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Organic Seed Priming and Nutrient Management Effect on Yield of Barnyard Millet (*Echinochloa esculenta*) under Irrigated Conditions

Diksha Nautiyal[1], Priyanka Bankoti[1]

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ABSTRACT

Background: The present investigation was undertaken with the objective of determining the impact of organic seed priming and nutrient management on yield attributes and yield of barnyard millet under irrigated environment of Uttrakhand.

Methods: The trials were performed during *Kharif* season of 2023 and 2024 at the Agriculture Research Farm, School of Agriculture Sciences, Shri Guru Ram Rai University, Dehradun, using factorial -randomized block design to evaluate the impact of various organic seed priming and nutrient management regimes. Plot treatments included two factors, Factor 1: Specific applicable strategies of the plan are Nutrient Management and Factor 2: Organic Seed Priming. Factor 1 includes N0: Control, N1: Vermicompost @ (2 tonnes/ha), N2: Neem Cake@ (1 tonnes/ha), N3: Alfalfa Meal @ (2 tonnes/ha) and Factor 2 includes P0: No Priming, P1: Panchagavya @3%, P2: Jeevamrit @3%. The different treatment combinations were (N0 P0) Control + No Priming=T1, (N0 P1) Control + Panchagavya = T2, (N0 P2) Control + Jeevamrit = T3, (N1 P0) Vermicompost + No priming =T4, (N1 P1) Vermicompost + Panchagavya= T5, (N1 P2) Vermicompost + Jeevamrit= T6, (N2 P0) Neem Cake + No priming= T7, (N2 P1) Neem cake + Panchagavya= T8, (N2 P2) Neem cake + Jeevamrit= T9, (N3P0) Alfalfa meal + No Priming= T10, (N3 P1) Alfalfa meal+ Panchagavya= T11, (N3 P2) Alfalfa meal+ Jeevamrit= T12.

Result: This measures how these variables affect the yield of barnyard millet and provides related important findings on efficiency in cultivation of crops. The findings revealed a positive significant relationship between the two factors on the improvement of barnyard millet either singly or jointly. Work on T5 *i.e.* Vermicompost + Panchagavya has been found most effective compared to T12 *i.e.* Alfalfa Meal+ Jeevamrit among all treated plants. To some extend these findings pay toward the revelation of appropriate information to enhance the strategies in Barnyard millet at Uttarakhand and toward the equitable combination of production and quality in Millets Farming.

Key words: Barnyard millet, *Kharif* season, Nutrient management, RBD-factorial, Seed priming.

INTRODUCTION

Traditionally planted in warm and temperate climates, barnyard millet (Echinochloa species) is a millet crop that is most commonly grown in Asia, specifically in China, Japan, Korea and India. Due to its high production volume, it is the fourth most popular minor millet and gives many impoverished people worldwide food security. Given its area (0.146 m ha^{-1}) and production (0.147 mt), India is the world's largest producer of barnyard millet, having produced 1034 kg/ha on average over the previous three years (IIMR, 2017-18). Barnyard millet is grown mostly for human consumption, though it can also be fed to animals. *Echinochloa frumentacea*, also known as Indian barnyard millet and *Echinochloa esculenta*., also known as Japanese barnyard millet, are two of the most widely used species of barnyard millet among the numerous cultivated and wild varieties (Sood *et al.,* 2015).

It is economically less input requiring, short duration crop that can withstand many biotic and abiotic stresses and can grow in less favourable environmental factors. These grains are rich in nutritional value and are cheaper as compared to the large cereals such as rice, wheat and maize besides the above agricultural attributes. It is a rich source of protein, fibre, carbohydrates and primarily micronutrients, zinc (Zn) and Iron (Fe) and enzymatic activity as well (Saleh *et al.,* 2013; Ugare *et al.,* 2014; Singh *et al.,* 2010; Chandel *et al.,* 2014). There are so many health benefits associated with these nutrients. These characteristics has made barnyard millet a suitable crop to be grown by subsistence farmers besides being grown

[1]School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun-248 007, Uttarakhand, India.

Corresponding Author: Priyanka Bankoti, School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun-248 007, Uttarakhand, India. Email: priyankabankoti28@gmail.com
ORCIDs: 0000-0003-3144-5347; 0009-0007-2169-3036

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in cases of failure of monsoons in rice/major crop growing areas (Gupta *et al.,* 2009). From the Himalayan region in the north to the Deccan region in the south, India's barnyard millet is grown. One of Uttarakhand's minor *kharif* crops, barnyard millet is produced in hills up to 2000 meters above sea level in rainfed conditions. It is typically grown on the slopes of mountainous regions and in the rolling fields of hilly, marginal, or tribal regions where there aren't many other options for enhancing the crop. Before we introduce the two domesticated species, the class also includes 20-30 perennial wild species that are widely distributed and can grow in damp or extremely moist conditions while coexisting peacefully with rice (Hilu, 1994).

Barnyard millet has 10.1% protein, 8.7% moisture, 3.9% fat, 6.7% crude fiber, 2.0% total fat, 68.8% carbohydrates and 398 kcal/100 g of energy per 100 g. The total dietary fiber content of the barnyard millet was found to be substantial (12.5%), with both soluble (4.2%) and insoluble (8.4%) fractions. (Ugare *et al*., 2014). Selvam *et al*. (2022) emphasized the importance of targeted yield model-based balanced nutrient recommendations to enhance the productivity and nutrient use efficiency of barnyard millet under varied soil conditions.

India's leading producers of barnyard millet are the northeastern area, Uttarakhand, Madhya Pradesh, Karnataka and Uttar Pradesh. Barnyard millet holds a special place in Uttarakhand's mountainous cropping system since it is cultivated for both human and animal consumption. The barnyard millet crop in Uttarakhand is planted in March or April and harvested in September or October. However, higher hills take longer to mature than mid and lower hills due to the early arrival of winter and lower grain production. The Directorate of Agriculture, Dehradun, 2019 reports that barnyard millet is produced on 46408 hectares of land in Uttarakhand, with an average grain yield of 13.81 q/ha and a total yearly production of 64093 MT. The reasons for the difference in grain production between the research farm and the farmer's field are low quality seeds, local variety seeding and inadequate adaption of sound agronomic procedures.

MATERIALS AND METHODS

During the *kharif* season, the field experiments were taken at the Agriculture Research Farm of the School of Agriculture Sciences, Shri Guru Ram Rai University, Dehradun (Uttarakhand). The trials were performed during *Kharif* season of 2023 and 2024. Geographically speaking, Dehradun is located at a height of 640 mm above mean sea level and at latitude 30.3165° N and longitude 78.0322°E. This area is found in the Himalayan foothills, sandwiched between the Yamuna and Ganges rivers on the west and east, respectively.

Agriculture Research Farm falls under warm and temperate climate. When compared with winter, the summers have much more rainfall, with hot and dry summer and severe cold winters. Normally, the South- West monsoon commences from the third/fourth week of June and continues up to the mid of September, with its peak in July-August. The area has average annual temperature is 20.4°C and receives 1441 mm of precipitation annually in June to September while a few showers also occur during winter. Occurrence of frost is confined to a shorter period from the end of December to January. May is the hottest, while January is the coldest month of year. The maximum mean relative humidity oscillates around 90 per cent during the monsoon period and 48 per cent during May respectively.

Methodology of seed priming using Panchagavya and Jeevamruth

Priming of the seeds was done using Panchagavya and Jeevamruth. In both treatments, the 30 ml of the Panchagavya or the Jeevamruth was diluted to 1 litre of clean water to create a 3% solution. Seeds of barnyard millet were selected and then healthy seeds were added in the respective solutions at a ratio (seed-to-solution) of 1:5 and incubated for 12 hours at ambient temperature (around 25-28°C). Following soaking, the seeds were rinsed out of the solution and shade-dried on clean filter paper till completely dry (23 hours) by which time they were again at their original moisture content and could be freely sown. This drying procedure gave uniform sowing as clumping did not occur. Thereafter, the primed seeds were sown immediately in the field the same day. In the case of the control treatment (P0), no priming was performed and untreated seeds were simply sown.

Methodology of application of organic nutrients

The last land preparation included applying the four different organic nutrient sources (vermicompost 2 t/ha, neem cake 1 t/ha and alfalfa meal 2 t/ha) observed in this experiment in a basal application rate and uniformly to the plots a week before sowing. These organic amendments were applied as manual broadcast and well integrated with the top 15 cm of soil by the assistance of a spade and tractor mounted rotavator to form an even distribution and an advanced decay. This was early applied because the idea was that it should give time enough to enable microbial activity and nutrient mineralization prior to seedling emergence. Neither top dressing nor split application was done, but an emphasis was laid in the effect of sole organic nutrient sources. The N0 control treatment plots have been kept in a nutrient-free state and were not subjected to any organic or inorganic fertilizer to act as a baseline during inter-comparison. In all treatments, including the control, no chemical fertilizer (use of urea, DAP or MOP) was applied thus making the whole trial to be managed under strictly organic conditions.

The soil nutrient status of the experimental plot

The nutrient status in soil was measured after the experiment had taken place and after two years of organic alleviations had been applied. The preliminary soil testing indicated

pH of slightly acidic to neutral (6.01-6.61), low-to medium organic carbon (0.12- 0.51%) as well as moderate availability of nitrogen (164-294 kg/ha), phosphorus (32.7-68.9 kg/ha) and potassium (81-348 kg/ha) as mentioned in Fig 1. After the use of organic amendments of vermicompost, neem cake and alfalfa meal, there was a steady increment in the soil fertility especially in the plot that was Panchagavya or Jeevamirth primed. Treated plots also recorded higher organic carbon that was between 0.60 to 0.30 per cent in soils amended with vermicompost and available nitrogen, phosphorus and potassium are considered to be higher by 20 per cent to 30 per cent than soils in control. Conversely, other plots were in control and the levels were stagnated or improved. The positive effect of these soil health changes was the probable cause of the improved grain and straw yields that were recorded and it is important to point out that long-term results of organic nutrient management on soil health have shown that it is advantageous.

The experiment was designed using a factorial randomized block design (FRBD) with two factors: Nutrient management and organic seed priming. Each factor was tested at three levels, resulting in a total of 12 treatment combinations, replicated three times, giving a total of 36 experimental units. The two factors and their respective levels are:

FACTOR 1: Nutrient management.
N0: Control.
N1: Vermicompost @ (2 tonnes/ha).
N2: Neem cake @ (1 tonnes/ha).
N3: Alfalfa meal @ (2 tonnes/ha).
FACTOR 2: Organic seed priming.
P0: No priming.
P1: Panchagavya @3% .
P2: Jeevamrit @3%.

Treatment combination:

T1 (N0 P0) Control + No priming
T2 (N0 P1) Control + Panchagavya
T3 (N0 P2) Control + Jeevamrit
T4 (N1 P0) Vermicompost + No priming
T5 (N1 P1) Vermicompost + Panchagavya
T6 (N1 P2) Vermicompost + Jeevamrit
T7 (N2 P0) Neem Cake + No Priming
T8 (N2 P1) Neem Cake + Panchagavya
T9 (N2 P2) Neem Cake + Jeevamrit
T10 (N3P0) Alfalfa Meal + No priming
T11 (N3 P1) Alfalfa Meal+ Panchagavya
T12 (N3 P2) Alfalfa Meal+ Jeevamrit

RESULTS AND DISCUSSION

Role of seed priming and organic nutrients

A physiological pre-sowing technique called “seed priming” aims to start the metabolic processes required for germination without actually causing radicles to emerge. Improved germination rates, uniform emergence and increased seedling vigor are the outcomes of this regulated hydration, which also accelerates cell division and initiates enzymatic activity (Harris *et al.,* 1999). According to Anitha and Subramanian (2014), organic priming agents like cow urine, beejamruth, vermiwash and FYM extracts are known to provide growth-promoting hormones (such as auxins and gibberellins), micronutrients and beneficial microbes. These factors further promote early growth and stress tolerance mechanisms.

Under a variety of environmental circumstances, organic seed priming has been shown in numerous studies to improve crop establishment. The enhanced field emergence and plant stand seen in our study’s treatments employing beejamruth and vermiwash priming are consistent

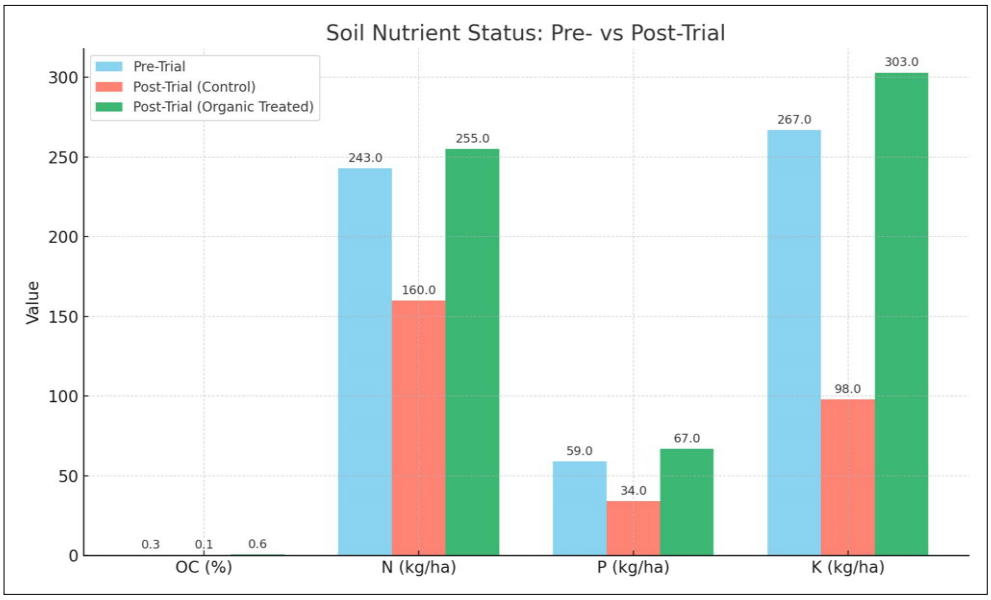


Fig 1: Soil nutrient status of experimental plot.

with these results and helped to raise values in yield-contributing parameters like test weight, panicle formation and tiller number.

Enhancing soil fertility, microbial activity and nutrient availability through organic nutrient management is essential for sustaining crop productivity. Organic inputs like farmyard manure (FYM), compost and biofertilizers release nutrients gradually and enhance the physical, chemical and biological health of soil, in contrast to chemical fertilizers that frequently cause soil degradation with prolonged use (Ramesh *et al.,* 2005; Ghosh *et al.,* 2010).

Barnyard millet responds favorably to organic sources of phosphorus and nitrogen, improving harvest index, grain yield and panicle length. Additionally, organic matter's ability to buffer nutrients lowers nutrient losses and improves crop uptake during crucial growth stages. When growing millet in low-input or rainfed systems, where early establishment and soil health are critical, the combined impact of organic seed priming and nutrient management is especially significant. Grain production, photosynthetic efficiency and biomass accumulation can all be greatly impacted by the combined effects of improved root architecture from priming and increased nutrient supply from organic inputs (Somasundaram *et al.,* 2007).

Percentage of field emergence

Nutrient management, as well as the organic seed priming treatment played an important role in modifying the percentage of emergency on field. The maximum field emergence of 91.0 was observed in T5 (Vermicompost + Panchagavya), T8 (Neem Cake + Panchagavya) at 89.0 and T11 (Alfalfa Meal + Panchagavya) at 88.5 among all combinations of treatments. In the control (T1), the lowest field emergence (62.0%) was found. Priming seeds with Panchagavya performed better than Jeevamrit and non-primed seeds in all the levels of nutrients.

This might be due to the improvement in emergence in Panchagavya and Jeevamrit due to increased microbial

Table 1: Grain yield and straw yield affected by different treatment combination.

	Grain yield (q/ha)			Straw yield (q/ha)		
Treatment	I Year	II Year	Pooled	I Year	II Year	Pooled
Nutrient management (N)						
N0	6.52	6.43	6.47	29.81	27.68	28.74
N1	14.33	14.25	14.29	41.59	42.91	42.25
N2	13.02	13.01	13.01	41.23	41.37	41.30
N3	13.25	13.08	13.16	41.13	41.16	41.15
Mean	11.78	11.69	11.73	38.44	38.28	38.36
CD@5%	0.45	0.42	0.37	1.03	0.60	0.61
SEm±	0.15	0.14	0.12	0.35	0.20	0.20
Organic seed priming (P)						
P0	10.55	10.43	10.49	34.22	33.15	33.69
P1	12.85	12.76	12.80	41.55	41.57	41.56
P2	11.94	11.89	11.91	39.55	40.12	39.83
Mean	11.78	11.69	11.73	38.44	38.28	38.36
CD@5%	0.39	0.36	0.32	0.89	0.52	0.52
SEm±	0.13	0.12	0.11	0.30	0.17	0.17
Interaction of nutrient management × organic seed priming (NÕP)						
T1 (N0 P0)	5.04	4.90	4.97	26.27	22.45	24.36
T2 (N0 P1)	7.246	7.22	7.23	32.68	30.52	31.60
T3 (N0 P2)	7.27	7.16	7.21	30.48	30.07	30.27
T4 (N1 P0)	12.83	12.73	12.78	39.09	40.24	39.67
T5 (N1 P1)	17.1	17.02	17.06	46.31	47.14	46.73
T6 (N1 P2)	13.08	13.00	13.04	39.38	41.36	40.37
T7 (N2 P0)	12.34	12.38	12.36	36.63	36.17	36.40
T8 (N2 P1)	13.61	13.56	13.58	44.03	44.91	44.47
T9 (N2 P2)	13.11	13.08	13.10	43.03	43.03	43.03
T10 (N3P0)	12	11.71	11.85	34.92	33.73	34.32
T11 (N3 P1)	13.45	13.22	13.33	43.18	43.72	43.45
T12 (N3 P2)	14.32	14.31	14.31	45.31	46.04	45.68
Mean	11.78	11.69	11.73	38.44	38.28	38.36
CD@5%	0.78	0.73	0.65	1.79	1.05	1.05
SEm±	0.26	0.24	0.22	0.60	0.35	0.35

activity and enzyme stimulation as well as improved seed-soil contact leading to more and faster seedling growth.

Biological yield (q/ha)

With respect to nutrient management, the maximum biological yield was recorded for the treatment N1 (56.55) and the minimum biological yield was recorded for the treatment N0 (35.22). With respect to organic seed priming treatment, maximum biological yield was recorded for the treatment P1 (54.37), while, the minimum biological yield was recorded for the treatment P0 (44.18). With respect to nutrient management and seed priming treatments, maximum biological yield was recorded for the treatment T5-N1P1 (63.79) and the minimum biological yield was recorded for the treatment T1-N0P0 (29.33). Bharathi *et al*. (2016) had recorded the same result. The statistically analysed data and the graphical representation of grain yield (q/ha) are given in Table 1.

Straw yield (q/ha)

With respect to nutrient management, maximum straw yield was recorded for the treatment N1 (42.25) and the minimum straw yield was recorded for the treatment N0 (28.74). With respect to organic seed priming treatment, maximum straw was recorded for the treatment P1(41.56) while, the minimum straw yield was recorded for the treatment P0 (33.69). With respect to nutrient management and seed priming treatments, maximum straw yield was recorded for the treatment T5-N1P1 (46.73) and the minimum straw yield was recorded for the treatment T1-N0P0 (24.36). The statistically analysed data and the graphical representation of straw yield (q/ha) are given in Table 1.

Grain yield (q/ha)

With respect to nutrient management, maximum grain yield was recorded for the treatment N1 (14.29) and the minimum grain yield was recorded for the treatment N0

Table 2: Biological yield and harvest index affected by different treatment combination.

	Biological yield (q/ha)			Harvest index (%)		
Treatment	I Year	II Year	Pooled	I Year	II Year	Pooled
Nutrient management (N)						
N0	36.33	34.11	35.22	0.17	0.17	0.183
N1	55.93	57.17	56.55	0.25	0.25	0.252
N2	54.25	54.38	54.31	0.23	0.23	0.240
N3	54.39	54.24	54.32	0.24	0.24	0.243
Mean	50.22	49.97	50.1	0.22	0.22	0.22
CD@5%	0.96	0.67	0.61	0.01	0.01	0.007
SEm±	0.32	0.22	0.20	0.003	0.003	0.002
Organic seed priming (P)						
P0	44.78	43.58	44.18	0.22	0.22	0.231
P1	54.40	54.33	54.37	0.22	0.22	0.231
P2	51.49	52.01	51.75	0.22	0.22	0.227
Mean	50.22	49.97	50.1	0.22	0.22	0.22
CD@5%	0.83	0.58	0.53	NS	NS	NS
SEm±	0.28	0.19	0.18	0.003	0.003	0.002
Interaction of nutrient management × organic seed priming (N×P)						
T1 (N0 P0)	31.31	27.35	29.33	0.15	0.17	0.16
T2 (N0 P1)	39.93	37.75	38.84	0.18	0.18	0.18
T3 (N0 P2)	37.75	37.23	37.49	0.18	0.18	0.19
T4 (N1 P0)	51.92	52.98	52.45	0.24	0.23	0.24
T5 (N1 P1)	63.41	64.17	63.79	0.26	0.25	0.26
T6 (N1 P2)	52.46	54.37	53.41	0.24	0.23	0.24
T7 (N2 P0)	48.97	48.55	48.76	0.25	0.25	0.25
T8 (N2 P1)	57.64	58.48	58.06	0.23	0.22	0.23
T9 (N2 P2)	56.14	56.11	56.13	0.23	0.23	0.23
T10 (N3P0)	46.92	45.44	46.18	0.25	0.25	0.25
T11 (N3 P1)	56.63	56.94	56.78	0.23	0.22	0.23
T12 (N3 P2)	59.63	60.35	59.99	0.23	0.23	0.23
Mean	50.22	49.97	50.10	0.22	0.22	0.22
CD@5%	1.67	1.16	1.07	0.01	0.01	0.01
SEm±	0.56	0.39	0.36	0.006	0.006	0.004

(6.47). With respect to organic seed priming treatment, maximum grain yield was recorded for the treatment P1 (12.80) while, the minimum grain yield was recorded for the treatment P0 (10.49). With respect to nutrient management and seed priming treatments, maximum seed yield was recorded for the treatment T5-N1P1 (17.06) and the minimum grain yield was recorded for the treatment T1-N0P0 (4.97). These results were very similar to Adeyeye and Akinfolarin, (2014). The statistically analysed data and the graphical representation of grain yield (q/ha) are given in Table 2.

Harvest index (%)

With respect to nutrient management, maximum harvest index was recorded for the treatment N1 (0.252) and the minimum harvest index was recorded for the treatment N0 (0.183). With respect to organic seed priming treatment, maximum harvest index was recorded for the treatment P1 (0.231). With respect to nutrient management and seed priming treatments, maximum harvest index was recorded for the treatment T5-N1P1 (0.26), while minimum harvest index was recorded for the treatment T1-N0P0 (0.16). The statistically analysed data and the graphical representation of grain yield (q/ha) are given in Table 1.

The findings show that applying organic amendements increases the productivity of barnyard millet. Among all the treatments applied in the present investigation, T5 Vermicompost and Panchagavya combination was found to be superior in its impact for improving various yield attributes. Even the better treatments like T12 (Alfalfa Meal + Jeevamrit) indicate that all the organic sources of nutrient were best along with seed priming. The yield achievements of the control group were significantly lower than those in the rest of the groups, which proves that only the adoption of nutrient management practices and seed priming can increase yield and improve the results.

CONCLUSION

Results showed that, when Vermicompost, Panchagavya, Alfalfa Meal and Jeevamrit used together increased the yields and main yield characteristics in barnyard millet. The study found that T5 (Vermicompost + Panchagavya) improved grain yield, biological yield, straw yield and harvest index and that T12 (Alfalfa Meal + Jeevamrit) came in close second. As a result of the study, we can say that using Vermicompost, Panchagavya, Alfalfa Meal and Jeevamrit as organic additives may increase barnyard millet yield. They make the soil healthier, increase the number of useful microbes and permit agriculture to be more sustainable because they replace the use of synthetic fertilizers. Thanks to nutrient-rich composts and active biological agents, seeds germinate well, roots develop and essential nutrients move up from the soil. These enhancements show up as stronger plants, better adaptation to different conditions and greater yield. It becomes especially necessary in the region's highlands, where the challenges of resources and soil health prevent traditional farming. As a result of this research, it is suggested that integrated organic nutrient management be adopted for barnyard millet farming in areas that are rainfed and less fertile. More long-term studies are needed to check the soil health, benefits in terms of cost and function of these treatments for smallholder farmers.

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Disclaimers

The research article's findings, interpretations and conclusions represent only the author's own views and do not represent the affiliated organization. Every attempt was made to ensure the accuracy and reliability of the information used in this study, but the author does not take responsibility for any problems or losses caused by its use. Because the research took place under special climate and farming conditions, it may not work for all regions without adjustments and reinforcement. Those who use the findings should study their location and work with experts before trying any solutions.

Conflict of interest

All authors declare that they have no conflict of interest.

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