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Integration of KSB, organic and inorganic inputs on yield, nutrient uptake and nutrient use efficiency under wheat in vertisols

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Abstract
A field experiment was conducted during the Rabi season of 2024-25 at the Research Farm, Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to evaluate how the combined application of potassium solubilizing bacteria (KSB), organic amendments, and inorganic fertilizers affects wheat yield, nutrient uptake, and nutrient use efficiency (NUE) in Vertisols. The study was arranged in a Randomized Block Design with eight treatments and three replications. The treatment involving 75% of the recommended dose of fertilizers (RDF) supplemented with KSB and vermicompost (T_8) produced the highest grain yield (24.90 q ha^{-1}) and straw yield (30.12 q ha^{-1}), as well as maximum uptake of nitrogen (73.48 kg ha^{-1}), phosphorus (13.49 kg ha^{-1}), and potassium (43.86 kg ha^{-1}). This treatment also showed superior NUE for N (41.93%), P (15.45%), and K (40.90%). These findings indicate that integrating biofertilizers and organic inputs with reduced chemical fertilizers improves nutrient efficiency while supporting sustainable wheat production in Vertisols.

Keywords: Wheat, Potassium solubilizing bacteria (KSB), Integrated nutrient management, Nutrient uptake, Nutrient use efficiency (NUE)

Introduction
Wheat (*Triticum aestivum* L.) is one of India's principal cereal crops, providing food and livelihood for millions. Achieving sustainable increases in wheat productivity is essential, particularly given declining soil fertility and the long-term overuse of chemical fertilizers. Prolonged reliance on synthetic inputs has contributed to nutrient imbalances, reduced nutrient use efficiency (NUE), and deteriorated soil health. Addressing these issues requires integrated approaches that balance yield improvement with soil conservation.

Integrated nutrient management (INM) is a strategy that combines organic manures, biofertilizers, and reduced chemical fertilizers to maintain soil fertility and improve crop nutrient uptake. Among biofertilizers, potassium-solubilizing bacteria (KSB) are notable for mobilizing soil potassium into forms available to plants. Potassium supports key physiological processes, including enzyme activation, osmotic regulation, and stress resistance, which are critical for optimal wheat performance.

The incorporation of organic inputs like farmyard manure (FYM) and vermicompost enhances soil structure, water retention, and microbial activity, providing a gradual release of nutrients. When these are combined with KSB and partial RDF, nutrient cycling and uptake efficiency are improved. This study aimed to determine how integrating KSB, organic amendments, and reduced chemical fertilizer rates can optimize wheat yield and nutrient utilization in Vertisols.

2. Materials and methods
The experiment was carried out at the Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, India (20.7002° N, 77.0082° E; 307.42 m AMSL). The region has a tropical climate with an average annual rainfall of 802.4 mm. The Vertisol soil at the site is deep, well-drained, and medium in available N, P, and K.

The trial followed a Randomized Block Design with eight treatments and three replications. Each plot measured 4.5 × 3.5 m². Wheat variety AKAW 4627 was sown at 100 kg ha⁻¹ using a seed drill at 22.5 cm row spacing. Seeds were inoculated with KSB before sowing.

Table 1: Treatment Details

Treatment No.	Treatments
T_1	Absolute control
T_2	RDF
T_3	RDF + KSB
T_4	75% RDF + KSB
T_5	75% RDF + KSB + FYM @ 5t ha^{-1}
T_6	75% RDF + KSB + FYM @ 5t ha^{-1}
T_7	75% RDF + Vermicompost @ 2.5 t ha^{-1}
T_8	75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1}

The wheat crop (AKAW 4627) was sown at the seed rate of 100 kg ha^{-1}. Before sowing, seed wheat was treated with KSB. The sowing was done with seed drill followed by light planking to cover the seed with row to row spacing of 22.5 cm. A uniformly fertile, rectangular plot was selected for conducting the field experiment during the rabi season of 2024-25.

3. Results and Discussion

3.1 Yield

Grain yield

The integration of KSB with organic and inorganic inputs significantly affected grain yield (Table 1; Fig. 1). Treatment T_8 recorded the highest grain yield (24.90 q ha^{-1}), followed by T_7 (24.15 q ha^{-1}). Yield improvement under T_8 reflects the synergistic effect of combining chemical fertilizers, biofertilizers, and organic inputs, which collectively enhanced nutrient availability and crop growth. The lowest yield (10.23 q ha^{-1}) was observed in the control.
These findings are consistent with earlier reports in wheat and other cereals (Panwar & Singh, 2000; Mikhailouskaya & Tcherhysh, 2005; Balasubramanian & Subramanian, 2005; Mikhailouskaya *et al*., 2009; Basak & Biswas, 2010; Sindhu *et al*., 2016) [12, 10, 9, 3, 16].

Straw yield

Straw yield followed a similar trend (Table 1; Fig. 2). T_8 achieved the maximum straw yield (30.12 q ha^{-1}), while T_7 produced 29.76 q ha^{-1}. Enhanced straw production may be attributed to improved nutrient availability, resulting in better vegetative growth. The control treatment recorded the lowest straw yield (12.59 q ha^{-1}). Similar results were documented by Mikhailouskaya *et al*. (2009) [9], Zhang *et al*. (2013) [20], and Kong (2014) [8].

Table 1: Effect of seed inoculated KSB on yield of wheat

Treatment	Treatment details	Grain	Straw
		(q ha^{-1})	
T_1	Absolute control	10.23	12.59
T_2	RDF	22.15	27.88
T_3	RDF + KSB	23.50	28.61
T_4	75% RDF + KSB	23.39	27.25
T_5	75% RDF + FYM @ 5t ha^{-1}	23.80	28.55
T_6	75% RDF + KSB + FYM @ 5t ha^{-1}	24.10	29.20
T_7	75% RDF + Vermicompost @ 2.5 t ha^{-1}	24.15	29.76
T_8	75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1}	24.90	30.12
	SE(m) ±	0.51	0.75
	CD at 5%	1.54	2.28

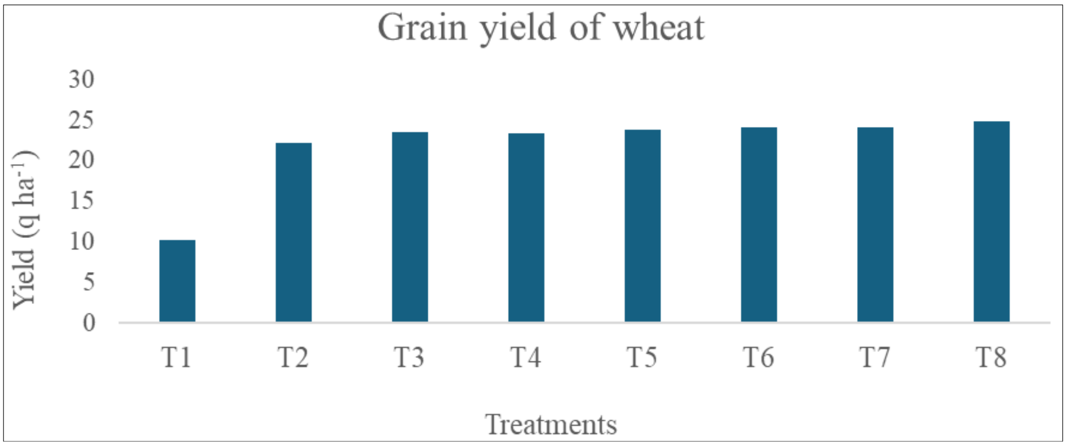

Fig 1: Effect of seed inoculated KSB on grain yield of wheat

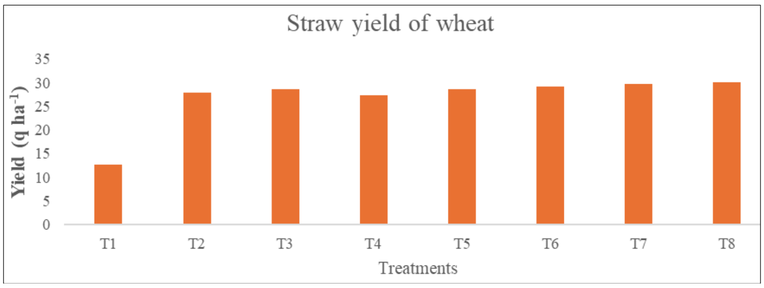

Fig 2: Effect of seed inoculated KSB on straw yield of wheat

3.2 Nutrient uptake
The integration of KSB with organic and inorganic fertilizers significantly improved nutrient uptake (Table 2; Figs. 3, 4, and 5).

Total nitrogen uptake

Wheat plant samples were analyzed at harvest to determine the nitrogen (N), phosphorus (P), and potassium (K) content in various plant parts, including grain and straw. The data on total uptake of nitrogen, presented in Table 2 and illustrated in figure 3. 8 recorded the highest total nitrogen uptake (73.48 kg ha^{-1}), followed by T_6 (69.84 kg ha^{-1}). The control treatment showed the lowest uptake (21.91 kg ha^{-1}). This reflects enhanced N availability and absorption due to microbial activity and organic matter inputs. Findings agree with Choudhary *et al*. (2018) [4] and Ibrahim & Ali (2018) [5], who reported that the positive effect of KSB on N, P and K uptake by forage sorghum and maize, respectively.

Table 2: Effect of seed inoculated KSB on uptake of nutrients

Treat.	Treatment details	Total uptake (kg ha^{-1})		
		N	P	K
T_1	Absolute control	21.91	3.64	16.25
T_2	RDF	55.19	9.22	37.00
T_3	RDF + KSB	58.57	10.64	39.95
T_4	75% RDF + KSB	56.00	9.66	37.90
T_5	75% RDF + FYM @ 5t ha^{-1}	64.92	11.23	40.12
T_6	75% RDF + KSB + FYM @ 5t ha^{-1}	69.84	12.25	41.96
T_7	75% RDF + Vermicompost @ 2.5 t ha^{-1}	68.98	12.30	41.68
T_8	75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1}	73.48	13.49	43.86
	SE (m) ±	1.90	0.47	2.92
	CD at 5%	5.77	1.41	8.87

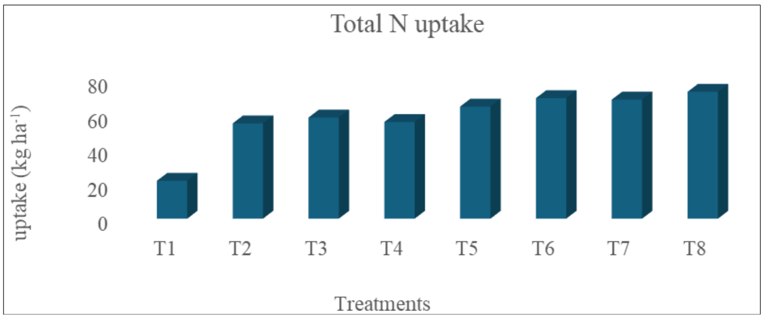

Fig 3: Effect of seed inoculated KSB on nitrogen uptake

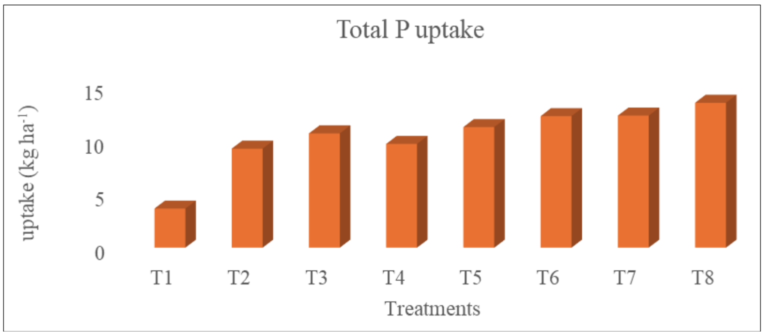

Fig 4: Effect of seed inoculated KSB on Phosphorus uptake of wheat

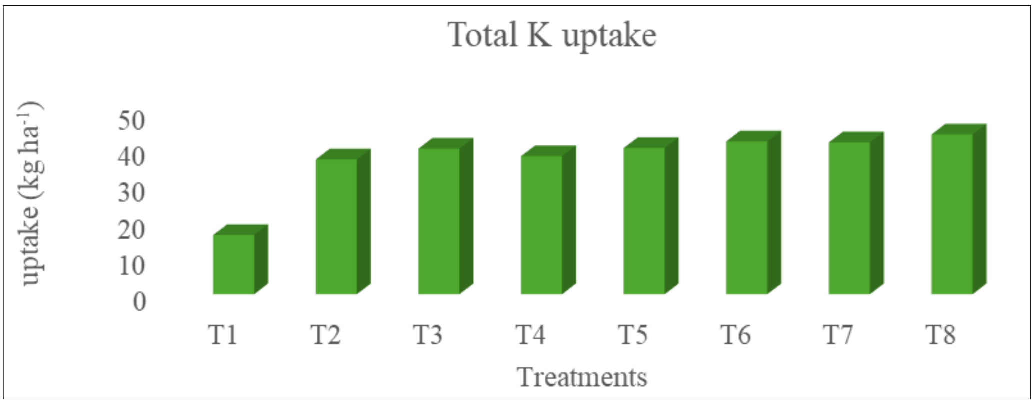

Fig 5: Effect of seed inoculated KSB on potassium uptake by Wheat

Total phosphorus uptake

The results regarding the total uptake of phosphorus by wheat under various treatments is presented in Table 2 and illustrated in figure 4.

Total P uptake was greatest under T_8 (13.49 kg ha^{-1}), followed by T_7 (12.30 kg ha^{-1}). The lowest uptake was in the control (3.64 kg ha^{-1}). These results align with Aishwarya *et al*. (2019) [1], who observed positive effects of KSB on nutrient uptake. They conducted a field experiment, where they analysed the effect of potassium and KSB on yield and nutrient uptake by wheat.

Total potassium uptake

On examination of data, it is nticed that effect of KSB, organic and inorganic inputs in different combinations have significant. The same has been presented in Table 2 and illustrated in figure 5.

T_8 also led in K uptake (43.86 kg ha^{-1}), followed by T_6 (41.96 kg ha^{-1}). This confirms the role of KSB in mobilizing soil K and improving crop utilization (Basem; Khani *et al*., 2019; Sharma & Singh, 2020) [7, 15].

3.3 Nutrient use efficiency

NUE is the plant nutrition that refers to how effectively plants use available nutrients to produce biomass or yield. It is a measure of the productivity of applied or available nutrients in supporting plant growth.

Nitrogen

The data related to nitrogen nutrient use efficiency effected by different treatments, including KSB, organic, and inorganic inputs in different combinations, are presented in Table 3 and illustrated in Figure 6.

The highest nutrient use efficiency of nitrogen (41.93%) was observed with 75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1} (T_8), followed by T_6- 75% RDF + KSB + FYM @ 5 t $ha^{-1,}$ i.e., 41.32%. The lowest nitrogen use efficiency among treatments was recorded in RDF (T_2) with 27.73%. Khanghahi *et al*. (2018) [6] demonstrated that bio-inoculation with potassium-solubilizing bacteria (KSB) strains isolated from paddy soil can effectively enhance the uptake of potassium, nitrogen, and phosphorus in rice plants. This approach also improves nutrient use efficiency and facilitates the remobilization of these nutrients to grains under flooded irrigation conditions.

Phosphorus

The data related to nutrient use efficiency of phosphorus influenced by various treatments, including KSB, organic and inorganic inputs in different combinations, is presented in Table 3 and illustrated in Figure 6.

The highest (15.45%) nutrient use efficiency of phosphorus was observed in 75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1} (T_8), followed by 75% RDF + KSB + FYM @ 5 t ha^{-1} (T_6) with 15.24%. The lowest phosphorus use efficiency among treatments was recorded in RDF (T_2) i.e., 9.30%. Khanghahi *et al*. (2018) [6] reported that bio-inoculation with potassium-solubilizing bacterial (KSB) strains isolated from paddy soil can serve as an effective strategy to enhance the uptake of potassium, nitrogen, and phosphorus in rice plants, as well as improve their use efficiency and remobilization to grains under flooded irrigation conditions.

Potassium

The data related to potassium's nutrient use efficiency influenced by various treatments, including KSB, organic, and inorganic inputs in different combinations, are presented in Table 3 and illustrated in Figure 6.

The highest nutrient use efficiency of Potassium (48.11%) was observed in 75% RDF + KSB (T_4), followed by 75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1} (T_8) with 40.90%. The lowest potassium use efficiency among treatments was recorded in RDF (T_2) with 34.83%. Mohammad *et al*. (2018) conducted an experiment revealing that KSB 37, KSB 39, and KSB 44 isolated from paddy soil exhibited multiple plant growth-promoting rhizobacteria (PGPR) traits, including potassium solubilization, indole-3-acetic acid (IAA) production, and tolerance to various environmental stresses. The application of these isolates as bio-inoculants significantly enhanced grain yield, potassium use efficiency, and potassium uptake in both straw and grain.

Table 3: Effect of seed-inoculated KSB on nutrient use efficiency

Treat.	Treatment details	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1.	Absolute control	--------	-------	-------
T_2	RDF	27.73	9.30	34.83
T_3	RDF + KSB	30.55	11.67	39.50
T_4	75% RDF + KSB	37.87	13.38	48.11

T_5	75% RDF + FYM @ 5t ha^{-1}	37.08	13.43	33.86
T_6	75% RDF + KSB + FYM @ 5t ha^{-1}	41.32	15.24	36.47
T_7	75% RDF + Vermicompost @ 2.5 t ha^{-1}	38.27	13.58	37.67
T_8	75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1}	41.93	15.45	40.90

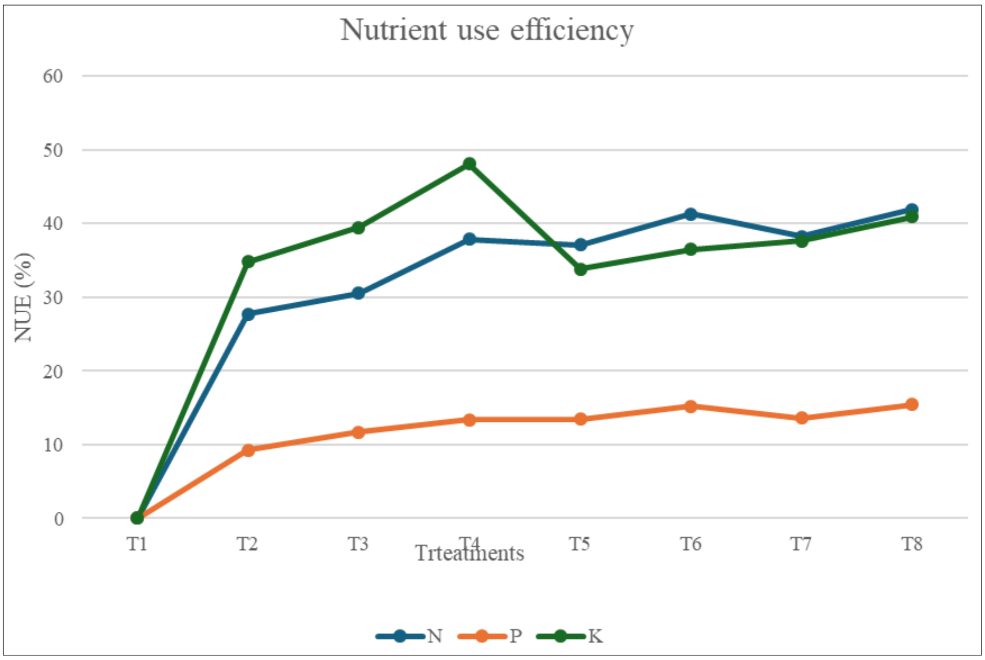

Fig 6: Effect of seed inoculated KSB on nutrient use efficiency

4. Conclusion

The integrated application of 75% RDF + KSB + Vermicompost @ 2.5 t ha^{-1} significantly enhanced wheat yield, nutrient uptake, and nutrient use efficiency. This approach effectively reduces dependence on chemical fertilizers while sustaining productivity. Seed inoculation with KSB, along with organic inputs, is thus a promising strategy for Vertisol-based wheat production.

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6. References

1. Aishwarya K, Meena RN, Singh AK, Meena SK. Effect of potassium and potassium solubilizing bacteria on yield and nutrient uptake by wheat *(Triticum aestivum L.)* var. GW 366. J Pharmacogn Phytochem. 2019;8(1):2530-2533.
2. Balasubramanian R, Subramanian P. Influence of biofertilizers on yield and nutrient uptake of rice. Oryza. 2006;43(4):293-295.
3. Basak BB, Biswas DR. Influence of potassium solubilizing microorganism (*Bacillus mucilaginosus*) and waste mica on potassium uptake dynamics by *sudan grass (Sorghum vulgare Pers.)* grown under two Alfisols. Plant Soil. 2010;326:183-193.
4. Choudhary AK, Thakur SK, Bhunia SR. Role of organic nutrient sources in improving productivity and soil health in dryland wheat. Int J Agric Sci. 2018;10(11):7178-7182.
5. Ibrahim MM, Ali BM. Effect of potassium solubilizing bacteria on nutrient uptake and yield of maize *(Zea mays L.)*. J Soil Sci Agric Eng. 2018;9(1):37-42.
6. Khanghahi MY, Younesi H, Gholamhoseini M. Biofertilization and integrated nutrient management improve potassium and phosphorus uptake and use efficiency in rice. Arch Agron Soil Sci. 2018;64(9):1181-1194.
7. Khani A, Moradi R, Jalilian J, Khalesro S, Moradi P. Potassium-solubilizing bacteria affect the growth, nutrient uptake, and yield of maize *(Zea mays L.)*. J Plant Nutr. 2019;42(10):1071-1081.
8. Kong X, Li J, Du S, Wei J. Effects of potassium solubilizing bacteria on tobacco growth and soil nutrient availability in potassium-deficient soil. Commun Soil Sci Plant Anal. 2014;45(11):1453-1462.
9. Mikhailouskaya NA, Tcherhysh A, Malinovskaya I, Kotyza J. Effects of microbial preparations on winter cereals in Belarus. Czech J Genet Plant Breed. 2009;45(Special Issue):348-350.
10. Mikhailouskaya NA, Tcherhysh A. Effect of bacterial fertilizers on productivity and nutrient uptake by *wheat* and *rye*. Microbiol J. 2005;67(4):432-436.
11. Mohammad S, Younesi H, Khanghahi MY. Use of native potassium-solubilizing bacteria to improve potassium uptake and yield in paddy rice. J Appl Biol Biotechnol. 2018;6(6):12-18.
12. Panwar JDS, Singh R. Effect of biofertilizers and FYM on yield and nutrient uptake of wheat. Indian J Agron. 2000;45(2):338-340.
13. Parmar P, Sindhu SS. Potassium solubilization by rhizosphere bacteria: influence of nutritional and environmental conditions. J Microbiol Res. 2013;3(1):25-31.

14. Sharma SN, Prasad R. Integrated nutrient management for sustainable crop production. Indian Farming. 2003;53(11):11-14.
15. Sharma V, Singh S. Effect of potassium solubilizing microorganisms and organic manures on potassium use efficiency and yield of wheat. Int J Chem Stud. 2020;8(3):1277-1281.
16. Sindhu SS, Parmar P, Phour M. Potassium solubilizing bacteria: A potential agent for sustainable crop production. In: Meena VS, Maurya BR, Verma JP, Meena RS, editors. Potassium Solubilizing Microorganisms for Sustainable Agriculture. New Delhi: Springer; 2016. p. 125-149.
17. Singh B, Ryan J. Managing fertilizer use efficiency under intensive cropping. J Crop Improv. 2015;29(3):243-270.
18. Subba Rao NS. Biofertilizers in Agriculture. 4th ed. New Delhi: Oxford and IBH Publishing; 1999.
19. Yadav KK, Sharma SK, Sharma Y. Effect of integrated nutrient management on wheat and soil fertility in alluvial soils of north India. Int J Curr Microbiol App Sci. 2017;6(9):1114-1121.
20. Zhang H, Wu X, Li G, Qin P. The effect of organic fertilizer on crop yield and soil properties in a long-term fertilization experiment in *okra (Abelmoschus esculentus)*. J Food Agric Environ. 2013;11(2):986-990.