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Influence of nutrient management practices on growth and yield of irrigated sorghum [*Sorghum bicolor* (L.)]

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Abstract
Field experiment was carried out at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai nagar (Tamil Nadu) during February-May, 2020 to study the influence of nutrient management practices on growth and yield of irrigated sorghum. Three replications of a experiment was executed using a randomized block design. There were altogether nine treatments *viz*., T1 - Control, T2 - 100% RDF (90:45:45 kg NPK/ha), T3 - 100% RDF + EFYM @ 750 kg/ha, T4 - 100% RDF + vermicompost @ 5 t/ha, T5 - 100% RDF + Soil application of ZnSO4 @ 25 kg/ha, T6 - 125% RDF + EFYM @ 750 kg/ha, T7 - 125% RDF + vermicompost @ 5 t/ha, T8 - 125% RDF + Soil application of ZnSO4 @ 25 kg/ha, T9 - 100% RDF + EFYM @750 kg/ha + Soil application of ZnSO4 @ 25 kg/ha, T10 - 100% RDF + Vermicompost @ 5 t/ha + Soil application of ZnSO4 @ 25 kg/ha,T11 - 125% RDF + EFYM @ 750 kg/ha + Soil application of ZnSO4 @ 25 kg/ha, T12 - 125% RDF + vermicompost @ 5 t/ha + Soil application of ZnSO4 @ 25 kg/ha. The combined integration of organic manures, inorganic fertilizer and micronutrient influenced the plant growth characters, yield attributes and yield of sorghum. Result of the experiment revealed that application of 125% RDF + vermicompost @ 5 t/ha + Soil application of ZnSO4 @ 25 kg/ha(T12) recorded higher plant height (188.34 cm), leaf area index (4.32), dry matter production (11793 kg/ha), grain (3578 kg/ha) and stover yield (9823 kg/ha) of irrigated sorghum as compared to rest of treatments.

Keywords: nutrient management, vermicompost, ZnSO4, irrigated sorghum

Introduction
Sorghum [Sorghum bicolor (L.)] is the fifth most crucial cereal crop in the world after rice, wheat, maize and barley. It is also called as king of millets, coarse grain, great millet, milo, durra and in India as jowar, cholam, jonna. It is grown in different parts of the tropical and subtropical regions in the world and an important staple food grain for millions of the worlds malnourished and most food- insecure people. Because of its multiple uses as grain, fodder, animal feed and recently used for renewable energy and sugar production. It is the only crop producing a reliable yield under the marginal environment characterized by biotic constraints and low inputs. Sorghum grain encompasses carbohydrates, protein, minerals, vitamins, salts and fats are vital for vigorous growth. Sorghum one of the most important crop for the impoverished and vulnerable people in society who need calories and micronutrients. (Dambiwal *et al*., 2017) [3].
Nutrient management practices includes the intelligent, judicious and effective utilization of all major plant-nutrient sources from organic and inorganic resources to get spectacular yields, enhance the soil physio-chemical properties and provide crop nutrition which are scientifically sound, economically appealing, practically feasible and environmentally safe (Gaikwad *et al*., 2018) [4]. In comparison to nutrient use in single or combination, balanced fertilizer incorporation has exhibited great effects on the several aspects of the growth, development, and biological yield of the crop. The productivity and quality of sorghum can be significantly increased by the effective use of fertilizers. For intensive production, fertilization is a major input, and the profitability of sorghum production systems rely on yield and input levels. Hence, the precise nutrient supply is necessary to achieve optimal production as well as a greater grain yield.
The use of organic nutrient sources to achieve the sustained growth of the crop production as the organic nutrient sources continuously supplies nutrients to the crop in a slow release form. The physical property of the soil, nutrient availability, soil flora, and fauna are significantly impacted by organic manures in a manner that directly influences plant growth and development. Hence, the recommendation of integrated use of organic and inorganic nutrient sources for the crop production is one of the alternatives to raise crop productivity and sustain soil fertility in the crop production system. The combined application of organic manures and inorganic fertilizers is promising not only in maintaining higher productivity but also improves the nutrient content, protein yield and nutrient uptake (Balasubramanian and Wahab, 2012) [1].

Materials and methods

Field experiment was conducted at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai nagar during February to May, 2020. The Experimental farm is located at 11o 24' N latitude and 79o 41' E longitude with an altitude of +5.79 m above the Mean Sea Level. The soil type of the experimental site was clay loam in texture with neutral in reaction (pH = 7.5), with low soluble salts (EC = 0.31 dSm-1), low in available nitrogen (232.5 kg ha-1), medium in available phosphorous (18.6 kg ha-1) and high in available potassium (316.5 kg ha-1).The experiment was laid out in Randomized Block Design (RBD) with three replications. The experiment contains twelve treatments *viz*., T1 - Control, T2 - 100% RDF (90:45:45 kg NPK/ha), T3 - 100% RDF + EFYM @ 750 kg/ha, T4 - 100% RDF + vermicompost @ 5 t/ha, T5 - 100% RDF + Soil application of ZnSO4 @ 25 kg/ha, T6 - 125% RDF + EFYM @ 750 kg/ha, T7 - 125% RDF + vermicompost @ 5 t/ha, T8 - 125% RDF + Soil application of ZnSO4 @ 25 kg/ha, T9 - 100% RDF + EFYM @750 kg/ha + Soil application of ZnSO4 @ 25 kg/ha, T10 - 100% RDF + Vermicompost @ 5 t/ha + Soil application of ZnSO4 @ 25 kg/ha, T11 - 125% RDF + EFYM @ 750 kg/ha + Soil application of ZnSO4 @ 25 kg/ha, T12 - 125% RDF + vermicompost @ 5 t/ha + Soil application of ZnSO4 @ 25 kg/ha.

The sorghum variety CO 30 was grown for the study. The recommended dose of 90:45:45 kg of NPK ha^{-1}. The required quantities of inorganic fertilizers incorporated to the soil through urea, single super phosphate and muriate of potash. Nitrogen was applied at two splits at basal and top dressing on 30 DAS. The entire dose of phosphorous and potassium incorporated into the soil at basal as per the recommended dose. Zinc applied through analytical grade zinc sulphate (ZnSO4.7H2O), containing 21 per cent zinc. The vermicompost and EFYM used in this experiment was collected from the Experimental Farm, Department of Agronomy, Annamalai University. The nutrient content of EFYM and vermicompost are 1.50% and 2.75% N, 2.80% and 0.95% P, 0.80% and 1.80% K, respectively. Calculated quantities of zinc, EFYM and vermicompost were applied as per the treatment schedule in the soil. At different stages of sorghum growth the plant height, LAI, DMP, stover yield and grain yield were recorded. The statistical analysis of data was done by analysis of variance technique at 0.05 probability level.

Results and discussion

Growth characters

The statistics on plant height, LAI and DMP of sorghum are furnished in Table1, illustrated the influence of different nutrient management practices on plant height, area index and dry matter production. Among the treatments, incorporation of 125% RDF + vermicompost @ 5 t/ha+ soil application of ZnSO4 @ 25 kg/ha (T12) recorded higher plant height (188.34 cm), leaf area index (4.32) and dry matter production (11793 kg/ha) at harvest stage over rest of the treatments. It was on par with the application of 125% RDF + EFYM @ 750 kg/ha + soil application of ZnSO4@ 25 kg/ha (T11). Mixed application of inorganic and organic nutrients improved the concentration of nutrients inside the plant cell, promoting rapid cell elongation and cell division, which increased plant height. These studies are done by Patel *et al*. (2013) [6] and Singh *et al*. (2015) [2, 8].

Vermicompost which contains high amount of macro and micro nutrients enhanced the nutritional status of soil when applied to the soil in combination with inorganic fertilizers primarily NO3, PO4, Ca, K, Mg, S and other essential nutrients in the available forms that are readily absorbed by the plants which led to higher leaf area index of sorghum thereby enabling the plants to improve photosynthetic rate, which in turn led to a greater accumulation of dry matter. The studies done by Sudhanshu (2013) [9] tends to support the present finding.

Table 1: Influence of nutrient management practices growth characters of irrigated sorghum at harvest stage

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg/ha)
T_1 – Control	125.86	2.37	4705
T_2 - 100% RDF (90:45:45 kg NPK/ha)	149.07	3.21	7960
T_3 - 100% RDF + EFYM @ 750 kg/ha	161.58	3.54	9264
T_4 - 100% RDF + Vermicompost @ 5 t/ha	163.90	3.60	9381
T_5 - 100% RDF + Soil application of $ZnSO_4$ @ 25 kg/ha	159.32	3.48	9032
T_6 - 125% RDF + EFYM @750 kg/ha	174.75	3.79	10312
T_7 - 125% RDF + Vermicompost @ 5 t/ha	176.70	3.83	10403
T_8 - 125% RDF + Soil application of $ZnSO_4$ @ 25 kg/ha	160.43	3.51	9159
T_9 - 100% RDF + EFYM @ 750 kg ha^{-1} + Soil application of $ZnSO_4$ @ 25 kg/ha	177.13	3.87	10534
T_{10} - 100% RDF + Vermicompost @ 5 t/ha+ Soil application of $ZnSO_4$ @ 25 kg/ha	179.06	3.93	10631
T_{11} - 125% RDF + EFYM @ 750 kg/ha + Soil application of $ZnSO_4$ @ 25 kg/ha	185.81	4.25	11523
T_{12} - 125% RDF + Vermicompost @ 5 t/ha + Soil application of $ZnSO_4$ @ 25 kg/ha	188.34	4.32	11793
SEm±	2.32	0.04	405
CD (*P*=0.05)	4.83	0.10	840

Yield characters and yield

The analyzing data furnished in Table 2 exerted distinctive nutrient management practices influenced significant effect on yield characters, grain and stover yield of sorghum over control. Among the different treatments implemented in this study, application of 125% RDF + vermicompost @ 5 t/ha + soil application of ZnSO4 @ 25 kg/ha (T12) was found efficient for recording higher number of earheads m-2 (14.81), number of filled grains per earhead (1169), thousand grain weight (23.61g), grain yield (3578 kg/ha) and stover yield (9823 kg/ha) of sorghum. This treatment was on par with the application of 125% RDF + EFYM @ 750 kg/ha + soil application of ZnSO4@ 25 kg/ha (T11). This could be due to adequate nutrient supply from both organic and inorganic sources, which could have improved nutrient efficiency as well as sink capacity were in consonant with the result of Shinde *et al.* (2010) [7].

Combined use of organic nutrient sources, inorganic fertilizers and micronutrients enhanced yield of sorghum. These stimulate plant growth regulators and improve soil physical and chemical properties *viz*., aeration, high porosity water-holding capacity, drainage and nutrients such as nitrates, phosphates, soluble potassium and exchangeable calcium. This might have helped in increased photosynthetic activity and resulted in excellent translocation of photosynthates to sink leading to improvement of yield attributes that ultimately enhanced the yield as reported by Choudhary *et al*. (2015) [2] in sorghum.

Table 2: Influence of nutrient management practices on yield attributes and yield of irrigated sorghum

Treatments	Number of earheads (m^{-2})	Number of filled grains per earhead	Thousand grain weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)
T_1 – Control	12.83	473	23.08	958	4389
T_2 - 100% RDF (90:45:45 kg NPK/ha)	14.25	745	23.19	2067	6978
T_3 - 100% RDF + EFYM @ 750 kg/ha	14.56	865	23.31	2545	7982
T_4 - 100% RDF + Vermicompost @ 5 t/ha	14.59	897	23.35	2607	8053
T_5 - 100% RDF + Soil application of $ZnSO_4$ @ 25 kg/ha	14.48	812	23.27	2418	7846
T_6 - 125% RDF + EFYM @ 750 kg/ha	14.64	979	23.38	2950	8768
T_7 - 125% RDF + Vermicompost @ 5 t/ha	14.69	1005	23.42	3005	8817
T_8 - 125% RDF + Soil application of $ZnSO_4$ @ 25 kg/ha	14.52	834	23.31	2493	7915
T_9 - 100% RDF + EFYM @ 750 kg ha^{-1} + Soil application of $ZnSO_4$ @ 25 kg/ha	14.72	1023	23.46	3076	8895
T_{10} - 100% RDF + Vermicompost @ 5 t/ha + Soil application of $ZnSO_4$ @ 25 kg/ha	14.75	1059	23.50	3125	8956
T_{11} - 125% RDF + EFYM @ 750 kg/ha + Soil application of $ZnSO_4$ @ 25 kg/ha	14.79	1142	23.52	3454	9640
T_{12} - 125% RDF + Vermicompost @ 5 t/ha + Soil application of $ZnSO_4$ @ 25 kg/ha	14.81	1169	23.61	3578	9823
SEm±	0.009	29.77	0.04	151.98	315.33
CD (*P*=0.05)	0.02	61.75	NS	315.23	654.72

Conclusion

Application of organic manures, inorganic fertilizers and micronutrient sources registered the increased values of parameters like growth, yield attributes, grain and stover yield of irrigated sorghum. Based on the results presented above, it is possible to conclude that incorporation of 125% RDF + vermicompost @ 5 t/ha + soil application of ZnSO4 @ 25 kg/ha (T12) is agronomically sound and economically feasible for enhancing the productivity and profitability of irrigated sorghum. Sustainable nutrient management system for sorghum not only enhances the crop yield but also maintains soil fertility and ecosystem, a felt need of present day agriculture.

Recommendation

It is recommended to use tobacco alkaloid compounds extract in the control of red flour beetles, *Tribolum castaneum*, in stores and silos.

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