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Yield and quality of little millet (*Panicum sumatrense*) as influenced by organic manures and inorganic fertilizers

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Abstract
Low soil fertility is one of the bottlenecks to sustain production and productivity. Anthropogenic factors such as inappropriate land use systems, monocropping, nutrient mining and inadequate supply of nutrients have aggravated the situation. Consumers also have become more aware of safe food produced with low environmental impact in which organic agriculture is of particular interest in this respect. The possible differences between organic and Inorganic (conventional) plant products are examined from the view of possible effects on human health. However, there can be considerable risk that the avoidance of chemical inputs in organic farming will result in poor food production. Organic farming is a system aimed at producing food with minimal harm to ecosystems, animals or humans which is often proposed as a solution. Keeping in view of sustained crop yields as well as soil health a long-term experiment is being conducted at Agricultural Research Station, Vizianagaram, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, from *Kharif*, 2015-16 to study the effect of organic manures in comparison with inorganic fertilizers on soil available nutrients, yield and quality of little millet crop. The organic inputs were supplied in the form of *in-situ* incorporation of green manures (Sunhemp), application of farmyard manure, neem cake and biofertilizers (Azospirillum and Phosphorus Solubilising Bacteria), whereas the inorganic fertilizers were applied as Recommended Dose of fertilizers (20-20-20 kg NPK/ha). The results revealed that significantly highest plant height (143.7cm), grain yield (858 kg/ha), straw yield (6801 kg/ha) were recorded when compared to the organic plot (140.5 cm, 730kg/ha and 6039 kg/ha respectively). But the soil available nitrogen, potassium, zinc and manganese were found significantly high in the organic plot (235 kg/ha, 326 kg/ha, 1.16 ppm and 8.57 ppm respectively) when compared to inorganic plot (224 kg/ha, 309 kg/ha, 0.99ppm and 6.98ppm respectively). Moreover, when we compare the grain quality the N content, Zn and Fe contents along with the antioxidants, phenols and tannins were also found significantly high in the organic plot.

Keywords: Little millet, organic, conventional, yield, soil fertility and nutrient uptake

Introduction
Millets are a group of highly variable small seeded grasses, widely grown around the world as cereal grains. Millets are tiny in size and round in shape and can be white, grey, yellow to red hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. Minor millets are claimed to be the future foods for better health and nutritional security. Small millets are highly nutritious superior to rice and wheat in terms of proteins, minerals and vitamins, non glutinous and non acid forming foods. Small millets comprising finger millet, foxtail millet, barnyard millet, little millet, proso millet and kodo millet are considered to be soothing, least allergic and most digestive grains available. Among all the small millets, little millet commonly called as sama is one of the reliable catch crop in view of its earliness and resistance to adverse agroclimatic conditions of high drought as well as water logging. In order to increase the crop productivity, nutrient management may be achieved by the integration of organic sources, biofertilizers and micronutrients.

The food habits of the world consumers are changing rapidly, especially in the developed countries where people have become more health conscious. Consumers have become more aware of safe food produced with low environmental impact in which organic agriculture is of particular interest in this respect. The possible differences between organic and inorganic plant products are examined from the view of possible effects on human health. Hence the demand for organic food products is on the rise. The organic agriculture produce has good market in developed countries like USA, Germany, France, Italy, Britain and Japan. Moreover, the farmers in the developing countries like India are realizing the potential for organic produce and subsequent prices. However, there can be considerable risk that the avoidance of chemical inputs in organic farming will result in poor food production.

But, agriculture must meet the twin challenge of feeding a growing population, with rising demand of high calorie diets, while simultaneously minimizing its global environmental impacts.

Millets are better adapted to dry infertile soils than most other crops and are therefore often cultivated under extremely harsh conditions. Introduction of high yielding varieties and intensive rice farming had led to increased use of chemical fertilizers and pesticides. Continuous, increased and discriminate use of sole chemical fertilizers lead to several harmful effects on the soil environment, ground and surface water and even atmospheric pollution, reducing the productivity of soil by affecting soil health in terms of physical, chemical and biological properties. Further several long term experiments indicated a declining trend in grain yield under intensified rice cropping with constant and high fertilizer inputs.

Continuous monoculture of a particular crop over a period of time has clearly indicated a long term degradation of soil resource base. Growing of high yielding varieties with indiscriminate use of fertilizers, poor water management practices and inefficient plant-protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce (Pradhan and Mondal, 1997) [10]. Hence enhancement and maintenance of system productivity and resource quality is essential for sustainable agriculture. Maintaining and improving the soil quality is thus crucial if agricultural productivity and environmental quality are to be sustained for generations (Reeves, 1997) [11]. Thus, organic matter inputs through organic amendments in addition to supplying nutrients, stimulate microbial diversity and activity and improved soil aggregation, which had positive effects on soil water content, temperature, aeration and mechanical impedance (Ferreras *et al*., 2006) [4].

In recent years the use of chemical fertilizers has increased many folds to derive higher yield but its hazardous effect on soil and human health cannot be ruled out. There is a demanding need to find out alternative sources of nutrients in terms of its economy, non- hazardous and ecofriendly nature. Therefore there is a need to go for the use of organic sources of nutrients which are cheaper and ecofriendly. Phosphate solubilizing bacteria have the ability to solubilize phosphate compound, present in the organic manures and soils. Azospirillum inoculation saves the addition of nitrogenous fertilizers by 10-20%. The present investigation was undertaken to study the effect of organic sources of nutrients on growth characters, yield and quality of little millet along with the soil health.

Material and Methods

The long term field experiment was being conducted for the past 5 years since *kharif*, 2015 at Agricultural Research Station, Vizianagaram, ANGRAU, to study the effect of organic method of farming using organic inputs in comparison with conventional method of farming using inorganic fertilizers on growth parameters, yield, soil fertility status grain quality and nutrient uptake at harvest in little millet. The soil was sandy loam in texture, neutral in reaction with low soluble salts, low in organic carbon (0.43%) and available nitrogen (240 kg/ha) and medium in available phosphorus (59 kg/ha) and potassium (315 kg/ha). The experiment was laid out with two treatments i.e. organic treated plot and inorganic treated plot (conventional plot). The Recommended Dose of Fertilizer (20:20:20 kg NPK ha^{-1}) was applied to the inorganic treated plot. Recommended dose of nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and murate of potash as basal dose. While, *in-situ* incorporation of green manure (sunhemp), application of FYM @ 5t ha^{-1} along with neem cake @ 0.5 t ha^{-1} as top dressing were applied to organic treated plot. Moreover, green manure (sunhemp) was grown *in-situ*, incorporated and biofertilizers in the form of *Azospirillum* and Phosphorus Solubilizing Bacteria @ 5 kg ha^{-1} were applied in organic plot. The biomass of the green manure crop incorporated was quantified and the total nutrients supplied to the organic plot in the form of FYM and neem cake was also analysed through standard procedures (Table 1). The crop was harvested at maturity stage and growth characters *viz*., plant height, no. of productive tillers/plant, inflorescence length and yield attributes *viz*., grain yield, straw yield were recorded. The initial soil samples were collected before sowing of the crop at 0-15 cm depth in 2015 and the final soil samples were collected after harvest of the crop during all the five years. The soil samples were analysed for pH, EC, organic carbon (Walkley and Black, 1934) [15], available Nitrogen (Subbiah and Asija, 1956) [14], available phosphorus (Olsen *et al*., 1954) [9] and available potassium (Merwin and Peech, 1950) [7]. The DTPA – extractable Zn, Cu, Mn and Fe in soil were estimated using Atomic Absorbtion Spectrophotometer as per the procedure of Lindsay and Norvel (1978) [6]. Plant samples were digested in diacid HNO_3: $HClO_4$ (9:4) mixture (Jackson, 1973) [5] for estimation of P, K and micronutrient contents, whereas the plant N content was analysed by digestion and distillation using Kelplus N autoanalyser.

Results and Discussions

While observing the pooled data, among the two treatments, significantly high grain and straw yields were recorded in inorganic plot (858 kg/ha and 6801 kg/ha) compared to the organic plot (730 kg/ha and 6039 kg/ha, respectively). Among both the treatments even after five years (Table 2) significantly higher grain yields were recorded in inorganic plot compared to the organic plot. Initially the difference in the grain yield between the two plots was 33% which after five years reduced to 17%. The increase in the yields can be owned to the fact that inorganic plot recorded higher growth and yield attributing characters when compared to the organic plot. Among the plant growth characters, plant height was found significantly high in the inorganic plot (143.7 cm) compared to the organic plot. The number of productive tillers, leaf length and leaf width are statistically on par with each other but the inflorescence length was found numerically high in the inorganic treatment (38.0 cm), but statistically it is nonsignificant. These results are in accordance with Pawer *et al*., (2013) and Mengel and Kirby, 1996 [8].

After completion of the fifth year of the experiment it is noted that pH and EC of soil were unchanged over their initial status in both the treatments (Table 3) which was in accordance with Rajiv *et al*., (2014). The Organic Carbon % has shown a increased trend in the organic plot (0.46%) by 0.3% compared to the initial value (0.43%) which was not statistically significant. These results are in accordance with Antara *et al*., 2017 [1]. The Organic Carbon % was increased with application of FYM and continuous *in situ* incorporation of green manures. The buildup of Organic Carbon could be attributed to the manures and subsequently addition of leaf residue and debris of plants (Bhandari *et al*., 2002) [2]. The soil available macronutrients N, P_2O_5 and K_2O showed an increasing trend over their parental status in both the organic and inorganic treatments. The pooled data of the soil available nitrogen and potassium was found significantly high in organic plot (235 kg/ha and 326 kg/ha, respectively) compared to the inorganic plot (224 kg/ha and 309 kg/ha, respectively), whereas the soil available phosphorus did not show any significant difference between the two treatments. The increase in soil available nutrients is due to the enhancement in the efficiency of nutrient use from all the sources through mineralization of soil organic matter, animal excreta, other manures and biofertilizers (Sedvi *et al*., 2005) [12]. The soil available Zn and Mn was found significantly high in the treatment of organic plot (1.16 ppm and 8.57 ppm) compared to the inorganic plot (0.99 ppm and 6.98 ppm) and no significant difference was found in soil available Fe and Cu among both the treatments.

After five years of the experiment the grain quality (Table 4) *viz*., nitrogen, phosphorus, potassium, zinc, iron, total anti-oxidant activity, total phenol content, total sugar, protein content and tannin content were analyzed in little millet grain. It was found that grain nitrogen, phosphorus, zinc, Iron, total sugar, protein content and tannin content were found highest in organic grain. Whereas potassium, total antioxidant activity and total phenol content was found highest in inorganic grain.

After 5 years when we study the N, P and K content and uptake of little millet plant (Table 5) it was observed that the N content and uptake was found significantly high in the organic treatment (1.25 % and 35.28 kg/ha, respectively) compared to the inorganic treatment (0.91 % and 24.66 kg/ha, respectively). Whereas, phosphorus and potassium content and uptake showed no significant difference between the treatments. Moreover, the content and uptake of iron was found significantly high in the organic treatment (42.24 ppm and 129.23 gm/ha). Compared to the inorganic treatment (35.72 ppm and 42.24 ppm respectively). The uptake This could be primarily due to increased availability of the nutrients in the crop root zone resulted in increased absorption of the elements by the plants as well as higher dry matter production. These results are similar to the findings of Singh *et al*., 2009 [13] and Datt *et al*., 2003 [3].

Table 1: Nutrient composition of different sources added to the organic and inorganic treatments

Organic source	Fresh biomass accumulation z(t ha^{-1})	Dry matter (t ha^{-1})	Nutrient concentration (%)			Nutrient accumulation (kg ha^{-1})		
			N	P	K	N	P_2O_5	K_2O
Sunhemp	13.4	1.50	1.8	0.34	1.5	27	5.1	22.5

Organic source	Quantity applied (t ha^{-1})	Nutrient concentration (%)			Nutrient accumulation (kg ha^{-1})		
		N	P	K	N	P_2O_5	K_2O
FYM	5	0.3	0.25	0.5	6	5	10
Neem cake	0.5	3	0.5	0.5	15	2.5	2.5
Total Nutrients supplied to organic plot (kg/ha)					48	29	39
Total Nutrients supplied to inorganic plot (kg/ha)					20	20	20

Table 2: Effect of organic and inorganic manures on growth, yield of little millet

S. No	Particulars	Organic plot						Inorganic plot						T Value	P Value
		2015-16	2016-17	2017-18	2018-19	2019-20	Mean	2015-16	2016-17	2017-18	2018-19	2019-20	Mean		
1	Plant height(cm)	143.3	132.7	139.3	155.2	131.7	140.5	142.8	152.9	132	150.2	140.7	143.7	4.09*	0.04*
2	No. of Productive tillers/ plant	6.73	6.47	11.3	7.3	12.7	8.9	6.20	8.9	9.67	8.0	9.8	8.5	1.05	0.40
3	Leaf length(cm)	28.6	29.6	28.7	38.2	29.8	31.0	29.1	31.8	28.8	40.9	27.5	31.6	0.43	0.71
4	Leaf width (cm)	1.00	0.87	1.40	0.85	0.78	0.93	1.00	1.62	1.27	0.90	0.73	1.10	0.89	0.47
5	Inflorescence length(cm)	30.9	32.2	36.1	37.2	38.8	35.0	32.1	40.8	35.7	40.3	40.7	38.0	0.06	0.12
6	Straw yield (q ha^{-1})	5855	5385	6973	5627	6352	6039	6956	7032	6947	6382	6688	6801	4.67	0.04
7	Grain yield (q ha^{-1})	501	659	813	698	978	730	670	858	835	778	1147	858	24.23**	0.001**

*Significant at P=0.05 level, ** Significant at P= 0.01 level

Table 3: Effect of organic and inorganic manures on soil health at harvest

S. No	Particulars	Initial Values	Organic plot						Conventional plot						T value	P value
			2015-16	2016-17	2017-18	2018-19	2019-20	Mean	2015-16	2016-17	2017-18	2018-19	2019-20	Mean		
1	pH	6.94	6.95	7.04	7.2	6.92	7.04	7.01	6.9	7.02	7.1	6.88	7.19	6.87	7.31	0.018
2	EC	0.24	0.38	0.35	0.15	0.23	0.27	0.23	0.39	0.39	0.13	0.22	0.3	0.24	3.92	0.059
3	Organic carbon (%)	0.43	0.44	0.44	0.45	0.46	0.46	0.46	0.42	0.42	0.43	0.43	0.43	0.43	1.78	0.216
4	Available N (kg ha^{-1})	240	201	222	235	242	237	235	189	205	226	234	224	224	5.56*	0.030*
5	Available P_2O_5 (kg ha^{-1})	59	61	67	60	64	65	65	57	61	64	62	61	62	1.05	0.403
6	Available K_2O (kg ha^{-1})	315	316	340	321	326	324	326	314	314	315	319	299	309	4.33*	0.049*
7	Available Fe (ppm)	9.6	7.32	8.77	5.43	6.43	6.14	10.80	9.32	10.13	9.85	11.8	8.29	9.34	2.02	0181
8	Available Mn (ppm)	6.03	1.06	1.18	1.22	0.91	1.16	8.57	7.48	6.70	4.35	2.35	5.71	6.98	19.30**	0.003**
9	Available Zn (ppm)	1.22	10.25	12.75	10.5	12.1	9.51	1.16	0.82	0.89	1.15	0.83	0.98	0.99	6.31*	0.024*
10	Available Cu (ppm)	2.35	3.05	3.36	2.55	2.1	2.24	2.48	2.39	2.65	2.42	1.93	2.07	2.19	0.77	0.523

*Significant at P=0.05 level, ** Significant at P= 0.01 level

Table 4: Comparison of quality parameters in little millet grain

Particulars	Organic treatment	Inorganic treatment
N (%)	0.96	0.70
P (%)	0.21	0.24
K (%)	0.58	0.65
Zn (ppm)	22.70	19.40
Fe (ppm)	32.40	27.40
Total anti-oxidant activity (mg AAE/100g)	88.40	63.10
Total Phenol Content (mg/100g)	52.80	45.60
Total sugar (%)	61.20	64.20
Protein content (%)	6.00	5.90
Tannin content (mg/100g)	393.30	376.70

Table 5: Effect of organic manures and inorganic fertilizers on Nutrient content and uptake of Little millet

Treat ments	Nitrogen		Phosphorus		Potassium		Zinc		Iron	
	Content (%)	Uptake (kg/ha)	Content (%)	Uptake (kg/ha)	Content (%)	Uptake (kg/ha)	Content (ppm)	Uptake (gm/ha)	Content (ppm)	Uptake (gm/ha)
Organic	1.25	35.28	0.27	8.41	0.75	30.44	29.53	105.79	42.24	129.23
Inorganic	0.91	24.66	0.31	10.07	0.84	37.01	25.30	91.65	35.72	113.07
T Value	17.00	4.43	0.933	0.818	1.92	1.33	2.95	3.847	4.76	7.57
P Value	0.003**	0.47*	0.449	0.498	0.194	0.313	0.097	0.061	0.049	0.016

* Significant at 0.05 ** Significant at 0.01

Conclusion

Long term application of organic manures *viz*., farmyard manure, neem cake and *in situ* green manuring are an excellent natural source containing nitrogen, phosphorus, potassium and micronutrients. This experiment certainly manifests the fact that organic soil management is necessary for restoring soil health, which is pre-requisite for sustenance of yield. But it will take time until the desired developments are obtained, considering that resource scarcity forms the major bottle neck towards its adoption in wider scale. The quantity of manure needed for a specific application depends upon its nutrient content and the rate at which nutrient becomes available for plant uptake. The use of manures may not increase the grain and straw yields in a very short period but will certainly help to enhance the organic matter content of the soil which improves the physical, chemical and biological properties of the soil along with the quality of the crop yield.

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