

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 7; July 2025; Page No. 901-905

Received: 20-06-2025
Accepted: 24-07-2025

Indexed Journal
Peer Reviewed Journal

Enhancing chickpea productivity through improved crop management practices in farmers' fields of Kalaburagi district, Karnataka

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DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i71.2473>

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Abstract

The present study was conducted by the All India Coordinated Research Project on Chickpea, Zonal Agricultural Research Station, and Krishi Vigyan Kendra, Kalaburagi, Karnataka (India), in selected farmers' fields to assess the yield gap between improved management practices and traditional farmers' practices under Front Line Demonstration (FLD). Chickpea [*Cicer arietinum* (L.)], a major rabi pulse crop in Karnataka, often exhibits lower yields in farmers' fields due to multiple constraints, primarily the non-adoption of improved technologies or crop management practices.

Front Line Demonstrations on Improved Crop Management (ICM) practices were conducted at 50 farmers' fields across four adopted villages in Kalaburagi district during the rabi seasons of 2022–23 and 2023–24. The ICM practices included the use of wilt-resistant chickpea variety BGD 111-1, seed treatment with *Trichoderma* (4 g kg⁻¹ seeds), application of biofertilizers (Rhizobium and PSB), integrated nutrient management (10:25:0 NPK kg ha⁻¹ + ZnSO₄ 15 kg ha⁻¹ + S 20 kg ha⁻¹), and integrated pest management.

The improved practices recorded a mean yield of 1703 kg ha⁻¹, which was 17.82% higher than farmers' practice (1474 kg ha⁻¹), along with higher mean net income (Rs. 57,768 ha⁻¹ vs. Rs. 43,333 ha⁻¹) and benefit-cost ratio (3.41 vs. 2.66) compared to traditional practices.

Keywords: Chickpea, front line demonstrations, yield, net return, B:C ratio

Introduction

Chickpea (*Cicer arietinum* L.) is a protein-rich legume of the semi-arid tropics, predominantly grown under rainfed conditions. In India, chickpea is cultivated over 10.74 million hectares, producing 13.54 million tonnes with an average productivity of 1261 kg ha⁻¹ (Anon., 2024) ^[1]. In Karnataka, it occupies 0.73 million hectares with a production of 0.47 million tonnes and an average productivity of 689 kg ha⁻¹ (Anon., 2024a) ^[2]. Chickpea is grown in almost all states, with major cultivation in Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, and Gujarat. In Karnataka, approximately 90% of chickpea area is concentrated in northern districts (Singh et al., 2015) ^[16].

Kalaburagi district, known as the "Pulse Bowl of Karnataka," ranks first in both area (1.36 lakh ha) and production (0.88 lakh tonnes), accounting for 53% of the state's chickpea area. However, the district's productivity (650 kg ha⁻¹) remains below the state and national averages (Anon., 2023) ^[3]. Chickpea is cultivated primarily for grain as dhal, a major source of protein for smallholder farmers, containing three times the protein of cereals. Tender green seeds are consumed as vegetables, and crushed seeds are used as animal feed.

Major constraints to chickpea productivity include cultivation on poor soils with inadequate or imbalanced nutrition, use of local or disease-susceptible varieties, lack

of seed treatment, and insufficient integrated weed and pest management (Shetty et al., 2013) ^[15].

Front Line Demonstration (FLD) is an effective extension approach, based on the principle that "seeing is believing." FLDs aim to showcase newly released crop production and protection technologies directly in farmers' fields, enabling scientists to identify factors contributing to higher yields, assess field-level constraints, and convince farmers to adopt improved practices. FLDs also foster continuous interaction between farmers and scientists, providing practical guidance to increase yields (Bhargav et al., 2017) ^[5].

Considering these factors, frontline demonstrations on chickpea were conducted in farmers' fields of Kalaburagi to highlight the production potential and economic benefits of the latest improved technologies.

Materials and Methods

The All India Coordinated Research Project on Chickpea, Zonal Agricultural Research Station, Kalaburagi, in collaboration with Krishi Vigyan Kendra, Kalaburagi, conducted Front Line Demonstrations (FLDs) on 50 farmers' fields across four adopted villages—Melkunda, Suntanur, Babalad, and Sannur—in Kalaburagi district during the rabi seasons of 2022–23 and 2023–24. The demonstrations were carried out under rainfed conditions on medium to deep black soils with low to medium fertility, within a pulse-based cropping system.

Prior to FLDs, farmers were selected through group meetings, and specific training was provided on improved chickpea cultivation practices. The Improved Crop Management (ICM) practices implemented included:

- Use of wilt-resistant chickpea variety BGD 111-1
- Seed treatment with *Trichoderma* (4 g kg⁻¹ seeds)
- Application of biofertilizers (Rhizobium and PSB, 1250

g ha⁻¹ each)

- Integrated nutrient management: 10:25:0 NPK kg ha⁻¹ + ZnSO₄ 15 kg ha⁻¹ + S 20 kg ha⁻¹
- Integrated Pest Management (Mishra et al., 2017) ^[9]

In the farmers' practice plots, existing local practices were followed for comparison.

Comparison of demonstration packages and farmers practice for chickpea FLD

Sl no	Particular	Demo package	Farmers practice	Gap
1.	Farming situation	Rainfed	Rainfed	-
2.	Variety	BGD 111-1	A-1	60 %
3.	Time of sowing	2 nd FN of October	1 st FN of October	30%
4.	Method of sowing	Line sowing	Line sowing	-
5.	Seed treatment	<i>Trichoderma</i> @ 4 g / kg seed	Not adopting	60%
6.	Biofertilizers application	Seed inoculation with <i>Rhizobium</i> and PSB @ 25 g / kg at sowing	Not adopting	60%
7.	Fertilizer dose	10:25:0 kg N:P:K ha ⁻¹ + Sulphur @ 20 kg / ha Zinc Sulphate (15 kg ha ⁻¹)	25 -30 kg DAP only	25%
8.	Weed management	Pre-emergence application of Pendimethalin @ 2.5 lit ha ⁻¹	Manual weeding	50%
9.	Plant protection	Need based application	Non judicious use of pesticides (3-4 sprays)	35%

The soils in the study area were generally medium to deep black soils with low to medium fertility. Field visits were organized for farmers and extension personnel to disseminate improved cultivation practices. Demonstration farmers were guided by scientists from the Krishi Vigyan Kendra (KVK) and Agricultural Research Station (ARS) in carrying out key field operations, including sowing, seed treatment, fertilizer application, pest and weed management, and harvesting during the training sessions and visits. Traditional practices were maintained in the control plots using the local variety A-1.

Data were collected from both FLD plots and farmers' practice plots. Based on these data, extension gap, technology gap, technology index, and benefit-cost ratio were calculated following the procedures described by Thakur et al. (2016) ^[21].

Technological gap = Potential yield - demonstration yield

Extension gap = demonstration yield - farmer's practice yield

$$\text{Technological Index} = \frac{\text{Potential yield} - \text{demonstration yield}}{\text{Potential yield}} \times 100$$

Each Front Line Demonstration (FLD) was conducted on 0.4 ha, with an adjacent 0.4 ha area maintained under farmers' practices as a control. Sowing was carried out from the first fortnight of October in both years, using a seed rate of 50 kg ha⁻¹. Full doses of nitrogen and phosphorus (10:25:0 NPK kg ha⁻¹) through diammonium phosphate were applied as a basal dose. Zinc sulfate (15 kg ha⁻¹) and sulfur (20 kg ha⁻¹) were applied 30 days after sowing. Seeds were treated with *Trichoderma viride* (4 g kg⁻¹), Rhizobium, and PSB (1250 g ha⁻¹ each). Integrated Pest Management (IPM) practices were implemented as needed, including:

1. Ovicidal spray with Profenophos 50 EC @ 2 L ha⁻¹
2. Pheromone traps @ 5 ha⁻¹
3. Bird perches @ 10 ha⁻¹
4. Contact insecticide @ 2 L ha⁻¹

Other cultivation practices in the demonstration plots followed recommended guidelines. Percent pest and disease incidence and grain yields were recorded.

To promote the demonstrated technologies, the Zonal Agricultural Research Station (ZARS) and Krishi Vigyan Kendra (KVK), in collaboration with developmental departments, NGOs, and mass media, organized extension activities including on-campus and off-campus training,

group discussions, farmers-scientist interactions, and dissemination of literature. Pest and disease surveillance was conducted through rapid field surveys, and information was communicated via All India Radio, Doordarshan, and print media.

Results and Discussion

The seed yield and economic performance of chickpea under both farmers' practices and improved technology demonstrations are presented in Tables 1 and 2. During 2022–23, productivity under FLD plots ranged from 1569 to 1903 kg ha⁻¹, with a mean yield of 1691 kg ha⁻¹, while in 2023–24 it ranged from 1539 to 1879 kg ha⁻¹, with a mean of 1716 kg ha⁻¹. In comparison, the farmers' practice plots yielded 1343–1648 kg ha⁻¹ (mean 1423 kg ha⁻¹) in 2022–23 and 1353–1613 kg ha⁻¹ (mean 1469 kg ha⁻¹) in 2023–24.

The percent yield increase of improved technologies over farmers' practices ranged from 11.27 to 21.80% in 2022–23 and 12.97 to 19.28% in 2023–24, with mean increases of 18.83% and 16.81%, respectively. On average, the FLD plots recorded a 17.82% higher yield compared to farmers' practices, indicating a significant improvement in chickpea productivity with the adoption of improved crop management practices (Ramesh et al., 2016) ^[11].

Table 1: Comparative performance of chickpea in terms of productivity and economic benefits under frontline demonstrations

Year	No of Demos	Total area (ha)	Average Yield (kg/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		B:C ratio	
			FLD	Local	FLD	Local	FLD	Local	FLD	Local	FLD	Local
2022-23	25	10	1691	1423	23250	25500	81168	68304	57918	42804	3.49	2.68
2023-24	25	10	1716	1469	24750	26650	82368	70512	57618	43862	3.33	2.65
Total / Average	50	20	1703	1474	24000	26075	81768	69408	57768	43333	3.41	2.66

The economic viability of improved technologies and farmers' practices was assessed based on prevailing input and output prices. The average cost of chickpea production under improved technologies was Rs. 23,250 ha⁻¹ and Rs. 24,750 ha⁻¹ during 2022–23 and 2023–24, respectively, whereas farmers' practice incurred higher costs of Rs. 25,500 ha⁻¹ and Rs. 26,650 ha⁻¹, mainly due to excessive use of pesticides for pod borer control.

Cultivation under improved technologies resulted in higher net returns, ranging from Rs. 49,626 to 65,946 ha⁻¹ (mean Rs. 57,918) in 2022–23 and Rs. 50,622 to 66,942 ha⁻¹ (mean

Rs. 57,618) in 2023–24. In comparison, farmers' practice yielded net returns of Rs. 37,941–52,437 ha⁻¹ (mean Rs. 42,804) and Rs. 40,588–55,084 ha⁻¹ (mean Rs. 43,862) for the respective years. On average, improved technologies provided an additional net return of Rs. 15,114 and Rs. 13,756 ha⁻¹ during 2022–23 and 2023–24, respectively.

The improved practices also achieved higher benefit-cost (B:C) ratios of 3.49 and 3.33, compared to 2.68 and 2.65 under farmers' practice in 2022–23 and 2023–24, respectively, demonstrating the economic advantage of adopting improved crop management practices.

Table 2: Seed yield, technology gap, extension gap and technology index of chickpea under FLD

Year	Potential yield	FLD yield	Farmers yield	Yield Increase (%)	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
2022-23	2000	1691	1423	18.83	309	268	15.45
2023-24	2000	1716	1469	16.81	284	247	14.20
Average	2000	1703	1474	17.82	297	258	14.83

Similar results have been reported in frontline demonstrations and research trials conducted elsewhere. Bhargav et al. (2017) [5], Samui et al. (2000) [12], Singh et al. (2016) [17], and Singh et al. (2014) [19] observed that adoption of integrated pest management (IPM) led to higher yields, reduced pod damage, and improved benefit-cost ratios in pulses. Seed treatment with plant growth-promoting rhizobacteria (PGPR) and *Rhizobium* also contributed to enhanced productivity (Gundappagol, 2006) [7].

Application of recommended doses of fertilizers (RDF) along with zinc, use of wilt-resistant varieties, and seed treatment with *Trichoderma* significantly improved chickpea growth and yield (Verma et al., 2004) [23]. Similar benefits were reported for black gram through adoption of resistant varieties, seed treatment, and timely weeding (Tomar et al., 2009) [22]. Raj et al. (2013) [10] highlighted that integrated crop management practices, including proper crop rotation, land preparation, and improved varieties, substantially increased yields compared to farmers' practices.

FLD-based adoption of recommended fertilizers and micronutrients enhanced pulse yields by 8–12% and 10%, respectively, compared to traditional practices (Samui et al., 2000 [13]). Weeding and irrigation at critical growth stages further increased chickpea yields by 11.5% over farmers' practices (Sharma et al., 2011) [14]. Across studies, higher benefit-cost ratios were consistently observed under improved practices (Singh et al., 2014 [18]; Anuratha et al., 2019 [4; 25–43]), particularly when IPM (pheromone traps, ovicidal chemicals, neem-based sprays, and contact insecticides) was integrated with improved crop management technologies.

Productivity and economic returns of maize, paddy, and pigeonpea under improved technologies were consistently

higher than those under farmers' practices (local checks), with greater gross returns, net returns, and benefit-cost ratios (Singh et al., 2014 [19]; Sreelakshmi et al., 2004 [18, 20]).

To enhance farmers' understanding and adoption of Integrated Crop Management (ICM) practices, Zonal Agricultural Research Station (ZARS) and Krishi Vigyan Kendra (KVK) conducted multiple extension activities. These included on-campus training (2 sessions with 75 participants), off-campus training (3 sessions with 329 participants), and training for extension functionaries (1 session with 36 participants) from line departments and NGOs, aimed at promoting horizontal spread of technology and creating awareness.

Periodic visits by ZARS/KVK scientists to demonstration fields, farmer visits to the research stations, phone consultations, and dissemination of literature through leaflets and pamphlets were conducted. Pest and disease monitoring was carried out through rapid surveys, with forecasts communicated via All India Radio, Doordarshan, and local print media. District-level field days were also organized to facilitate mass interaction among farmers and scientists, emphasizing the practical benefits of improved chickpea production technologies.

The stepwise dissemination of improved production techniques demonstrated that participatory approaches, involving active collaboration between farmers and scientists, were most effective. Knowledge sharing, participation in training programs, use of mass media, and involvement of extension agencies significantly influenced farmers' attitudes and adoption of improved practices (Kirar et al., 2004) [8]. This participatory approach has strengthened collaborations among farmer groups, ZARS, and KVK scientists, enhancing farmers' access to up-to-date information and technologies, thereby boosting crop

productivity.

Conclusion

Field-level demonstrations provide an opportunity to showcase the productivity potential and profitability of the latest technologies under natural farming conditions. The Front Line Demonstrations (FLDs) in chickpea not only highlighted the benefits of improved practices over existing farmers' methods but also created awareness and motivated other farmers to adopt suitable production technologies.

On average, the adoption of improved production technologies in demonstrated plots increased chickpea yield to 1703 kg ha⁻¹ and net returns to Rs. 57,768 ha⁻¹, with a benefit-cost (B:C) ratio of 3.41, compared to 2.66 under farmers' practices. The performance of the wilt-resistant variety BGD 111-1 can be further enhanced by consistent adoption of recommended production technologies. These findings underscore the need for wider dissemination of improved production technologies through effective extension methods, such as training programs and field demonstrations. Farmers should be encouraged to adopt recommended agronomic practices to enhance chickpea productivity and economic returns under rainfed conditions.

References

1. Anonymous. Annual report. All India Coordinated Research Project on Chickpea, Kalyanpur, Kanpur. 2024a. p.93-102.
2. Anonymous. Annual report. Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, Krishi Bhavan, New Delhi. 2024. p.119-123.
3. Anonymous. Annual report. Krishi Vigyan Kendra, Kalaburagi, University of Agricultural Sciences, Raichur, Karnataka. 2024b. p.63-39.
4. Babu S, Darjee S, Alekhya G. Enhancing farmer prosperity: implementing integrated farming systems for increased income. *Agriculture Archives: an International Journal*. 2022;1(1):45-52.
5. Anuratha A, Ravi R, Selvi J. Impact of cluster frontline demonstration on black gram in Nagapattinam district of Tamil Nadu. *J Pharmacogn Phytochem*. 2019;8(2):722-5.
6. Bhargav KS, Khedkar NS, Gayatri GR, Ambawatia A, Gupta N, Patel N. Evaluation of front line demonstration on chickpea in Shajapur District of MP. *Int J Pure Appl Biosci*. 2017;5(5):293-7.
7. Bhargav KS, Khedkar NS, Gayatri GR, Gupta N. Evaluation of front line demonstration on chickpea and pigeonpea in Shajapur District of MP. *Int J Pure Appl Biosci*. 2017;5(5):293-7.
8. Muzaffar SS. Meeting the demand: achieving zero hunger through balanced food supply and demand. *Agriculture Archives: an International Journal*. 2022;1(1):33-40.
9. Gundappagol RC, Gopali JB, Dharmaraj PS. Combined efficiency of plant growth promoting rhizobacterial (PGPR) strains and *Rhizobium* in pigeonpea. Abstr., National Symposium on Legumes for Ecological Sustainability – Emerging Challenges & Opportunities. Kanpur: IIPR; 2006 Nov 3-5. p.60.
10. Asma J, Subrahmanyam D, Krishnaveni D. The global lifeline: a staple crop sustaining two thirds of the world's population. *Agriculture Archives*. 2023;2(1):10-6.
11. Kirar BS, Mahajan SK, Nashine R. Impact of technology practices on the productivity of soybean in FLD. *Indian Res J Ext Edu*. 2004;5(1):15-7.
12. Unnisa SA, Ervaguda R, Rasool A, Krismastuti FSH. Plant-based silver nanoparticles for colorimetric detection of metal ions and catalytic degradation of dyes: a review. *Environmental Reports: an International Journal*. 2025;2(1):50-65.
13. Mishra DK, Singh KK, Roy N, Kumar V. Impact of front line demonstrations (FLDs) on yield of pulses in NICRA villages of Bundelkhand region of U.P. *Int J Plant Sci*. 2017;12(2):169-72.
14. Naik DB, Rao BB, Kumar CU, Bhavani NL. Phytochemical analysis of different varieties of *Sorghum bicolor* in Telangana State, India. *Agriculture Archives*. 2022;1(1):16-20.
15. Raj AD, Yadav V, Rathod JH. Impact of frontline demonstration (FLD) on the yield of pulses. *Int J Sci Res*. 2013;9(3):1-4.
16. Ramesh A, Raut RL, Bisen S, Bisen U, Dhuware SR. Impact study of front line demonstration on productivity of pigeonpea (*Cajanus cajan*) and chickpea (*Cicer arietinum*) at farmers' field in Chhattisgarh plain of Madhya Pradesh. *Int J Agric Sci*. 2016;8(53):2758-60.
17. Tiwari AK. Empowering farmers: integrating farming systems for sustainable prosperity. *Agriculture Archives: an International Journal*. 2023;2(1):25-32.
18. Samui SK, Mitra S, Roy DK, Mandal AK, Saha D. Evaluation of front line demonstration on groundnut. *J Indian Soc Coastal Agric Res*. 2000;18(2):180-3.
19. Samui SK, Mitra S, Roy DK, Mandal AK, Saha D. Evaluation of front line demonstration on groundnut. *J Indian Soc Coastal Agric Res*. 2000;18(2):180-3.
20. Sharma AK, Kumar V, Jha SK, Sachan RC. Front line demonstrations on Indian mustard: an impact assessment. *Indian J Ext Educ*. 2011;11(3):25-31.
21. Asma J, Subrahmanyam D, Krishnaveni D. Tungro virus disease in India: historical insights and contemporary prevalence trends in rice cultivation. *Agriculture Archives*. 2023;2(2):41-7.
22. Shetty PK, Ayyappan S, Swaminathan MS, editors. Climate change and sustainable food security. Bangalore: NIAS; New Delhi: ICAR; 2013. ISBN: 978-81-87663-76-8.
23. Unnisa SA, Shareena M, Ervaguda R, Rasool A. Food adulteration practices and awareness among urban consumers – a case study of Hyderabad city, Telangana, India. *J Food Biotechnol*. 2024;5(2):20-32. doi:10.51470/FAB.2024.5.2.20.
24. Alemu TT. Effect of storage time and room temperature on physicochemical and geometric properties of banana (*Musa spp.*) fruit. *J Plant Biota*. 2023;2(1):30-40.
25. Singh AK, Prakash V, Kumar S, Dwivedi SK. Pulses production in India: present status, bottleneck and way forward. *J Agri-Search*. 2015;2(2):75-83.
26. Singh RK, Singh D, Singh R. Enhance the productivity of pigeonpea through improved technology. *Int J Agric*

- Environ Bioresearch. 2016;1(1):73-84.
27. Pithiya MB, Sharma SK, Sharma M, Kotwal N. Advancements and challenges in plant tissue culture: a comprehensive overview. J Plant Biota. 2022;2(2):55-63.
 28. Singh D, Patel AK, Baghel SK, Singh MS, Singh A, Singh AK. Impact of front line demonstration on the yield and economics of chickpea (*Cicer arietinum* L.) in Sidhi district of Madhya Pradesh. J Agric Res. 2014;1(1):22-5.
 29. Saini PK, Sachan K, Surekha S, Islam NA. Rice tolerance to iron-deficient and iron-toxic soil conditions: elucidating mechanisms and implications. J Plant Biota. 2022;2(2):65-72.
 30. Singh D, Patel AK, Baghel SK, Singh MS, Singh A, Singh AK. Impact of front line demonstration on the yield and economics of chickpea (*Cicer arietinum* L.) in Sidhi district of Madhya Pradesh. J Agric Res. 2014;1(1):22-5.
 31. Jerjero T, Muluneh M. Evaluation of improved soybean (*Glycine max*) varieties under rainfed condition for traits of yield and yield component at Ari Zone, South Ethiopia. J Plant Biota. 2024;4(1):1-5.
 32. Sreelakshmi CH, Kumar CV, Shivani D. Productivity enhancement of pigeonpea (*Cajanus cajan* L.) through improved production technology. Madras Agric J. 2012;99(4-6):248-50.
 33. Olubunmi-Ajayi TS, Akinrinola OO, Ibrahim A, Adeyemi IO. Assessing technical, economic, and allocative efficiencies of maize-rice-based farmers across scale economies in Southwest Nigeria. Agriculture Archives: an International Journal. 2025;3(1):12-21.
 34. Ayana DT, Olika GI. Effect of mulching practice as soil moisture conservation for tomato (*Lycopersicon esculentum* Mill.) production under supplemental irrigation in Yabello district of Borana zone, Ethiopia. Acta Biol Forum. 2024;3(2):43-7.
 35. Thakur AP, Bhushan S. Economic impact of front line demonstrations on cereal and pulse crops in Godda district of Jharkhand. J Econ Soc Dev. 2016;12(2):106-11.
 36. Tomar RKS, Sahu BL, Singh RK, Prajapathi RK. Productivity enhancement of black gram (*Vigna mungo* L.) through improved production technologies in farmer's field. J Food Legumes. 2009;22(3):202-4.
 37. Vidhya CS, Swamy GN, Das A, Noopur K, Vedula M. Cyclic lipopeptides from *Bacillus amyloliquefaciens* PPL: antifungal mechanisms and their role in controlling pepper and tomato diseases. Microbiology Archives: an International Journal. 2023;2(2):85-93.
 38. Boratkar MV, Nadaf H, Pandey MK, Gunturu PB. Genetic analysis of CMS based rabi sorghum (*Sorghum bicolor* [L.] Moench) single cross hybrids for grain yield and yield components. Environmental Reports: an International Journal. 2025;2(2):101-10.
 39. Verma CB, Yadav RS. Effect of boron and zinc application on growth and yield of pigeonpea. Indian J Pulses Res. 2004;17(2):149-51.
 40. Dahal B, Bag AG, Raut S. Integrated nutrient management for lentil cultivation: improving soil fertility, nutrient content, and economic returns. Acta Biol Forum. 2024;3(2):70-6.
 41. Sahoo L, Mohapatra D, Swain S, Kanaka S, Sinha V. CRISPR-Cas9 technology and its impact on plant biology. J Plant Biota. 2023;2(3):120-7.
 42. Beleri PS. Microbial solutions to soil health: the role of biofertilizers in sustainable agriculture. Environmental Reports. 2023;2(1):33-9.
 43. Nirmala P, Chapla J. Assessment of soil degradation due to dyeing effluents in Thangallapally area, Rajanna Siricilla, Telangana. Agriculture Archives: an International Journal. 2024;3(1):35-42.