Natural farming practices impact on yield and macro nutrient uptake of sorghum

Abstract

The objective of the experiment is to study the effect of different natural farming practices on sorghum yield and nutrient uptake. For this a field experiment was carried out in 2023 at the Eastern block - Field No. NA 02, Tamil Nadu Agricultural University (TNAU), Coimbatore. The experiment included a randomized block design with nine treatments and three replications. Zero Budget Natural Farming techniques were fully implemented, encompassing the use of Ghanajeevamirit as a basal application, treating seeds with Beejamirit, applying Jeevamirit every two weeks via irrigation, practicing intercropping and mulching, and employing Whapasa (Alternate Furrow irrigation). Additionally, both organic and integrated plots were integrated into the approach. Results revealed that application of 50% organic and 50% inorganic treatments with organic pest repellants as ICM (T_8) produced noticeably highest grain yield (2781 kg ha^{-1}), stover yield (5682 kg ha^{-1}) and NPK uptake (135.39, 45.09 and 80.49 kg ha^{-1}), which was comparable to T_9 ICM using chemical pest repellants. In comparison to natural farming plots, the organic farming plot (T_7) showed considerably higher grain yields (2555 kg ha^{-1}), stover yields (5456 kg ha^{-1}) and NPK uptake (122.49, 39.40, and 66.91 kg ha^{-1}). There were considerably greater grain yield (2294 kg ha^{-1}), stover yield (5173 kg ha^{-1}) and NPK uptake (108.32, 34.17, and 56.17 kg ha^{-1}) in complete Natural Farming plot T_2, which include all components (B+J+G+M+I+W) compared to control treatment which had considerably lower grain yield (1597 kg ha^{-1}), stover yield (4306 kg ha^{-1}) and NPK uptake rates (58.28, 15.49 and 27.75 kg ha^{-1}).

Keywords: Grain and Stover yield, Integrated Crop Management, Natural Farming, Nutrient uptake, Organic Farming, Sorghum.

Introduction

Fertilizers and pesticides are the major essential inputs in agriculture. Heavy metals accumulated in the soil, surface water and ground water as a result of the intensive use of inorganic chemical fertilizers and pesticides in the post green revolution period. The majority of farmers in India have small or marginal plots of land, and their main issue is that if they spend more money on inputs and don't get a satisfactory yield due to poor pest and disease management or unfavorable weather conditions, their production costs will rise. Working with nature to produce nutritious food, keep ourselves well and maintain the health of the land is the philosophy of natural farming (Devarinti *et al.*, 2016). The key to natural farming is reducing the external inputs that harm the natural soil composition on the farm. With the similar principle but using local supplements, Subash Palekar in India has developed Zero-Budget Natural Farming (ZBNF). The strategy is based on the "four wheels" of ZBNF: (1) soil microbial activity is stimulated to make nutrients available to plants and protect against pathogens using a microbial inoculum, "jiwamrita"; (2) young roots are protected from fungi and soil-borne diseases using a microbial culture, "beejamrita"; (3) soil organic matter is produced and topsoil is conserved by mulching ("acchadana"); and (4) soil aeration ("whapahasa") by improving soil structure and reducing tillage (Jo Smith *et al.,* 2020). In addition, Zero Budget Natural Farming makes a significant theoretical and practical contribution to issues relating to food and agriculture in the modern world (Ankush Kumar *et al.,* 2020).

In India, sorghum is popularly known as "Jowar" and is also known as "Great millet". It is consumed worldwide as food, animal feed and a staple diet by the underprivileged in many nations. After wheat, rice, maize and barley, sorghum is the fifth-most important annual cereal crop in the world. Additionally, sorghum is utilized in the manufacturing of ethanol, grain alcohol, starch, glue, and paper (Doifode *et al.,* 2021). It has the capacity to adapt to challenging climatic conditions. It is a staple food for low-income people in Africa and is grown in many tropical and subtropical regions of the world (Hariprasanna *et al.*, 2016). Although it has low protein content and contains hydrocyanic acid, it is nonetheless enjoyed by animals due to its succulence and palatability despite its inferior quality. Natural farming can contribute to sustainable sorghum production by focusing on soil health, nutrient cycling, and ecosystem balance. While it may not always yield as much as conventional methods in the short term, it offers potential long-term benefits for both crop yield and environmental sustainability. Farmers should carefully consider local conditions and adapt natural farming practices accordingly to optimize sorghum production.

Materials and methods

Soil samples were analyzed in 2023 at the Eastern block - Field No. NA 02, Tamil Nadu Agricultural University (TNAU), Coimbatore, to examine "Natural farming practices impact on yield and macro nutrient uptake of sorghum". The experimental research field was situated at 11°0'27" N Latitude, 76°56'29" E Longitude and at an altitude of 427 meter above the Mean Sea Level (M.S.L). The soil was

Sandy clay texture, with soil pH of 8.33 and EC of 0.51 dSm^{-1}, organic carbon status of 5.14 g kg^{-1}, available N content of 376 kg ha^{-1}, Olsen P content of 19 kg ha^{-1} and K content of 859 kg ha^{-1} are the initial soil properties. Standard techniques are used to estimate the chemical characteristics of the soil. pH and EC, using 1:2.5 soil water extraction (Jackson, 1973), organic carbon using chromic acid wet digestion (Walkley and Black, 1934), available nitrogen using the alkaline permanganate method (Subbiah and Asijia, 1956), available phosphorus using the 0.5M $NaHCO_3$ extraction method and available potassium using the neutral normal ammonium acetate extraction method, along with flame photometry. With nine treatments and three replications, the experiment was set up using a Randomized Block Design (RBD). Seeds for sorghum (CO 32) were seeded on February 15, 2023 and the crop was harvested on June 5, 2023.

Treatment details:

T_1: Control (no addition of any inputs except labor for operations including weeding).

T_2: Complete Natural Farming (NF): Beejamrit (B) + Ghanjeevamrit (G) @250 kg ha^{-1} + Jeevamrit (J) @500 lit ha^{-1} + Mulching (M) @5 t ha^{-1} + Intercropping (I) + Whapasa (W).

T_3: Natural Farming (NF): Mulching (M) @5 t ha^{-1} + Intercropping (I) + Whapasa (W).

T_4: Natural Farming (NF): Beejamrit (B) + Ghanjeevamrit (G) @250 kg ha^{-1} + Jeevamrit (J) @500lit/ha + Intercropping (I) + Whapasa (W).

T_5: Natural Farming (NF): Beejamrit (B) + Ghanjeevamrit (G) @250 kg ha^{-1} + Jeevamrit (J) @500 lit ha^{-1} + Mulching (M) @5 t ha^{-1} + Whapasa (W).

T_6: Natural Farming (NF): Beejamrit (B) + Ghanjeevamrit (G) @250 kg ha^{-1}+ Jeevamrit (J) @500 lit ha^{-1} + Mulching (M) @5 t ha^{-1} + Intercropping (I).

T_7: All India NPOF - National Project on Organic Farming package (5 t ha^{-1} FYM + 5 tha^{-1} Vermicompost + panchagavya 3% spray, Fish meal traps @ 12 Nos ha^{-1}, Yellow sticky trap @12 Nos ha^{-1}, Neem cake 250 kg ha^{-1}, Neem oil @ 5%, Agniasthra @ 5%).

T_8: Integrated Crop Management (ICM): (50 % organic + 50 % inorganic, Pest and disease management with organic repellants).

T_9: Integrated Crop Management (ICM): (50 % organic + 50 % inorganic, Pest and disease management with chemicals repellants).

50% organic includes Vermicompost (2.5 t ha^{-1}), Azophos (4 kg ha^{-1}) and Poultry manure (5 t ha^{-1}) were applied as basal. 50% inorganic includes urea (195 kg ha^{-1}), SSP (75 kg ha^{-1}) and MOP (75 kg ha^{-1}) were applied as basal.

In natural farming (NF) methods, seeds were treated with beejamrit and Ghanjeevamrit was applied to the soil at a rate of 250 kg ha^{-1} a day before planting and cotton stalks were mulched at a rate of 5 t ha^{-1} after sowing. Seed treatment with *Trichoderma viride* (5 g kg^{-1}) and *Bacillus subtilis* (5 g kg^{-1}) was carried out in AI-NPOF package and ICM techniques. In order to prevent the plant from stem borer infestation in rabi sorghum, Dimethoate (30 EC 12 ml ha^{-1}) was sprayed for T_9. Neem oil at 5% and Agniasthra at 5% were also sprayed for T_7 and T_8. In T_1, T_7, T_8 and T_9 two handweeding operations are performed. In treatments T_7, a 3% foliar application of Panchagavya was applied. The percentage of nutrient content in grain and stover was multiplied by the grain and stover yield (kg ha^{-1}), and the result was divided by 100 to determine the nutrient uptake by grain and stover at harvest. The total amount of nutrients absorbed by the crop was determined by summing the uptake of both grain and stover. The statistical analysis was carried out utilizing R software, specifically using the "grapesAgri1" package, version 1.0.0, as described in Gopinath *et al*.'s 2021 study.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in grain/stover (\%) x Grain/stover yield (kg ha}^{-1}\text{)}}{100}$$

Results and discussion

Grain yield and Stover yield

In comparison to other farming techniques, T_8 - ICM (50% organic + 50% inorganic, Pest and disease management with organic repellants) had significantly higher sorghum grain yield

(2781 kg ha^{-1}) and stover yield (5682 kg ha^{-1}), and was comparable to T_9 - ICM (50% organic + 50% inorganic, Pest and disease management with chemicals repellants) in terms of grain yield (2778 kg ha^{-1}) and stover yield (5680 kg ha^{-1}). The result was similar to the finding of (Shuaibu, Bala *et al.*, 2018) that when sorghum was treated with a combination of inorganic fertilizer and chicken manure, the maximum grain yield was also noted. While the grain and stover yields for the T_7 - AI NPOF Package were 2555 kg ha^{-1} and 5456 kg ha^{-1}, respectively. However, sorghum grain yield and stover yield from organic farming were significantly higher than those from T_2: Complete NF: B + G + J + M + I + W, grain yield (2294 kg ha^{-1}) and stover yield (5173 kg ha^{-1}). This outcome was comparable to the finding that rabi sorghum had a grain yield that was considerably greater using an organic production approach than it did with Subhash Palekar Natural Farming (Kudari and Babalad, 2021). The treatment consisting of all components, Complete NF: B+G+J+M+I+W, produced significantly greater sorghum grain yield (2294 kg ha^{-1}) and stover yield (5173 Kg ha^{-1}) than any other natural farming methods. The remaining natural farming methods produced grain and stover yields that are comparable, which is tallied with the finding of Pujeri, Gaddanakeri *et al.*, (2022). The control had the lowest grain yield (1597 kg ha^{-1}) and stover yield (4306 kg ha^{-1}).

Nutrient uptake

The treatment T_8 - ICM (50% organic + 50% inorganic, Pest and disease management with organic repellants) recorded significantly higher sorghum NPK uptake (135.39, 45.09, 80.49 kg ha^{-1}), which was comparable to T_9 - ICM (50% organic + 50% inorganic, Pest and disease management with chemicals repellants) NPK uptake (133.90, 44.22, 79.60 kg ha^{-1}), among the various farming techniques. Organo-mineral fertilizer combinations produced the best results on every plot. The results are consistent with those published by Buba *et al.*, (2021). As opposed to T_2: Complete NF: B + G + J + M + I + W, NPK uptake, T_7: AI NPOF Package recorded NPK uptake of (122.49, 39.40, 66.9 kg ha^{-1}), respectively, which was considerably greater. The finding is in line with one reported by Amit kumar *et al.*, (2022), that application of vermicompost 5t/ha accumulated significantly higher nitrogen, phosphorus and potassium compared to no manure plot in sorghum crop. The treatment using all of the natural farming methods, T_2: Complete NF: B+G+J+M+I+W, had a significantly greater NPK absorption (108.32, 34.17, 56.17 kg ha^{-1}). The remaining natural farming methods (T_3, T_4, T_5, T_6) are found to be equivalent to NPK absorption. The control farming method had the lowest NPK uptake of any farming method (58.28, 15.49, 27.75 kg ha^{-1}). The most pertinent explanation for a higher intake of nutrients could be attributed to the larger biomass production (Komal Gupta and SS Bhadauria, 2022).

Table 1: Grain and stover yield (kg ha^{-1}) of sorghum

Treatments	**Grain yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**
T1: Control	1597	4306
T2: Complete NF: B + G + J + M + I + W	2294	5173
T3: NF: M + I + W	1954	4834
T4: NF: B + G + J + I + W	2029	4906
T5: NF: B + G + J + M + W	2035	4911
T6: NF: B + G + J + M + I	2040	4917
T7: AI NPOF Package	2555	5456
T8: ICM (plant protection by organic repellants)	2781	5682
T9: ICM (plant protection by chemical repellants)	2778	5680
SEd	44.45	126.81
CD (P=0.05)	94.24	268.83

Table 2: Nitrogen uptake (kg ha^{-1}) of sorghum Grain and Stover

Treatments	**Grain**	**Stover**	**Total N uptake**
T1: Control	19.96	38.32	58.28
T2: Complete NF: B + G + J + M + I + W	34.86	73.45	108.32
T3: NF: M + I + W	27.55	60.90	88.45
T4: NF: B + G + J + I + W	30.23	67.21	97.44
T5: NF: B + G + J + M + W	30.52	68.26	98.78
T6: NF: B + G + J + M + I	30.80	69.32	100.13
T7: AI NPOF Package	40.11	82.38	122.49
T8: ICM (plant protection by organic repellants)	45.05	90.34	135.39
T9: ICM (plant protection by chemical repellants)	44.72	89.17	133.90

SEd	0.79	1.09	2.34
CD (P=0.05)	1.67	2.31	4.96

Table 3: Phosphorus uptake (kg ha^{-1}) of sorghum Grain and Stover

Treatments	Grain	Stover	Total P uptake
T1: Control	5.58	9.90	15.49
T2: Complete NF: B + G + J + M + I + W	11.92	22.24	34.17
T3: NF: M + I + W	8.01	16.91	24.93
T4: NF: B + G + J + I + W	9.73	19.62	29.36
T5: NF: B + G + J + M + W	9.97	20.13	30.10
T6: NF: B + G + J + M + I	10.40	20.65	31.05
T7: AI NPOF Package	14.30	25.09	39.40
T8: ICM (plant protection by organic repellants)	16.68	28.41	45.09
T9: ICM (plant protection by chemical repellants)	16.39	27.83	44.22
SEd	0.29	0.44	0.63
CD (P=0.05)	0.61	0.94	1.33

Table 4: Potassium uptake (kg ha^{-1}) of Sorghum Grain and Stover

Treatments	Grain	Stover	Total K uptake
T1: Control	6.22	21.53	27.75
T2: Complete NF: B + G + J + M + I + W	15.82	40.34	56.17
T3: NF: M + I + W	10.35	29.97	40.32
T4: NF: B + G + J + I + W	13.39	36.79	50.18
T5: NF: B + G + J + M + W	13.63	37.32	50.95
T6: NF: B + G + J + M + I	13.87	37.86	51.73
T7: AI NPOF Package	18.90	48.01	66.91
T8: ICM (plant protection by organic repellants)	21.96	58.52	80.49
T9: ICM (plant protection by chemical repellants)	21.66	57.93	79.60

SEd	0.28	0.93	1.50
CD (P=0.05)	0.59	1.98	3.18

Conclusion

The study found that compared to other farming techniques, T_8 ICM (plant protection by organic repellants) and T_9 ICM (plant protection by chemical repellants) produced significantly greater grain yields, stover yields and NPK uptake. While T_7 (AI NPOF Package) considerably underperformed ICM practices, it significantly outperformed T_2 (complete NF: B + G + J + M + I + W) in terms of grain yield, stover yield and nutrient uptake. When compared to other natural farming techniques (T_3, T_4, T_5, T_6), T_2: Complete NF: B + G + J + M + I + W produced considerably higher grain yield, stover yield and nutrient uptake. Implementing all of the components, such as Beejamrit, Ghanjeevamrit, Jeevamrit, Mulching, Intercrop and Whapasa, boosts the population of microorganisms that aid in nutrient solubilization in the root zone and enhances nutrient uptake, which ultimately leads to increased grain and stover yield in the complete Natural Farming (T_2).

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