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Effect of farm yard manure and distillery byproducts on soil enzymatic activity of *Rabi* sorghum crop under *Vertisols*

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Abstract
The field experiment was laid out to know the "Effect of FYM and distillery byproducts on soil enzyme activity, with a *rabi* sorghum crop under *vertisols*, the experiment was carried out at Regional Agricultural Research Station (RARS), Vijayapura, during *rabi* seasons of 2020-21. The experiment comprising 11 treatments was laid out in recommended complete block design with three replications. The treatments were consisted of T_1: FYM @ 3t ha^{-1}; T_2: Pressmud @ 3 t ha^{-1}; T_3: Spentwash @ 5ml kg^{-1} of soil (1:10 dilution spentwash: water); T_4: 3 t ha^{-1} (Spentwash + FYM (1:3 mixing and curing for 25 days)); T_5: 3 t ha^{-1} (Spentwash + Pressmud (1:3 mixing and curing for 25 days)); T_6: T_1 + 100% RDF; T_7: T_2 + 100% RDF; T_8: T_3 + 100% RDF; T_9: T_4 + 100% RDF; T_{10}: T_5 + 100% RDF and T_{11}: Absolute control. The treatment receiving spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers shows highest enzymatic activities (urease, dehydrogenase, acid phosphatase and alkaline phosphatase) over all other treatments and similar trends were followed at 24, 48, 72 DAS and after harvest and followed by when combined application of spentwash with FYM and same with pressmud (both the combinations were cured and mixed at 1:3 ratios for 25 days) as compared to applied FYM or pressmud alone. Hence, the application spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers and combined application of spentwash with FYM and same with pressmud (both the combinations were cured and mixed at 1:3 ratio for 25 days) are the best options for dryland agricultural production for enhancing the soil as well as crop productivity.

Keywords: Distillery spentwash, enzyme activity, farm yard manure, and sorghum

Introduction
Sorghum (*sorghum bicolor*) is one of the most important cereal crops widely grown for food, feed, fodder, forage and fuel in the semi-arid tropics of Asia, Africa, America and Australia. It is an important grain and forage crop of semi- arid regions due to its high adaptability and suitability to rain-fed low input agriculture. Sorghum is the fifth most important cereal crop after rice, wheat, maize and barley. In India, it is mostly grown in dry land as food grain for humans and fodder for animal feed and is the main cereal food for over 750 million people living in semi-arid tropical region of Africa, Asia and Latin America. (*Anon*, 2011) [1]. Sorghum is the second most important crop in Karnataka after paddy. The total area under sorghum cultivation is 26 percent of the cultivated area. Sorghum being cultivated in during *Kharif* (area 3.20 lakh ha) and *rabi* (12.19 lakh ha) seasons. Vijayapur stands first in the production of sorghum in the state. Sorghum is the staple food of the people of North Karnataka. It is mainly used for preparing rotis. The stalks of sorghum stover are used as cattle fodder.

Industrial pollution has been continuously soaring and causing serious threats to the soil, water and air quality. This increase in industrialization has not only covered large areas, but also created a large quantity of wastewater which is difficult to handle. However, the challenge is to properly use wastewater, so that the application of wastewater does not cause any soil and environments problem. Sugarcane industry is among the major agro-based industries making an appreciable contribution towards the socio-economic development of many countries. This industry is involved in the processing of sugar. Additionally, this industry produced many byproducts such as bagasse, pressmud and distillery spent wash (DSW). Among these byproducts, DSW is produced in a large quantity and contains a huge organic load that makes it a potential source as an agricultural input. DSW is the unwanted residual liquid waste generated during alcohol production and pollution caused by it is one of the most critical environmental issue.

India has about 620 sugar mills and about 400 molasses-based distilleries with an installed capacity of 2716 million litre of alcohol and a potential to generate an average of 40697 million litres of spentwash. Among the major states, Karnataka stands 3rd which having the total installed capacity and total effluent generated about 187millon litre per year and 2799 million litre per year respectively. The spentwash generation depends on the type of fermentation, process, type of distillation process, distillation with or without reboiler, evaporation system molasses quality, yeast culture and recycle. (Source: All India distillery Association New Delhi). DSW is acidic in nature and have a brown color due to the pigment called "melanoidin" which is refractory in nature to the biological treatment and it is used as a source of plant nutrients and organic matter for various agriculture crops. Organic acid such as lactic acid, tartaric acid, succinic acid, acetic acid and malic acid also documented in the DSW. Apart from this it also contains soluble proteins. The composition of this effluent found very similar to that of farm yard manure. It has high organic matter of 31.50 per cent and has narrow C:N ratio of 15.75 (Rajkkannu and Manikam, 1996) [10] so it helps in the faster decomposition of the organic manure and readily availability of the nutrients.

Spentwash is non-toxic, biodegradable, purely of plant origin and contains large quantities of soluble organic matter and plant nutrients, which the sugarcane plant has absorbed from the soil. The salts commonly present in this effluent are of K and SO_4 apart from N, P and micronutrients and all these elements are essential nutrients of plants. Therefore, its fertilizer potential can suitably be harnessed in agriculture by controlled land application following proper methods (pre-plant application or with proper dilution). Hence, utilization of distillery effluents in agriculture would save cost on fertilizers and facilitate reduction in pollution load.

Soil enzymes are group of enzymes that inhabits in soil and play a key role in maintaining of ecology, physical and chemical properties, fertility and health of soil. These enzymes work in biochemical processes of overall organic matter decomposition in the soil system. These enzymes catalyze the reaction that is necessary in vital processes of soil microorganisms, stabilization of soil structure, decomposition of organic wastes and nutrient cycling. Soil containing a high microbial diversity is characteristic of a healthy soil plant relationship, whereas those with low microbial diversity are characterized as an unhealthy soil. Soil enzymatic activities can be used as an index of soil fertility and microbial functional diversity in catalyzing several biochemical reactions. Soil enzymes play a vital role in the nutrient transformation, recycling and nutrient availability to the plant from the soil and they are likely to be influenced by the organic manure and fertilizer application. Thus, soil enzymes are considered to be biological indicators for understanding of changes in natural (Kuscu, 2019) [9] and agricultural (Kizilkaya *et al*., 1998) [8] fields against environmental factors and soil quality and fertility (Dotaniya *et al.*, 2019) [5].

Materials and Methods

The field experiment was laid out to know the 'Effect of Farm Yard Manure and distillery byproducts on soil enzymatic activity of *rabi* sorghum crop under *vertisols'*, the experiment was carried out at Regional Agricultural Research Station (RARS), Vijayapura, during *rabi* seasons of 2020-21.The soil is clay loam in texture with 3.6, 36.3 and 60.1 per cent sand, silt and clay, respectively. The soil is alkaline in reaction (pH 8.68) and low in soluble salts (0.45 dS m^{-1}). The soil was low in organic carbon (4.28 g kg^{-1}) and available nitrogen (58.0 mg kg^{-1}) and medium in available P (5.8 mg kg^{-1}), while it was high in K (165.8 mg kg^{-1}) and sulphur (15.25 mg kg^{-1}). The exchangeable calcium, magnesium and sodium were 20.20, 13.2 and 5.34 c mol (p^+) kg^{-1}. The DTPA extractable micronutrient content *viz*., iron, manganese, zinc and copper were 2.85, 2.21, 0.52 and 1.85 mg kg^{-1}, respectively. The activities of dehydrogenase, urease, acid phosphatase and alkaline phosphatase were 25.21 µg TPF g^{-1} soil hr^{-1}, 35.64 µg NH_4^+- N g^{-1} h^{-1}, 26.53 µg PNP g^{-1} h^{-1} and 25.21 µg PNP g^{-1} h^{-1}. The experiment comprising 11 treatments was laid out in randomized complete block design with three replications. The treatments were consisted of T_1: FYM @ 3t ha^{-1}; T_2: Pressmud @ 3 t ha^{-1}; T_3: Spentwash @ 5ml kg^{-1} of soil (1:10 dilution spentwash: water); T_4: 3 t ha^{-1} (Spentwash + FYM (1:3 mixing and curing for 25 days)); T_5: 3 t ha^{-1} (Spentwash + Pressmud (1:3 mixing and curing for 25 days)); T_6: T_1 + 100% RDF; T_7: T_2 + 100% RDF; T_8: T_3 + 100% RDF; T_9: T_4 + 100% RDF; T_{10}: T_5 + 100% RDF and T_{11}: Absolute control.

The distillery byproducts such as distillery spentwash and pressmud are taken from the Godavari Biorefinery Ltd. Sameeravadi, Mudhol taluka of Bagalkot district. DSW was mixed and cured with FYM and PM in 1:3 ratio for 25 days before application to the field. The characteristics of the FYM, pressmud (PM), distillery spentwash (DSW) and their combination were presented in the Table 1. The data collected from the experiment at different growth stages and from laboratory analysis was subjected to statistical analysis as described by Gomez and Gomez (1984) [6]. The level of significance used in 'F' test was 0.05. A critical difference value was calculated wherever the 'F' test found to be significant.

Results and Discussion

Urease activity

Data presented in the Table 2 revealed that urease activity in soil ranged from 30.40 to 109.17, 34.50 to 144.30, 31.17 to 134.50 and 35.4 to 80.6 µg NH_4^+- N g^{-1} h^{-1} at 24DAS, 48DAS, 72DAS and after harvest, respectively with various levels and combinations of FYM and distillery byproducts. The urease activity in soil was high when only with combination of spentwash with FYM and pressmud both at 1:3 ratio for mixing and curing for 25 days as compared to without combinations were applied and similar trends were followed at 24, 48, 72 DAS and after harvest. The urease activity in soil was highest with combination of spentwash with both FYM and pressmud at 1:3 ratio for mixing and curing for 25 days were 91.70 and 90.40; 112.80 and 106.83; 98.60 and 97.50; 73.7 and 72.6 higher than without combinations applied at 24 DAS, 48 DAS, 72 DAS and after harvest, respectively. Highest urease activity in soil was observed when spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers over all other treatments and similar trends were followed at 24, 48, 72 DAS and after harvest. Irrespective of organic manures and their combinations with spentwash, spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied without conjunction with recommended dose of fertilizers invariably showed higher urease activity in soil over all other organic manures. Highest urease activity in soil was observed where only spentwash at 5ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of NP fertilizers (56.1%) applied followed by the combinations of FYM + spentwash (53.7%) and pressmud + spentwash (52.6%) in both at 3: 1 ratio for mixing and curing for 25 days over control after harvest of the crop. Among the extracellular enzymes related with nitrogen (N), urease is responsible for the breakdown of urea. In general, amidohydrolases are good proxies in nitrogen mineralization and they transform small nitrogen containing organic compounds into inorganic N compounds like ammonia (NH_3). Urease breakdown specifically urea into ammonia and carbon dioxide (CO_2). Application of DSW along with chemical fertilizers increases the urease activity in the soil, it implies that application organic along with inorganic fertilizers provide nutrient rich environment, which is essential for the synthesis of urease enzyme in soil. Urease activity in soil is highly influenced by the application of distillery spentwash. This might be due to the tremendous increase in microbial population, availability of essential nutrients and organic carbon content of the soil applied through the distillery spentwash. The high concentration of soluble organic carbon added from the DSW application might be responsible for the enhanced urease activities (Kalaiselvi and Mahimairaja, 2009) [7]. Several folds increase the urease activity in soil due to the lower doses of spentwash application might be due to the addition of organic matter and subsequent increase in the microbial biomass in the soil (Saliha *et al.*,2005) [12].

Dehydrogenase Activity

Data presented in the Table2 revealed that dehydrogenase activity in soil ranged from 22.47 to 91.90, 28.70 to 132.40, 26.47 to 107.40 and 24.47 to 87.30 µg TPF g^{-1}h^{-1} at 24DAS, 48DAS, and 72DAS and after harvest, respectively with various levels and combinations of FYM and distillery byproducts. The dehydrogenase activity in soil was high when only with combination of spentwash with FYM and pressmud both at 1:3 ratio for mixing and curing for 25 days as compared to without combinations were applied and similar trends were followed at 24, 48, 72 DAS and after harvest. The dehydrogenase activity in soil was highest with combination of spentwash with both FYM and pressmud at 1:3 ratio for mixing and curing for 25 days were 82.90 and 80.00; 95.40 and 93.50; 89.50 and 83.73; 77.70 and 76.60 higher than without combinations applied at 24 DAS, 48 DAS, 72 DAS and at harvest, respectively. Highest dehydrogenase activity in soil was observed when spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers over all other treatments and similar trends were followed at 24, 48, 72 DAS and after harvest. Irrespective of organic manures and their combinations with spentwash, spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers invariably showed higher dehydrogenase activity in soil over all other organic manures. Highest dehydrogenase activity in soil was observed where only spentwash at 5ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers (72%) applied followed by the combinations of FYM + spentwash (70%) and pressmud + spentwash (68.8%) in both at 3: 1 ratio for mixing and curing for 25 days over control after harvest of the crop. Soil dehydrogenase one of the most important soil enzyme and commonly used to indicate the soil microbial activity. The enzyme has a key place in determining the health of the soil as it is the integral part of the intact cell and does not accumulate extracellularly. Dehydrogenase enzyme considered an important enzyme for the oxidative processes in the soil increased gradually with DSW application and this is solely attributed to the higher organic matter supply through spentwash. The activity of dehydrogenase enzyme in soil was significantly influenced by the application of the distillery spentwash. The activity of dehydrogenase enzyme increases in DSW applied treatment and this increase was more along with the NP fertilizers than the control or no application. Enzyme activity in the soil environment is considered to be a major contributor of overall soil microbial activity. Enzyme activity in soil is an indirect indication on the microbial activity, which is directly correlated with soil microbial population. Greater activity of dehydrogenase in soil was associated with the spentwash application (Kalaiselvi and Mahimairaja, 2009) [7]. Dehydrogenase activity in soil depends on the content of soluble organic carbon (Casida, 1977; Zaman *et al.*, 2002) [3, 14] and the increased organic matter in the surface soil horizon enhanced the soil enzyme activities. The increase in activity of dehydrogenase enzyme was maximum by the application of DSW alone or in combination with FYM and PM or may be with the chemical fertilizers may be result from the favourable soil pH range which increases the activity of dehydrogenase enzyme. The soil pH plays a significant role in the activity of all the microorganism (dehydrogenase) (Singh *et al.*, 2003) [13].

Acid phosphatase Activity

Data presented in the Table 2 revealed that acid phosphatase activity in soil ranged from 33.73 to 68.40, 34.97 to 84.70, 34.03 to 73.30 and 29.03 to 66.70 µg PNP g^{-1} h^{-1} at 24DAS, 48DAS, 72 DAS and after harvest, respectively with various levels and combinations of FYM and distillery byproducts. The acid phosphatase activity in soil was high when only with combination of spentwash with FYM and pressmud (both the combination were cured and mixed at 1:3 ratio (3 t ha^{-1}) for 25 days) as compared to without combinations were applied and similar trends were followed at 24, 48, 72 DAS and after harvest. The acid phosphatase activity in soil was highest with combination of spentwash with both FYM and pressmud at 1:3 ratio for mixing and curing for 25 days were 57.50 and 54.30; 64.47 and 62.93; 64.40 and 59.53; 55.80 and 53.60 higher than without combinations applied at 24 DAS, 48 DAS, 72 DAS and after harvest, respectively. Highest acid phosphatase activity in soil was observed when spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers over all other treatments and similar trends were followed at 24, 48, 72 DAS and after harvest. Irrespective of organic manures and their combinations with spentwash, spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers invariably showed higher acid phosphatase activity in soil over all other organic manures. Highest acid phosphatase activity in soil was observed where only spentwash at 5ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers (56.4%) applied followed by the combinations of FYM + spentwash (51.2%) and pressmud + spentwash (48.9%) in both at 3: 1 ratio for mixing and curing for 25 days over control after harvest of the crop. Phosphorus (P) is an essential element for transportation of energy, and formation of cellular structures and nucleic acids. Phosphatases are the enzymes that catalyze the hydrolysis of ester-phosphate bonds, leading to the release of P, which can be taken up by plants or microorganisms. Application of organic manures increases the activity of acid phosphatase enzyme in soil. Phosphatase enzyme governs the transformation of C, N and P from organically bound form to plant available forms in soil. Application of balanced amount of nutrients and manures (DSW, FYM and PM) improve the organic matter and microbial biomass carbon status of the soil, which corresponded with higher enzyme activity in soil. Phosphatase play an important role in cycling of N and other nutrients (Roy *et al.*, 2007: Compton and Cole, 1998) [11, 4] even in poor soils, and they contribute to an increase in concentrations of N, P, C and other nutrients (Bormann *et al.*, 1994) [2].

Alkaline phosphatase Activity

Data presented in the Table2 revealed that alkaline phosphatase activity in soil ranged from 33.90 to 92.80, 39.63 to 98.20, 35.80 to 95.60 and 30.60 to 83.50 µg PNP g^{-1} h^{-1} at 24DAS, 48DAS, and 72DAS and after harvest, respectively with various levels and combinations of FYM and distillery byproducts. The alkaline phosphatase activity in soil was high when only with combination of spentwash with FYM and pressmud both at 1:3 ratio for mixing and curing for 25 days as compared to without combinations were applied and similar trends were followed at 24, 48, 72 DAS and after harvest. The alkaline phosphatase activity in soil was highest with combination of spentwash with both FYM and pressmud at 1:3 ratio for mixing and curing for 25 days were 74.10 and 69.30; 83.50 and 79.73; 80.30 and 78.83; 68.80 and 65.37 higher than without combinations applied at 24 DAS, 48 DAS, 72 DAS and after harvest, respectively. Highest alkaline phosphatase activity in soil was observed when spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers over all other treatments and similar trends were followed at 24, 48, 72 DAS and after harvest. Irrespective of organic manures and their combinations with spentwash, spentwash at 5 ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers invariably showed higher alkaline phosphatase activity in soil over all other organic manures. Highest alkaline phosphatase activity in soil was observed where only spentwash at 5ml kg^{-1} of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers (63.3%) applied followed by the combinations of FYM + spentwash (56.3%) and pressmud + spentwash (55.2%) in both at 3: 1 ratio for mixing and curing for 25 days over control after harvest of the crop. In the organic phosphorus (P) mineralization process, acid and alkaline phosphatases are involved in phosphomonoester hydrolysis to release phosphate. The enzyme activities in the soil were closely related to the organic matter content. Application of balanced amounts of nutrients and manures improved the organic matter and microbial biomass carbon status of soils, which corresponded with higher enzyme activity. Activity of alkaline phosphatase enzyme increases the availability of phosphorous in the soil. Activity of alkaline phosphatase increases with the application of distillery effluent (spentwash) along with the NP fertilizers. The activity alkaline phosphatase enzyme was maximum at the 48 DAS of the sorghum crop this might be due to the higher metabolic and root activity and higher absorption of nutrients from the soil. The increase in activity of alkaline phosphatase enzyme was maximum by the application of DSW alone or in combination with FYM and PM or may be with the chemical fertilizers may be result from the favourable soil pH range which increases the activity of alkaline phosphatase (Singh *et al.*, 2003) [13]. The activity alkaline phosphatase enzyme was maximum at the 48 DAS of the sorghum crop this might be due to the higher metabolic and root activity and higher absorption of nutrients from the soil.

Table 1: Characterization of FYM, pressmud (PM), distillery spentwash (DSW), FYM+DSW, PM+DSW and DSW: Water=1:10 dilution

Sl. No.	Particulars	FYM	Pressmud	DSW	*FYM+DSW	*PM+DSW	*DSW: W =1:10
I	**Chemical Properties**						
1.	pH	6.9	6.5	4.2	6.5	6.0	6.8
2.	EC dS m^{-1}	1.08	0.34	30.5	5.5	20.02	20.12
3.	OC (%)	22.25	35.08	35.5	28.12	33.20	22.21
4	C:N ratio.	15.1	19.44	15.8	28.12	17.47	21.77
II	**Major Nutrients (%)**						
4.	Nitrogen	0.76	1.80	2.0	1.00	1.9	1.02
5.	Phosphorus	0.25	1.02	0.23	0.36	0.75	0.18
6.	Potassium	0.68	1.28	9.6	4.72	7.72	3.62
III	**Secondary Nutrients (%)**						
7.	Calcium	0.82	10.25	2.05	1.25	8.02	1.08
8.	Magnesium	0.44	3.20	1.7	0.62	2.82	0.72
9.	Sulphur	0.28	6.99	3.2	1.32	5.42	0.52
10	Sodium	0.22	0.42	0.49	0.21	0.30	0.11
IV	**Micro Nutrients (mg kg^{-1})**						
12	Zinc	58.30	119.4	17.00	55.12	100.0	6.01
13	Iron	1230.00	1202	54.14	1120.21	1025.3	21.2
14	Copper	18.10	77.4	0.9	16.21	69.2	0.51
15	Manganese	424.4	253.2	9.85	400.32	214.2	3.3
16	BOD (mg/L)	-	-	5500	-	-	-
17	COD (mg/L)	-	-	15750	-	-	-

* FYM+DSW: FYM + Distillery Spentwash (DSW) (3:1 ratio mixing of FYM and DSW and curing for 25 days) * PM+DSW: Pressmud (PM) + Distillery Spentwash (3:1 ratio mixing of PM and DSW and curing for 25 days) *DSW: Water =1:10: Dilution with water

Table 2: Effect of FYM and distillery byproducts on soil enzymatic activity

Treatment detail	Urease (μg NH_4^+- N g^{-1} h^{-1})				Dehydrogenase (μg TPF g^{-1} h^{-1})				Acid phosphatase (μg PNP g^{-1} h^{-1})				Alkaline phosphatase (μg PNP g^{-1} h^{-1})			
	24 DAS	48 DAS	72 DAS	After harvest	24 DAS	48 DAS	72 DAS	After harvest	24 DAS	48 DAS	72 DAS	After harvest	24 DAS	48 DAS	72 DAS	After harvest
T1: FYM @ 3t ha^{-1}	88.7	95.7	89.5	72.3	75.3	87.8	82.8	72.3	45.5	51.8	47.4	40.8	70.1	74.5	72.4	62.8
T2: Pressmud @ 3 t ha^{-1}	84.0	90.5	87.6	68.2	70.9	82.4	76.4	65.9	41.5	47.8	44.7	36.8	63.8	71.0	68.9	58.9
T3: Spentwash @ 5ml kg^{-1} of soil *	100.6	139.3	123.5	76.8	85.8	122.3	107.3	83.2	63.4	78.0	70.6	61.7	89.9	94.3	91.4	80.6
T4: 3 t ha^{-1} (Spentwash + FYM)**	91.7	112.8	98.6	73.7	82.9	95.4	89.5	77.7	57.5	64.5	64.4	55.8	74.1	83.5	80.3	68.8
T5: 3 t ha^{-1} (Spentwash + Pressmud)**	90.4	106.8	97.5	72.6	80.0	93.5	83.7	76.6	54.3	62.9	59.5	53.6	69.3	79.7	78.8	65.4
T6: T1 + 100% RDF	94.3	112.3	103.3	74.6	78.9	97.4	88.4	78.6	48.5	58.8	50.4	43.8	73.0	79.4	75.3	66.7
T7: T2 + 100% RDF	90.2	103.6	97.5	70.7	74.1	91.5	83.2	70.7	46.5	52.5	49.4	41.5	70.1	74.7	70.6	62.0
T8: T3 + 100% RDF	109.2	144.3	134.5	80.6	91.9	132.4	107.4	87.3	68.4	84.7	73.3	66.7	92.8	98.2	95.6	83.5
T9: T4 + 100% RDF	94.5	130.4	121.2	76.5	85.1	103.6	95.3	81.8	62.2	69.5	66.1	59.5	80.3	88.4	84.7	70.0
T10: T5 + 100% RDF	92.7	126.9	119.3	74.8	83.1	112.3	88.6	78.5	58.5	64.8	61.4	56.8	77.9	82.0	81.3	68.3
T11: Absolute control	30.4	34.5	31.2	35.4	22.5	28.7	26.5	24.5	33.7	35.0	34.0	29.0	33.9	39.6	35.8	30.6
CD @ 5%	11.0	10.1	12.3	8.9	8.7	11.3	9.4	8.83	8.0	8.4	9.9	8.5	7.1	8.1	7.8	7.9
S.Em. ±	3.7	3.4	4.2	3.0	2.9	3.8	3.2	3.01	2.7	2.8	3.3	2.9	2.4	2.7	2.6	2.6

*1:10: spentwash: water dilution**1:3 ratio for mixing and curing for 25 day

Conclusion

Application of spentwash at 5 ml kg^{-1} soil in 1:10 dilution with water + 100 percent RDF increases the enzymatic activity in the soil and followed by the combinations of FYM + spentwash (both the combinations mixing and curing at 3: 1 ratio for 25 days) in conjunction with full dose of RDF. Hence, the application of spentwash at 5 ml kg^{-1} soil in 1:10 dilution with water is recommended for sorghum production and followed by the combinations of FYM + spentwash (both the combinations mixing and curing at 3: 1 ratio for 25 days) in conjunction with full dose of RDF.

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