



Weed Seed Bank and Weed Dynamics in Soybean as Influenced by Long Term Nutrient Management

S.U. Pawar¹, H. Sharath¹, R.N. Khandare¹, Apeksha Thombre¹, Megha Koturwar¹, Priya Shinde¹

10.18805/LR-5653

ABSTRACT

Background: Nutrient management is a prevalent agronomic practice enhancing soil fertility and crop productivity. It directly impacts weed growth through nutrient availability and indirectly intensifies resource competition, shaping weed community dynamics.

Methods: The long-term field experiment on nutrient management was initiated in 2006-07 at Long-term Fertilizer Experiment Research, VNMKV, Parbhani, Maharashtra, India. The experiment was laid out in randomized block design (RBD) with ten treatments comprising organic, inorganic and integrated nutrient management practices and three replications. This study on weed dynamics and weed seed bank was carried out in this experiment during *kharif* season of 2023 and 2024.

Result: The results revealed that application of 100% NPK+FYM @5 tonnes ha⁻¹ recorded the highest seed yield (2518, 2442 and 2480 kg ha⁻¹) and straw yield ((3526, 3131 and 3329 kg ha⁻¹) and was followed by treatment comprising of 150% NPK, while minimum seed yield was recorded with control followed by treatment with application of 100% N. The density of weed seeds decreased with increase in soil depth under all the nutrient management treatments. The total weed dry weight was higher in FYM @10 t/ha, 100% NP and 150% NPK while, lower weed dry weight was recorded in 100% N, 50% NPK and absolute control.

Key words: Long-term nutrient management, Weed seed bank, Weed dynamics.

INTRODUCTION

Soybean (*Glycine max*) grown during the monsoon season is commonly infested by a diverse range of weeds including grasses, sedges and broad-leaf weeds, because of favorable temperature and moisture conditions. The annual grass weeds *viz.*, *Echinochloa colona*, *Echinochloa crusgalli*, *Cyperus rotundus*, *Cynodon dactylon*, *Cyperus iria* and dicot weeds like *Phyllanthus niruri*, *Euphorbia* spp., *Commelina benghalensis*, *Eclipta alba* and *Corchorus acutangulus* etc. compete with the crop (Sharma and Shrivastava, 2002).

A balanced nutrient supply is essential for achieving optimal growth as well as yield and quality of crops. When nutrient levels drop below critical thresholds, plant metabolic processes are adversely affected, which in turn reduces the protein and oil production in crops such as soybean (Dwivedi *et al.*, 2007). Therefore, integration of chemical fertilizers with farmyard manure (FYM) can improve yield-related traits, increase soybean yield and enhance nutrient content and uptake, ultimately leading to greater productivity in soybean cultivation.

Weeds significantly limit crop productivity by competing for resources such as nutrients, water and light. The composition, density and biomass of weed flora are influenced by several factors including crop type, land conditions, cropping pattern, irrigation practices, soil characteristics and weed management strategies. Nutrients availability play a crucial role in shaping weed dynamics and consequently, crop yield. Even with fertilizer application, crop yields may decline due to intense weed competition, as weeds often absorb nutrients more efficiently. The extent of yield loss depends on weed

¹Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani-431 402, Maharashtra, India.

Corresponding Author: S.U. Pawar, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani-431 402, Maharashtra, India. Email: pawarsu7@rediffmail.com
ORCIDs: 0000-0003-2312-7672, 0009-0008-8066-3045, 00000-0001-6911-9809, 0009-0008-1699-8588, 0009-0007-6359-0043, 0009-0007-6468-1609

How to cite this article: Pawar, S.U., Sharath, H., Khandare, R.N., Thombre, A., Koturwar, M. and Shinde, P. (2026). Weed Seed Bank and Weed Dynamics in Soybean as Influenced by Long Term Nutrient Management. *Legume Research*. **49(7)**: 1250-1256. doi: 10.18805/LR-5653.

Submitted: 12-03-2026 **Accepted:** 02-05-2026 **Online:** 01-06-2026

species, population density and soil nutrient status. Studies have shown that soil nutrient content strongly affects weed population, diversity indices and community structure (Neve *et al.*, 2009). Furthermore fertilization induced challenges in soil nutrients can alter weed diversity and community succession, thereby influencing crop biomass and yield (Tarek, 2008).

Fertilizer application is a common agronomic practice used to enhance soil fertility and improve crop productivity. It influences weed growth both directly, by increasing nutrient availability and indirectly, by intensifying competition for resources, thereby shaping weed community dynamics. Balanced fertilization, particularly with optimal levels of nitrogen (N), phosphorus (P) and potassium (K), promotes vigorous crop growth and results in dense plant stands that restrict light availability to weeds, ultimately affecting

their diversity. Increased competition for light is a major factor contributing to weed suppression and improved crop yield (Yin *et al.*, 2006). Soil nutrient status also plays a significant role in determining weed density, diversity and community composition. Effective nutrient management can reduce weed infestation and alter species distribution. Moreover, the combined use of inorganic fertilizers and organic manures has been shown to modify weed flora, as reported in long-term studies involving NPK and FYM applications (Hossain *et al.*, 2009).

Long-term nutrient management experiments are valuable for addressing recurring challenges in nutrient management and for optimizing crop productivity. These studies provide important insights for developing and refining management strategies. In situations where herbicide use is minimal or absent, weed dynamics-especially in alternative cropping systems-are influenced by the prolonged interaction of several factors, including crop rotations (Smith and Gross, 2006; Anderson, 2015), tillage practices (Armengot *et al.*, 2016) and variations in nutrient sources and application rates (Little *et al.*, 2021). Additionally, short-term cultural and mechanical weed control practices also contribute to these dynamics (Liebman *et al.*, 1997). Therefore, a comprehensive understanding of the interactions among these factors is crucial for developing sustainable nutrient and weed management strategies, particularly in systems with limited reliance on herbicides. The present study was undertaken to evaluate weed density, species composition and weed seed bank as influenced by organic, inorganic and integrated nutrient management practices over a long-term period.

MATERIALS AND METHODS

The long-term fertilizer field experiment was initiated in 2006-07 at Long-term Fertilizer Experiment Research, VNMKV, Parbhani, Maharashtra, India. The experiment has been laid out in randomized block design with 10 treatments replicated thrice. This study on weed dynamics and weed seed bank was carried out during *kharif* season 2023 and 2024. The treatments comprised T_1 - 50% NPK, T_2 - 100%NPK, T_3 - 150% NPK, T_4 - 100% NPK+25 kg $ZnSO_4$ ha⁻¹, T_5 - 100% NP, T_6 - 100% N, T_7 - 100% NPK+FYM@ 5 tonnes ha⁻¹, T_8 - 100% NPK-Sulphur, T_9 - Only FYM@ 10 tonnes ha⁻¹ and T_{10} - Absolute control. The soil of the experimental site was Vertisol (montmorillonitic). The site of experiment was located at 76°46' E longitude and 19°16' N latitude with an elevation of 408.46 m above the mean sea level. Fertilizers were applied to the soil on the day of sowing of seeds as per treatment except to the control treatment. The sources of nutrients were fertilizers (urea, single super phosphate, muriate of potash, diammonium phosphate, zinc sulphate) and FYM was applied 15 days prior to the sowing for soybean crop in *kharif*. The recommended dose of fertilizer (RDF) was 30:60:30 kg NPK per hectare. The plot size was 13.5 m × 10 m, soybean variety MAUS-162 was sown at a spacing of 45 cm × 5 cm. Weed seed distribution in the soil was studied at different depths through pot culture

experiments before sowing of soybean during 2023 and 2024. Soil samples were collected from the experimental site after the harvest of previous *Rabi* crop in sequence. The soil samples were taken at 0-5 cm and 5-10 cm dried under shade. One kg of soil from each depth was weighed and kept in plastic pots containing holes at the bottom side to study the emerging weeds present in the soil. The pots were watered manually as and when needed to maintain adequate moisture. After germination, the weed seedlings were identified, counted and removed and again soil was thoroughly stirred and watered regularly for another flush of weeds. The cycle of operation was repeated till all the weed seeds were exhausted. Weed counts (number 0.25 m²) were recorded at different stages from two spots per plot. These weeds were categorized as monocot and dicot weeds and expressed as number m⁻² and averaged over two random spots per plot. After sorting as monocot and dicot weeds, these categories of weeds were dried in hot air oven at 60°C, till constant dry weight was recorded. The dry weight of weeds as expressed separately for monocot and dicot weeds as g m⁻² at different stages. The available nitrogen content was determined using the alkaline potassium permanganate method, following the procedure described by Subbiah and Asija (1956). Available phosphorus was measured from the soil using 0.5M Sodium bicarbonate, employing Olsen's method as outlined by Jackson (1967). Available potassium measured using neutral normal ammonium acetate (NH₄OAc) and the potassium content in the extract was determined using a Flame Photometer, following the method described by Piper (1966). The soybean plants from each net plot were threshed and seeds were cleaned. The cleaned seeds obtained from each plot were weighted and expressed as seed yield of soybean in kg ha⁻¹. The experimental data collected on plant growth parameters and yield components of soybean were subjected to Fisher's method of "Analysis of Variance" (ANOVA) as outlined by (Panse and Sukhatme, 1954).

RESULTS AND DISCUSSION

The data related to the seed and straw yield of soybean, weed dry weight at different stages and weed seed bank as influenced by long term nutrient management treatments during the course of investigation were critically interpreted and results are presented below.

The dominant monocot and dicot weeds associated with soybean during experimentation were *Brachiaria eruciformis*, *Cyperus rotundus* among monocots and *Phyllanthus niruri*, *Acalypha indica*, *Ipomoea maxima*, *Euphorbia geniculata*, *Euphorbia microphylla* among dicots.

Seed yield and straw yield of soybean as influenced by different treatments

Seed yield (kg ha⁻¹)

The data on seed yield (kg ha⁻¹) of soybean showed significant differences among the treatments due to the long-term nutrient management.

Significantly higher seed yield (2518, 2442 and 2480 kg ha⁻¹) was recorded with the treatment receiving 100%NPK+FYM which was on par with the treatments receiving 150% NPK (2333, 2398 and 2366 kg ha⁻¹), 100%NPK + Zn (2259, 2348 and 2304 kg ha⁻¹) and 100% NPK (2258, 2334 and 2297 kg ha⁻¹). While, the lowest seed yield was recorded with the control (898, 944 and 921 kg ha⁻¹) and 100% N (1037, 1044 and 1041 kg ha⁻¹) during 2023, 2024 and pooled analysis.

The increased seed yield observed under the combined application of inorganic fertilizers and organic sources may be attributed to a sustained supply of nutrients and more efficient utilization of applied inputs. This improvement can be linked to enhanced microbial activity, which plays a key role in nutrient transformation and fixation processes. Comparable results have also been reported by Arbad and Ismail (2011) and Ravankar *et al.* (1995). In contrast, the reduced yield recorded under the application of 100%

nitrogen alone may be associated with increased soil acidity and the gradual deterioration of soil quality resulting from the continuous use of nitrogen over several years (Dutta *et al.*, 2013). Khandare *et al.* (2026) also reported higher soybean and safflower yields with application of 100% NPK+5 t FYM ha⁻¹ along with maximum and significantly more population of bacteria, fungi, actinomycetes and soil microbial biomass C.

Straw yield (kg ha⁻¹)

Analysis of the data presented in Table 1 revealed that straw yield differed significantly among the various nutrient management practices. The highest straw yield (3526, 3131 and 3329 kg ha⁻¹) was obtained with the application of 100% NPK in combination with FYM, which proved superior to the other treatments during 2023. However, in 2024 and based on pooled mean data, this treatment remained statistically comparable with 150% NPK, followed by 100%

Table 1: Effect of long-term nutrient management on seed and straw (kg/ha) yield of soybean.

Treatments	Seed yield (kg/ha)			Straw yield (kg/ha)		
	2023	2024	Pooled mean	2023	2024	Pooled mean
T ₁ : 50% NPK	1935	2200	2068	2700	2897	2799
T ₂ : 100% NPK	2259	2334	2297	3051	3082	3067
T ₃ : 150% NPK	2333	2398	2366	3253	3117	3185
T ₄ : 100% NPK+Zn	2259	2348	2304	3060	3078	3069
T ₅ : 100% NP	2102	2213	2158	2973	3092	3033
T ₆ : 100% N	1037	1044	1041	1680	1246	1463
T ₇ : 100% NPK+FYM@ 5 t/ha	2518	2442	2480	3526	3131	3329
T ₈ : 100% NPK-S	1954	2313	2134	2404	2991	2698
T ₉ : FYM@10 t/ha	1907	2185	2046	2562	2792	2677
T ₁₀ : Absolute control	898	944	921	1492	926	1209
S.Em.±	91.9	61.7	67.9	157.0	102.3	176.6
CD@ 5%	266.7	178.9	217.1	455.6	296.8	564.9
General mean	1920	2042	1981.5	2670	2635	2653

Table 2: Effect of long-term nutrient management on weed seed bank in soybean (No. of weed seeds kg⁻¹ of soil) during 2023.

Treatments	0-5 cm			5-10 cm		
	Monocot weeds	Dicot weeds	Total	Monocot weeds	Dicot weeds	Total
T ₁ : 50% NPK	1.07 (0.67)	1.72 (2.67)	1.88 (3.33)	0.91 (0.33)	1.34 (1.33)	1.46 (1.67)
T ₂ : 100% NPK	1.18 (1.00)	2.26 (4.67)	2.45 (5.67)	0.91 (0.33)	1.56 (2.00)	1.7 (2.50)
T ₃ : 150% NPK	1.28 (1.33)	2.67 (6.67)	2.9 (8.00)	1.08 (0.67)	1.95 (3.33)	2.11 (4.00)
T ₄ : 100% NPK+Zn	1.86 (2.96)	3.09 (9.00)	3.53 (12.00)	1.47 (1.67)	2.24 (4.53)	2.58 (6.2)
T ₅ : 100% NP	1.07 (0.67)	2.85 (7.67)	2.96 (8.33)	1.22 (1.00)	1.95 (3.33)	2.2 (4.3)
T ₆ : 100% N	0.89 (0.33)	1.97 (3.67)	2.06 (4.00)	1.08 (0.67)	1.48 (1.83)	1.66 (2.33)
T ₇ : 100% NPK+FYM@ 5 t/ha	1.18 (1.00)	2.45 (5.67)	2.64 (6.67)	1.08 (0.67)	1.62 (2.23)	1.81 (2.90)
T ₈ : 100% NPK-S	1.24 (2.00)	2.12 (4.00)	2.34 (5.00)	1.08 (0.67)	1.68 (2.33)	1.86 (3.00)
T ₉ : FYM@10 t/ha	1.69 (2.33)	2.92 (8.00)	3.29 (10.33)	1.35 (1.33)	2.11 (4.00)	2.41 (5.30)
T ₁₀ : Absolute control	0.89 (0.33)	1.96 (3.33)	2.04 (3.67)	1.08 (0.67)	1.46 (1.67)	1.68 (2.33)
S.Em.±	0.09	0.19	0.24	0.22	0.15	0.14
CD@ 5%	0.31	0.62	0.78	NS	0.49	0.45
General mean	1.23	2.40	2.61	1.09	1.74	1.94

*Values in parentheses are means of original values; Data transformed to square root transformation $\sqrt{(x+0.5)}$.

NPK + Zn and 100% NPK. The lowest straw yield was observed under the control treatment, followed by the application of 100% nitrogen alone.

Weed studies

Data related to the weed seed bank and the dry weight of weeds at different growth stages during 2023 and 2024, as influenced by various treatments, are presented in Table 2 to 5.

Weed seed bank studies

Weed seed bank at 0-5 cm soil depth (no. kg⁻¹ soil)

At the 0-5 cm soil depth, the number of monocot weed seeds varied significantly across treatments. The highest monocot seed count was recorded under 100% NPK + Zn (2.96 and 3.06 kg⁻¹ soil), followed by FYM @ 10 t ha⁻¹ (T₉) (2.33 and 2.64 kg⁻¹ soil), 100% NPK - S (T₈) (2.00 and

2.28 kg⁻¹ soil) and 150% NPK. In contrast, the lowest number of monocot weed seeds was observed in the control treatment and in plots receiving 100% nitrogen alone (T₆), followed by 50% NPK during both years of the study.

A significantly higher number of dicot weed seeds was also recorded under 100% NPK + Zn, followed by FYM @ 10 t ha⁻¹ and 100% NP. The lowest dicot seed population was found in the 50% NPK treatment. Similarly, the total weed seed bank was highest under 100% NPK + Zn, followed by FYM @ 10 t ha⁻¹ and 100% NP, whereas the minimum number of weed seeds was recorded in plots receiving 50% NPK.

Weed seed bank at 5-10 cm soil depth (No. kg⁻¹ soil)

At soil depth of 5-10 cm depth overall number of weed seeds was lower as compared to 0-5 cm depth. Among the treatments significantly higher number of monocot, dicot

Table 3: Effect of long-term nutrient management on weed seed bank in soybean (No. of weed seeds kg⁻¹ of soil) during 2024.

Treatments	0-5 cm			5-10 cm		
	Monocot weeds	Dicot weeds	Total	Monocot weeds	Dicot weeds	Total
T ₁ : 50% NPK	1.16 (0.85)	1.85 (2.92)	2.06 (3.77)	0.98 (0.46)	1.38 (1.48)	1.55 (1.94)
T ₂ : 100% NPK	1.29 (1.18)	2.35 (5.08)	2.59 (6.26)	0.99 (0.48)	1.68 (2.39)	1.81 (2.87)
T ₃ : 150% NPK	1.52 (1.82)	2.78 (7.25)	3.04 (8.77)	1.15 (0.83)	2.04 (3.68)	2.23 (4.51)
T ₄ : 100% NPK+Zn	1.88 (3.06)	3.20 (9.75)	3.7 (13.21)	1.50 (1.86)	2.34 (4.98)	2.71 (6.84)
T ₅ : 100% NP	1.17 (0.86)	2.98 (8.38)	3.12 (9.24)	1.29 (1.18)	2.05 (3.72)	2.32 (4.90)
T ₆ : 100% N	1.05 (0.61)	2.12 (3.98)	2.26 (4.59)	1.15 (0.82)	1.59 (2.04)	1.83 (2.86)
T ₇ : 100% NPK+FYM@ 5 t/ha	1.32 (1.23)	2.58 (6.15)	2.80 (7.38)	1.18 (0.89)	1.70 (2.47)	1.94 (3.36)
T ₈ : 100% NPK-S	1.67 (2.28)	2.20 (4.32)	2.53 (5.94)	1.16 (0.84)	1.75 (2.59)	1.98 (3.43)
T ₉ : FYM@10 t/ha	1.77 (2.64)	3.03 (8.68)	3.43 (11.32)	1.31 (1.23)	2.22 (4.41)	2.48 (5.64)
T ₁₀ : Absolute control	0.95 (0.41)	2.03 (3.61)	2.12 (4.03)	1.14 (0.81)	1.55 (1.89)	1.79 (2.70)
S.E.m.±	0.09	0.10	0.07	0.08	0.13	0.12
CD@ 5%	0.31	0.37	0.20	0.22	0.39	0.36
General mean	1.23	3.60	2.61	1.09	1.74	1.94

*Values in parentheses are means of original values; Data transformed to square root transformation $\sqrt{(x+0.5)}$.

Table 4: Dry weight of weeds as influenced by long-term fertilizer application during 2023 and 2024 at 15 DAS.

Treatments	Dicot weed dry wt. (g m ⁻²)		Monocot weed dry wt. (g m ⁻²)		Total weed dry wt. (g m ⁻²)	
	2023	2024	2023	2024	2023	2024
T ₁ : 50% NPK	0.94 (0.41)	0.98 (0.46)	1.03 (0.58)	0.98 (0.45)	1.26 (0.99)	1.19 (0.92)
T ₂ : 100% NPK	1.54 (2.07)	1.35 (1.35)	1.05 (0.61)	1.06 (0.62)	1.24 (0.93)	1.37 (1.42)
T ₃ : 150% NPK	0.86 (0.26)	1.05 (0.62)	1.12 (0.76)	1.13 (0.80)	1.78 (2.68)	1.56 (1.97)
T ₄ : 100% NPK+Zn	1.11 (0.77)	1.06 (0.63)	1.02 (0.55)	1.04 (0.60)	1.37 (1.31)	1.31 (1.23)
T ₅ : 100% NP	1.65 (2.45)	1.59 (2.03)	1.24 (1.03)	1.32 (1.26)	2.00 (3.48)	1.94 (3.29)
T ₆ : 100% N	1.37 (1.66)	1.14 (0.81)	0.74 (0.05)	0.84 (0.21)	1.44 (1.72)	1.23 (1.02)
T ₇ : 100% NPK+FYM@ 5 t/ha	1.52 (2.11)	1.39 (1.48)	0.97 (0.44)	1.92 (3.21)	1.74 (2.55)	2.27 (4.69)
T ₈ : 100% NPK-S	1.23 (1.24)	1.13 (0.78)	1.01 (0.53)	1.44 (1.57)	1.51 (1.77)	1.69 (2.35)
T ₉ : FYM@10 t/ha	1.98 (3.85)	1.64 (2.19)	0.99 (0.49)	1.97 (3.41)	2.16 (4.34)	2.47 (5.59)
T ₁₀ : Absolute control	0.82 (0.17)	0.96 (0.43)	0.85 (0.24)	1.03 (0.58)	1.03 (0.51)	1.22 (1.01)
S.E.m.±	0.24	0.22	0.06	0.09	0.12	0.08
CD@ 5%	NS	0.66	0.18	0.26	0.40	0.23
GM	1.30	1.23	1.00	1.27	1.55	1.62

*Values in parentheses are means of original values; Data transformed to square root transformation $\sqrt{(x+0.5)}$.

and total weed seeds were observed under 100%NPK +Zn (6.2 and 6.84 kg⁻¹ of soil) followed by FYM @10 t/ha during first and second year of study respectively. Significantly lower number of monocot weed seeds was noticed in 50% NPK and 100% N and absolute control treatments.

From this study, it was observed that, the abundance of weed seeds decreased with increase in soil depth irrespective of the nutrient management treatments, similar to the observations made by Kelton *et al.* (2011). There were substantial variations in soil nutrient contents among different treatments and substantial temporal changes in nutrient conditions under each treatment. Thus, weed species with a narrow nutrient niche are likely to be eliminated gradually. In addition, fertilization treatments might have also affected the competition between weed and crop (Yin *et al.*, 2006).

Total weed seeds were higher in 100%NPK +Zn followed by FYM @10 t/ha during first and second year of experimentation respectively. Significantly lesser number of monocot weeds was observed in 50% NPK and absolute control.

Dry weight of weeds (gm⁻²)

The data on weed dry weight at different growth stages of soybean are presented in Table 4 and 5.

Dry weight of weeds at 15 DAS

From the data (Table 5), it was observed that at 15 DAS there were no significant difference with respect to weed dry weight of dicot weeds during first year of study while during second year significantly higher weed dry matter was observed in treatment FYM@10 t/ha and 100%NPK+FYM@ 5 t/ha while, lower dry weight of broad leaf weeds was recorded in control. Regarding data on dry weight of monocot

Table 5: Dry weight of weeds as influenced by long-term fertilizer application during 2023 and 2024 at 30 DAS.

Treatments	Dry weight of dicot weeds (gm ⁻²)		Dry weight of monocot weeds (gm ⁻²)		Total dry weight of weeds (gm ⁻²)	
	2023	2024	2023	2024	2023	2024
T ₁ : 50% NPK	1.01 (0.5)	1.03 (0.57)	1.14 (0.82)	1.11 (0.74)	1.35 (1.32)	1.34 (1.31)
T ₂ : 100% NPK	1.65 (2.2)	1.82 (2.83)	1.02 (0.54)	1.06 (0.64)	1.8 (2.67)	1.99 (3.47)
T ₃ : 150% NPK	2.15 (4.05)	2.38 (5.27)	1.23 (1.01)	1.30 (1.21)	2.36 (5.06)	2.62 (6.48)
T ₄ : 100% NPK+Zn	2.85 (7.56)	2.50 (5.95)	1.33 (1.27)	1.38 (1.41)	3.05 (6.82)	2.76 (7.35)
T ₅ : 100% NP	2.73 (6.93)	2.71 (6.90)	1.17 (0.95)	1.26 (1.10)	2.8 (7.88)	2.91 (8.00)
T ₆ : 100% N	1.65 (2.19)	1.82 (2.85)	1.09 (0.74)	1.06 (0.63)	1.85 (2.93)	1.98 (3.47)
T ₇ : 100% NPK+FYM@ 5 t/ha	1.72 (2.45)	1.77 (2.66)	1.1 (0.71)	1.15 (0.82)	1.91 (3.16)	1.99 (3.48)
T ₈ : 100% NPK-S	1.95 (3.26)	2.11 (3.97)	1.31 (1.23)	1.39 (1.43)	2.23 (4.5)	2.43 (5.40)
T ₉ : FYM@10 t/ha	2.53 (6.75)	2.59 (6.23)	1.26 (1.13)	1.39 (1.44)	2.80 (7.89)	2.86 (7.67)
T ₁₀ : Absolute control	1.37 (1.34)	1.48 (1.73)	0.86 (0.24)	1.06 (0.63)	1.44 (1.58)	1.68 (2.36)
S.E.m.±	0.16	0.11	0.11	0.08	0.18	0.10
CD@ 5%	0.50	0.32	NS	0.23	0.56	0.31
GM	1.96	2.02	1.15	1.21	2.16	2.25

*Values in parentheses are means of original values; Data transformed to square root transformation $\sqrt{(x+0.5)}$.

Table 6: Effect of long-term nutrient management on soil chemical properties before sowing of soybean (2023).

Treatment	pH	EC (dSm ⁻¹)	OC(%)	Available nutrients (kg ha ⁻¹)		
				N	P	K
T ₁ : 50% NPK	8.22	0.238	0.626	247	15.35	650.47
T ₂ : 100% NPK	8.24	0.249	0.659	254	16.84	702.25
T ₃ : 150% NPK	8.25	0.255	0.670	268	18.85	751.03
T ₄ : 100% NPK+Zn	8.28	0.253	0.655	259	17.29	694.17
T ₅ : 100% NP	8.21	0.247	0.576	244	16.49	661.86
T ₆ : 100% N	8.16	0.247	0.573	241	10.53	628.43
T ₇ : 100% NPK+FYM@ 5 t ha ⁻¹	7.58	0.236	0.698	279	19.05	801.15
T ₈ : 100% NPK-S	8.21	0.246	0.627	247	16.29	674.25
T ₉ : Only FYM@ 10 t/ha	7.52	0.224	0.674	255	17.40	748.59
T ₁₀ : Absolute control	8.27	0.236	0.55	226	10.24	624.00
Initial values (2006) at start of long term fertilizer experiment	8.10	0.218	0.55	216	16.00	766.00

weeds was significantly higher in 100% NP which was on par with 150% NPK while, lower dry weight of monocot weeds was recorded in 100% N. With respect to the total weed dry weight FYM @10 t/ha (T_9) recorded higher weed dry weight (4.34 g m^{-2}) and it was at par with 100% NPK+FYM@ 5 t/ha, 100% NP (3.48 g m^{-2}) and 150% NPK (2.68 g m^{-2}). The results of present study were observed to be in line with the findings of Khatri *et al.* (2020) who reported that application of FYM @ 10 t ha⁻¹ followed by recommended fertilizer dose recorded higher weed density and dry weed weight compared to any of N, P_2O_5 and K_2O or all nutrient omitted treatments. While the control treatment recorded a lower weed dry weight (0.51 g m^{-2}).

Dry weight of weeds at 30 DAS

Significantly higher dry weight of dicot weeds was recorded in treatment 100% NPK + Zn (T_4) and it was at par with 100% NP (T_5) and FYM @10 t/ha (T_9) at 30 DAS during first and second year of study (Table 5). While, lower dicot weed dry weight was recorded in 50% NP (0.5 g m^{-2}). For monocot weeds, the effect of treatments was observed to be non significant during first year and during second year FYM @10t/ha recorded highest dry weight of monocot weeds.

Treatment 100%NPK + Zn (T_4) recorded higher total weed dry weight and it was at par with FYM @10 t/ha (4.34 and 3.41 g m^{-2}) and 150% NPK, while 50% NPK and control recorded lower weed dry weight. Higher weed dry matter under treatments with FYM application could be attributed to the increased availability of nutrients in a balanced form and improved physio-chemical properties of the soil (Table 6). Significantly lower dry matter accumulation by weeds was recorded under the treatment with no fertilizer application. The application of manure in cropping systems increases weed density and biomass (Kaur and Kaur, 2018). The use of both organic and inorganic fertilizers in agro-systems not only benefits the crop but also weeds, whose nutrient uptake system is more efficient than that of crop plants (Hunkova *et al.*, 2011). Application of 100% organics (100% Rec. N through different organic sources each equivalent to 1/3 of Rec. N *i.e.* FYM+ vermicompost + non edible oil cake) + VAM produced significantly higher crop yield coupled with organically weed management practice *i.e.* weed free and application of rice bran @ 4 t ha^{-1} which not only were economically viable and efficient organic weed management options but also kept dominant weeds below threshold level (Sharma *et al.*, 2023).

CONCLUSION

Based on the two years findings and pooled results, it can be concluded that, application of 100% NPK+FYM @5 t ha⁻¹ was found productive recording the highest seed yield (2518 , 2442 and 2480 kg ha^{-1}) and straw yield (3526 , 3131 and 3329 kg ha^{-1}) in soybean was followed by application of 150% NPK, while minimum seed yield was recorded with control followed by application of 100% N. The weed

seed density decreased with increase in soil depth in all the nutrient management treatments. The total weed dry weight was higher with sole application of FYM @10 t/ha, 100% NP and 150% NPK while, lower weed dry weight was recorded in 100% N, 50% NPK and absolute control.

ACKNOWLEDGEMENT

The present study carried out at research centre on Long-term Fertilizer Experiment Research, VNMKV, Parbhani along with the necessary facilities.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

- Anderson, R.L. (2015). Integrating a complex rotation with no-till improves weed management in organic farming. *review. Agron. Sustain. Dev.* **35**(3): 967-974. doi: 10.1007/s13593-015-0292-3
- Arbad, B.K. and Ismail, S. (2011). Effect of integrated nutrient management on soybean (*Glycine max*)-safflower (*Carthamus tinctorius*) cropping system. *Indian Journal of Agronomy.* **56**(4): 340-345.
- Armengot, L., Blanco-Moreno, J.M., Bàrberi, P., Bocci, G., Carlesi, S., Aendekerk, R. *et al.* (2016). Tillage as a driver of change in weed communities: A functional perspective. *Agriculture Ecosyst. Environ.* **222**: 276-285. doi: 10.1016/j.agee.2016.02.021.
- Dutta, J., Sankhyani, N.K., Sharma, S.P., Sharma, G.D. and Sharma, S.K. (2013). Sulphur fractions in acid soil continuously fertilized with chemical fertilizers and amendments under maize-wheat system. *J. Indian Soc. Soil Sci.* **61**(3): 195-201.
- Dwivedi, A.K., Muneshwar, S., Kauraw, D.L., Wanjar, R.H. and Chauhan, S.S. (2007). Research Bulletin on impact of fertilizer and manure use for three decades on crop productivity and sustainability and soil quality under soybean wheat system on vertisol in central India. *AICRP on LTFE IISS (ICAR), Nabibagh, Bhopal.* 49-51.
- Hossain, R., Bodruzzaman, M., Kabir, M.R., Sarker, M.A.I. and Islam, M.Z. (2009). Long term fertilizers residual effects on weed flora of wheat in rice-wheat crop rotation. *Bangladesh Res. Pub. J.* **3**(1): 861-872.
- Hunkova, J., Winkler, E. and Demjanova. (2011). The weed seed bank assessment in two soil depths under various mineral fertilising. *Acta Univ. Agric. Silv. Mendelianae Brunensis.* **59**(5): 105-112.

- Jackson, M.L. (1967). Soil Chemical Analysis Prentice Hall of India Pvt. Ltd., New Delhi. p. 205.
- Kaur, R. and Kaur, B.S. (2018). Understanding crop-weed-fertiliser-water interactions and their implications for weed management in agricultural systems. *Crop Protectet*. **103**: 65-72.
- Kelton, J.A., Price, A.J., Santen, E., Balkcom, K.S., Arriaga, F.J. and Shaw, J.N. (2011). Weed seed bank density and composition in a tillage and landscape variability study. *Commun. Biometry Crop Sci*. **6**: 21e30.
- Khandare, R., Gajbhiye, B., Waikar, S., Vaidya, P., Wanjari, R. and Baig K.S. (2026). Long-term Effects of fertilizers and manure on productivity of soybean (*Glycine max* L.) - Safflower (*Carthamus tinctorius*) cropping system and soil health under *vertisols* in Central Platue of India. *Legume Research*. **49(2)**: 306-311. doi: 10.18805/LR-5479.
- Khatrri, N., Pande, B.P., Yadav, M., Chaurasia, B.P., Bista, M. and Kunwar, B. (2020). Weed dynamics and yield of wheat in long term soil fertility experiment under rice-rice-wheat cropping system. *J. Agric. Environ*. **12(4)**: 21-28.
- Liebman, M., Gallandt, E.R. and Jackson, L. (1997). Many little hammers: ecological management of crop-weed interactions. *Agric. Ecol. J*. **1**: 291-343. doi: 10.1016/B978-012378260-1/50010-5.
- Little, N.G. DiTommaso, A., Westbrook, A.S., Ketterings, Q.M. and Mohler, C.L. (2021). Effects of fertility amendments on weed growth and weed-crop competition: A review. *Weed Sci*. **69(2)**: 132-146. doi: 10.1017/wsc.2021.1
- Neve, P., Vila-Aiub, M. and Roux, F. (2009). Evolutionary thinking in agricultural weed management. *New Phytol*. **184**: 783-793.
- Pansee, V.G. and Sukhatme, P.V. (1954). Statistical methods for agricultural workers. ICAR Publication, p 359.
- Piper, C.S. (1966). Soil and Plant Analysis. Hans Publisher, Bombay.
- Ravankar, H.N., Patil, P.M., Mahod, N.B. and Deshmukh, P.W. (1995). Effect of organic and inorganic on yield and nutrient availability under soybean wheat sequence in Vertisol. *PKV Research Journal*. **31(2)**: 75-79.
- Sharma, A., Kachroo, D., Puniya, R. and Stanzen, L. (2023). Weed dynamics and productivity of french bean (*Phaseolus vulgaris* L.) as influenced by organic sources of nutrients and weed management. *Legume Research*. **46(8)**: 1092-1096. doi: 10.18805/LR-4828.
- Sharma, R.K. and Shrivastava, V.K. (2002). Weed control in soybean. *Indian Journal of Agronomy*. **47(2)**: 269-272.
- Smith, R.G. and Gross, K.L. (2006). Rapid change in the germinable fraction of the weed seed bank in crop rotations. *Weed Sci*. **54(6)**: 1094-1100. doi: 10.1614/WS-06-090R.1.
- Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. **25**: 259-260.
- Tarek, A.E. (2008). Chemical fertiliser could offer a real solution for minimizing over consumption of herbicides for controlling weeds in faba bean. *Trends Appl. Sci. Res*. **3**: 142-153.
- Yin, L., Cai, Z. and Zhong, W. (2006). Changes in weed community diversity of maize crops due to long-term fertilization. *Crop Protection*. **25(9)**: 910-914.