	360	386
W_3: Fomesafen + Fluazifop-p-butyl	449	449
W_4: Weed-free	473	521
SEm±	15	18
C.D. (p=0.05)	41	361
Factor C: Foliar nutrition		
F_1: Water spray (500 L ha^{-1})	372	51
F_2: Nano urea (0.25%)	396	372
F_3: 18 : 18 : 18 NPK (2%)	445	430
SEm±	13	486
C.D. (p=0.05)	36	15

Table: 4 Effect of weed and nutrition management on microbial count at the harvest stage of blackgram during 2022-23 and 2023-24

Treatment	Actinomycetes count (× 10^4 CFU g^{-1} soil)		Bacteria count (× 10^6 CFU g-1 soil)		Fungi (× 10^5 CFU g^{-1} soil)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
Factor A: Seed Inoculation						
I_1: Rhizobium +PSB	44.5	40.7	39.7	39.9	3.1	3.0
I_2: Rhizobium sp. +PGPR	48.6	45.7	45.1	44.4	3.9	3.9
SEm±	1.4	1.2	1.9	0.8	0.3	0.3
C.D. (p=0.05)	3.9	3.4	5.4	2.1	NS	NS
Factor B: Weed Management						
W_1: Weedy check	38.8	35.0	36.6	34.8	2.9	3.2
W_2: Propaquizafop + Imazethapyr	43.9	38.0	40.2	37.8	3.6	3.6
W_3: Fomesafen + Fluazifop-p-butyl	48.4	46.6	43.1	44.4	3.4	3.4
W_4: Weed-free	55.1	53.3	49.8	51.6	4.0	3.6
SEm±	2.0	1.7	2.7	1.1	0.4	0.5
C.D. (p=0.05)	5.6	4.9	7.6	3.0	NS	NS
Factor C: Foliar nutrition						
F_1: Water spray (500 L ha^{-1})	44.5	40.7	40.0	39.3	2.9	3.0
F_2: Nano urea (0.25%)	45.5	42.5	42.0	42.0	3.9	3.6
F_3: 18 : 18 : 18 NPK (2%)	49.7	46.4	45.2	45.1	3.7	3.7
SEm±	1.7	1.5	2.3	0.9	0.4	0.4
C.D. (p=0.05)	NS	4.2	NS	2.6	NS	NS

Disclaimer (Artificial intelligence)

Author(s) hereby declare 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.

References

Aziz, B. R., & Zrar, D. B. (2021). Effect of foliar application of nano-NPK fertilizer on growth and yield of broad bean (Vicia faba L.). *Zanco Journal of Pure and Applied Sciences*, 33(4), 90-99.

Harisha, S., Seenappa, C., Lalitha, B. S., Raddy, G., & Pandu, U. (2021). Bio-efficacy of new post-emergent herbicides on growth and yield of blackgram. *Indian Journal of Weed Science*, 53(1), 107-110

Khan, E., Ahmad, I., Hussain, S., Hafiz, B. A., & Iqbal, H. (2018). Influence of nipping and foliar application of nutrients on growth and yield of chickpea in rain-fed condition. *Legume Research*, 41(5), 740-744. https://doi.org/10.18805/LR-342

Khanna, V., Sharma, P., & Sharma, S. (2011). Studies on synergism between Rhizobium and plant growth promoting rhizobacteria in lentil (*Lens culinaris* medicus). *Journal of Food Legumes*, 24(2), 158-159.

Khot, D. B., Pagar, R. D., & Munde, S. D. (2015). Effect of different weed management practices on yield and economics of summer blackgram (*Vigna mungo* L.). *Agriculture for Sustainable Development*, 3(1), 21-22.

Mansoori, N., Bhadauria, N., & Rajput, R. L. (2015). Effect of weed control practices on weeds and yield of blackgram (Vigna mungo). *Legume Research*, 38(6), 855-857.

Mishra, A., & Tosh, G. C. (1979). Chemical weed control studies on dwarf wheat. Research Journal (*Orissa University of Agriculture and Technology*), 10, 1-6.

Patidar, J., Kewat, M. L., Sondhia, S., Jha, A. K., & Gupta, V. (2023). Bio-efficacy of fomesafen + fluazifop-p-butyl mixture against weeds and its effect on productivity and profitability of soybean (Glycine max) in Central India. *The Indian Journal of Agricultural Sciences*, 93(7), 750–755.

Priyanka, & Mohan, J. (2010). Assessment of the potential of PGPR Bacillus sp. in enhancing symbiotic efficiency in chickpea with Mesorhizobium. Biochem. *Cellular Architecture*., 10(1), 57-63.

Shah, M. H., & Pramanik, K. (2020). Bio-efficacy of herbicides for weed management in groundnut under lateritic soil of West Bengal. *Crop and Weedresearch*, 16(1), 29-34

Singh, D., Mir, N. H., Singh, N., & Kumar, J. (2014). Promising early post-emergence herbicides for effective weed management in soybean. *Indian Journal of Weed Science*, 46(2), 135-137.

Székács, A. (2021). Herbicide mode of action. In Herbicides (pp. 41-86). Elsevier.

Yadav, J., & Verma, J. P. (2014). Effect of seed inoculation with indigenous Rhizobium and plant growth promoting rhizobacteria on nutrient uptake and yields of chickpea (Cicer arietinum L.). *European Journal of Soil Science*., 63, 70-77.

Zahir, Z. A., Arshad, M., & Frankenberger, W. T. (2004). Plant growth promoting rhizobacteria: Applications and perspectives in agriculture. *Advances in Agronomy*, 81(1), 98-169.