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Effect of organic manures and sources of sulphur on growth and yield of kharif pearl millet (*Pennisetum glaucum* L.)

Neeraganti Mohan and Shikha Singh

Abstract
A field experiment was conducted during *kharif season* of 2021, at crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj in North Eastern plains of Eastern Uttar Pradesh with the objective to study the effect of Organic manures and Sources of Sulphur on growth, yield and economics of Pearl millet (*Pennisetum glaucum* L.) Var. ABV - 04 under Randomized block design comprising of 9 treatments of which treatments (T1-T9) with different combination of Organic manure like FYM, Vermicompost and Poultry manure along with Sources of Sulphur like Ammonium sulphate, Pyrite and Gypsum which are replicated thrice. The result revealed that vermicompost 5t/ha + Pyrite 45Kg/ha recorded Maximum plant height (200.20cm), Highest plant dry weight (46.29gm), Earhead Length (23.00cm), number of Grains/earhead (1975.67), Grain yield (2723Kg/ha), Stover yield (3839.80 Kg/ha).

Keywords: Ammonium sulphate, FYM, growth, gypsum, pearl millet, poultry manure, pyrite, vermicompost, yield

Introduction
The millets are a group of highly variable small grained grasses, widely grown around the world as cereal crops. It is a dual-purpose crop grown as grain for food and fodder for animals. Millets are important crop in the semi-arid tropics of Asia and Africa. In Asia, it is especially grown in the country like India and in African continent is grown in countries like Nigeria and Niger. Millets are favoured due to its productivity and short growing season under dry and high temperature conditions.

Pearl millets [*Pennisetum glaucum* (L.) is an important crop of rainfed areas of Africa India and Serves as staple food for West Africa. It is the most widely cultivated millet crop, occupying prominent position in global agriculture. India is the largest producer of pearl millets in world occupying about 9.4 million hector area with annual production 10.1million tones with average productivity of 1069 kg/ha. India is largest producer of pearl millets covering about 8.75 million ha of marginal and sub marginal lands primarily in the states of Rajasthan, Gujarat, Haryana, Uttar Pradesh and Maharashtra and ranking 3rd after rice and wheat in acreage. In addition to its grain consumption as human feed, it is also as green fodder in India. Pearl millet may be an alternative crop that exhibits great advantages in physiological characteristics when compared to other cereals as it is resistant to drought, low soil fertility, high salinity and high temperature tolerance [Singh *et al*., 2019]. Because of it drought escaping mechanism pearl millet can grow in areas that have extended dry periods. The balanced fertilization as shown in positive effects on various aspects of growth development and biological yield of the crop in comparison to nutrient use in single or in combination.

Farmyard manure
Farmyard manure rich in organic matter can be supplemented with NPK fertilizers. Although, it is costlier than chemical fertilizers on nutrient basis but other beneficial effects which it has on soil can compensate for the added cost. A good response of pearl millet to application of bulky organic manures such as FYM, compost and vermicompost has been reported for all the pearl millet-growing areas. Bulky organic manures supply not only macronutrients but also micronutrients. Besides nutrient supply, bulky organic manures are very effective in improving the moisture- holding capacity of the soil. Long-term experiments reveal that application of 2.5

tonnes of FYM for zone A and 5.0 tonnes of FYM for zone B every year in combination with 40 kg N/ha was helpful for yield stability in pearlmillet.

Vermicompost

Vermicompost has also been advocated as a good organic manure for use in integrated nutrient management practices in field crops. Use of vermicompost as a biofertilizer and substitute for chemical fertilizers is advised by pioneers of organic farming. It was also thought that yearly application of this manure would encourage earthworm in a great and sufficient numbers. Vermicompost has approximately double the amount of nutrients as compared to FYM which improves physical and chemical properties of soil.

Poultry manure

Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In fresh poultry excreta uric acid or urate is the most abundant nitrogen compound (40-70 per cent of total N) while urea and ammonium are present in small amounts. Farmers with farms close to poultry farms use poultry manure regularly for their crops, with good returns. Poultry manure is a more concentrated source of crop nutrients, especially NPK and calcium. Being naturally organic, it does not need composting and can be applied directly to the fields from the farm.

Sulphur

Sulphur is one of the essential elements required for the normal growth of plants and it plays an important role as a constituent of many plant processes as plant metabolism depends on S and a deficiency of this nutrient will cause basic metabolic impairment, which will not only reduce crop yield but also the quality of produce. When there is not a sufficient supply of S, the application of high rates of other nutrients (N, P, and K) may not result in increased yields, due to imbalances in the N/S and P/S ratios in the plants. In addition, an adequate and balanced supply of nutrients favours the proper development of crops, with a positive impact on the yield. Sulphur application in deficient soils significantly increased crop yield in the on-farm studies. Although water shortages affect crop production and productivity in rainfed areas in the semi-arid tropic regions of India, widespread deficiency of sulphur, also hold back productivity of rainfed systems, resulting in low water use efficiency.

Ammonium sulphate

Ammonium sulphate is used primarily where there is a need for supplemental Nitrogen and Sulphur to meet the nutritional requirement of growing plants. Since it contains only 21% of N, there are other fertilizer sources that are more concentrated and economical to handle and transport. However, it is excellent source of S which has numerous essential functions in plants, including protein synthesis. Because of N fraction is present in ammonium form, ammonium sulphate is frequently used for flooded soil for rice production, where nitrogen-based fertilizers are poor choice due to denitrification losses. A solution containing dissolve ammonium sulphate is often added to post-emergence herbicide sprays to improve their effectiveness on weed control. This practice of increasing herbicide efficiency with ammonium sulphate is particularly effective when water supply contains significant concentration of calcium, magnesium, or sulphur. A high-purity grade of ammonium sulphate is often used for their purpose to avoid plugging spray nozzles.

Gypsum: Plants are becoming more deficient for sulfur and the soil is not supplying enough it. Gypsum is an excellent source of sulfur for plant nutrition and improving crop yield. Meanwhile, calcium is essential for most nutrients to be absorbed by plants roots. Without adequate calcium, uptake mechanisms would fail. Calcium helps stimulate root growth. One of gypsum's main advantages is its ability to reduce aluminum toxicity, which often accompanies soil acidity, particularly in subsoils. Gypsum can improve some acid soils even beyond what lime can do for them, which makes it possible to have deeper rooting with resulting benefits to the crops. Surface-applied gypsum leaches down to the subsoil and results in increased root growth.

Pyrite: Iron pyrites are waste products from mining operations and are also mined products. They have been used with varying success to supply Fe to plants, to supply S to plants, and to ameliorate sodic soils when oxidized to acid which forms gypsum in calcareous soil. Several forms of pyrite exist depending upon origin and crystallinity. Most of the literature indicates that oxidation of pyrite in soil is slow and sometimes requires years depending on origin and particle size; the need for small particle size is critical.

Materials and Methods

A field experiment was conducted during kharif season of 2021, at Crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj which is located at 25o 24' 42" N latitude, 81o 50' 56" E longitude and 98 m altitude above the mean sea level (MSL). To assess the effect of Organic manures and Sources of Sulphur on growth and yield of Pearl millet (*Pennisetum glaucum* L.). The experiment was laid out in Randomized Block Design comprising of 9 treatments which are replicated thrice. Each treatment net plot size is 3m × 3m. The treatment are categorized as with recommended dose of nitrogen through urea and potash through Muriate of Potash, in addition with Organic manure and Sources of Sulphur when applied in combinations as follows, T1 – FYM 10 t/ha + Ammonium Sulphate -25 kg/ha, T2 – FYM 10 t/ha + Pyrite - 45 kg/ha, T3 – FYM 10 t/ha + Gypsum -60 kg/ha, T4 – Vermicompost 5 t/ha + Ammonium Sulphate -25 kg/ha, T5 – Vermicompost 5 t/ha + Pyrite -45 kg/ha, T6 – Vermicompost 5 t/ha + Gypsum -60 kg/ha, T7 – Poultry manure 2 t/ha + Ammonium Sulphate -25 kg/ha, T8- Poultry manure 2 t/ha + Pyrite 45 kg/ha, T9 – Poultry manure 2 t/ha + Gypsum -60 kg/ha. The pearl millet crop was harvested treatment wise at harvesting maturity stage. Growth parameters *viz.* plant height (cm), dry matter accumulation g plant-1 were recorded manually on five randomly selected representative plants from each plot of each replication separately and after harvesting, seeds were separated from each net plot and were dried under sun for three days. Later winnowed, cleaned and grain yield per ha was computed and expressed in tonnes per hectare. After complete drying under sun for 10 days stover yield from each net plot was recorded and expressed in kgs per hectare. The data was computed and analysed by following statistical method of Gomez and Gomez (1984). The benefit: cost ratio was worked out after price value of seed with straw and total cost included in crop cultivation.

Table 1: Details of treatment combination.

S. No	Treatment No.	Treatment combination
1	T_1	FYM 10t/ha + 25kg/ha Ammonium Sulphate
2	T_2	FYM 10t/ha + 45kg/ha Pyrite
3	T_3	FYM 10t/ha + 60kg/ha Gypsum
4	T_4	Vermicompost 5t/ha + 25kg/ha Ammonium Sulphate
5	T_5	Vermicompost 5t/ha + 45kg/ha Pyrite
6	T_6	Vermicompost 5t/ha + 60kg/ha Gypsum
7	T_7	Poultry Manure 2t/ha + 25kg/ha Ammonium Sulphate
8	T_8	Poultry Manure 2t/ha + 45kg/ha Pyrite
9	T_9	Poultry Manure 2t/ha + 60kg/ha Gypsum

Results and Discussions

Effect on growth parameters: Plant height

It is evident from Table 1. That plant height measured increased with advancement in crop growth. At harvest the treatment T5 (Vermicompost 5 t/ha + 45 kg/ha Pyrite) recorded maximum height of 212.43 cm. At harvest maximum plant height of 159.40cm was recorded with treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite. However, treatment FYM 10 t/ha + 45 kg/ha Pyrite, Vermicompost 5 t/ha + 60 kg/ha Gypsum recorded statistically at par with Vermicompost 5 t/ha + 45 kg/ha Pyrite. Increased availability of nutrients through vermicompost in the soil through mineralization of organic sources could have triggered cell elongation and multiplication resulting in higher growth rate of shoots in turn plant height of pearl millet in organic. Combinations of organics and inorganics ensured ready availability of nutrients at initial stages of crop due to improved soil properties and prolonged nutrient availability through organics also helped increase plant height. The increase in plant height due to Sulphur might be due to beneficial effect of sulphur on the various metabolic activities and also because of its important role in cell division, photosynthetic process and formation of chlorophyll in the leaf. Similar findings were also reported by Degra *et al*. (2008) [7], Narolia *et al*., (2011) [13], Singh *et al*., (2009).

Dry matter accumulation

At Harvest highest plant dry weight was found in treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite (40.70 g). However, treatment FYM 10 t/ha + 45 kg/ha Pyrite, Vermicompost 5 t/ha + 60 kg/ha Gypsum, Poultry Manure 2 t/ha + 45 kg/ha Pyrite were found to statistically at par with treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite. The improved Physico-chemical properties and availability of nutrients at a slow rate for a longer period with the use of organics might be responsible for more tillers, maximum leaf area and increased photosynthesis leading to accumulation of significantly higher dry matter. The increase in plant height due to Sulphur might be due to beneficial effect of sulphur on the various metabolic activities and also because of its important role in cell division, photosynthetic process and formation of chlorophyll in the leaf. The results were in agreement with the findings of Dahich and Gupta (2005), Degra *et al*. (2008) [7].

Table 2: Effect of organic manures and sources sulphur on growth parameters of kharif pearlmillet.

S. No.	Treatment No.	Plant height(cm)	Plant dry weight (g/plant)	Crop growth rate(g/m2/plant)	Relative Growth rate (g/g/day)
1	T1	175.70	33.68	2.85	0.00255
2	T2	195.17	42.24	3.14	0.00227
3	T3	182.53	37.93	4.21	0.00347
4	T4	185.90	39.07	4.85	0.00393
5	T5	200.20	46.29	4.14	0.00270
6	T6	192.10	43.37	5.76	0.00441
7	T7	177.67	34.95	4.70	0.00426
8	T8	189.20	41.17	5.57	0.00443
9	T9	179.97	37.66	4.28	0.00361
	CD (P=0.05)	10.27	6.24	-	-
	S.Em±	3.46	2.10	1.54	0.0014

Table 3: Effect of organic manures and sources sulphur on yield and yield attributes of kharif pearlmillet.

S. No.	Treatment No.	Ear head length(cm)	No. of grains/Earhead	Grain yield (Kg/ha)	Stover yield (Kg/ha)
1	T1	16.93	1693.33	2434	3586.34
2	T2	21.53	1944.67	2624	3726.86
3	T3	16.73	1785.67	2171	3147.35
4	T4	17.13	1807.67	2471	3557.49
5	T5	23.00	1975.67	2723	3839.80
6	T6	19.63	1885.00	2580	3682.04
7	T7	16.03	1649.00	2230	3300.11
8	T8	17.43	1862.00	2540	3641.94
9	T9	16.30	1732.67	2327	3397.55
	CD(P=0.05)	3.42	59.56	160.84	236.82
	S.Em±	1.15	20.05	54.13	79.71

Yield and Yield Attributes: Ear head length

Significant effect was observed by the statistical analysis of ear head length. Treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite resulted in significantly highest ear head length (23.00 cm). However, FYM 10 t/ha + 45 kg/ha Pyrite, Vermicompost 5 t/ha + 60 kg/ha Gypsum were found to be statistically on par with Vermicompost 5 t/ha + 45 kg/ha Pyrite. Increase in ear head length was due to cumulative effect of growth and vigour of plants which leads to increased supply of metabolites which have significant effect on growth character and yield attributes and also higher rate of photosynthesis as well as higher translocation of photosynthates from source to sink for the development. Sulphur application through pyrite increased ear head length because sulphur is a part of amino acid (Cystine) which helps in chlorophyll formation, photosynthetic process, activation of enzymes and seed formation. Similar results were also reported by Kumar *et al*., (2014) [11], Degra *et al*. (2008) [7], Singh *et al*., (2009).

Number of grains/ear head

Significant effect was observed by the statistical analysis of number of grains/ear head. Treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite recorded significant and highest number of grains/ear head (1975.67). However, FYM 10 t/ha + 45 kg/ha Pyrite recorded statistical parity with Vermicompost 5 t/ha + 45 kg/ha Pyrite. Increase in number of grains per ear was due to cumulative effect of growth and vigour of plants which leads to increased supply of metabolites which have significant effect on growth character and yield attributes and also higher rate of photosynthesis as well as higher translocation of photosynthates from source to sink for the development. Sulphur application through pyrite increased number of grains per ear head because sulphur is a part of amino acid (Cystine) which helps in chlorophyll formation, photosynthetic process, activation of enzymes and seed formation. Similar results were also reported by Kumar *et al*., (2014) [11], Degra *et al*. (2008) [7], Singh *et al*., (2009).

Grain yield

The grain yield showed increasing trend with the application of organic manure and sources of sulphur in pearl millet. The highest grain yield was obtained with the treatment Vermicompost 5 t/ha + 45 kg/ha Pyrite (2723Kg), however FYM 10t/ha + 45kg/ha Pyrite were found to be statistically on par with Vermicompost 5t/ha + 60kg/ha Gypsum. The increased yield in organic treatment through vermicompost can be attributed improved physical conditions of the soil apart from slow release of nutrients during entire crop growth period. The gradual release and steady supply of nutrients from vermicompost throughout the growth and development of plants could have maintained the photosynthetic efficiency and production of metabolites at higher level and later on the translocation of photosynthates to various sinks resulting into higher grain yield. High yields with pyrite application could be ascribed to accelerated nutrient uptake which helped the plants to put optimum growth. Similar findings were reported by Sharma and Gupta (2003) [16], Singh *et al*., (2009).

Stover yield

The application of Organic manure and Different sources of sulphur had also significantly influenced the stover production of the pearl millet crop. Highest stover yield (3839.80kg/ha) was recorded Vermicompost 5t/ha + 45kg/ha Pyrite, however, FYM 10t/ha + 45kg/ha Pyrite, Vermicompost 5t/ha + 60kg/ha Gypsum were found to be statistically on par with Vermicompost 5t/ha + 45kg/ha Pyrite. The increased stover yield in organic treatment through vermicompost can be attributed improved physical conditions of the soil apart from slow release of nutrients during entire crop growth period. Further, yield improvement was possible on account of better nutrient use efficiency. High yields with pyrite application could be ascribed to accelerated nutrient uptake which helped the plants to put optimum growth. Similar findings were reported by Sharma and Gupta (2003) [16], Singh *et al*., (2009).

Economics

Among the different combination of organic manure and sources of sulphur, Vermicompost 5 t/ha + 45 kg/ha Pyrite recorded higher net return (82.362 x 103 ₹/ha), gross return (136.167 x 103 ₹/ha) and benefit: cost ratio (1.53).

Conclusion

Treatment Vermicompost 5 t/ha + 45 kg/ha recorded highest growth and yield parameters, which may be more preferable for farmers since it is economically more profitable and hence, can be recommended to the farmers.

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