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# Effect of FYM and distillery byproducts on growth and yield of *rabi* sorghum crop under vertisols

**Muttavva Awaradi, Kumara BH, SB Patil, Anusha KN and Ranjitha G**

## Abstract
The field experiment was laid out to know the "Effect of FYM and distillery byproducts on growth and yield 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 experiment comprising 11 treatments was laid out in randomized complete block design with three replications. The treatments were consisted; $T_1$: FYM @ 3 t ha$^{-1}$; $T_2$: Pressmud @ 3 t ha$^{-1}$; $T_3$: Spentwash @ 5 ml 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.
Result revealed that the highest growth and yield of rabi sorghum were recorded 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 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 are the best options for dryland agricultural production for enhancing the soil as well as crop productivity.

**Keywords:** FYM, distillery byproducts, growth, yield, *rabi* sorghum crop, vertisols

## 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. (CCCF, 2011). 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. 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 folder. In south Karnataka sorghum is primarily grown for cattle feed. Vijayapur stands first in the production of sorghum in the state.
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, press mud 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 issues. DSW contain large load of both organic and inorganic substances. Also, DSW contains sufficient amount of macronutrients (N, P, K, Ca, Mg, S) and micronutrients (Zn, Cu, Fe, Mn), which in turn improves the growth and yield of crops.

India has about 620 sugar mills and about 400 molasses-based distilleries with an installed capacity of 2716 million liter of alcohol and a potential to generate an average of 40697 million liters of spentwash. Among the major states, Karnataka stands 3rd which having the total installed capacity and total effluent generated about 187 million liter per year and 2799 million liter 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 percent and has narrow C:N ratio of 15.75 (Rajkkannu and Manikam, 1996) [7] 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 (Baskar *et al*., 2003) [2].

## Materials and Methods

The field experiment was initiated in 2020-2021 at RARS, Vijayapur. It comes under Northern Dry Zone of Karnataka (Zone 3), situated at 16° 49' N latitude and 75° 43' E longitude and at an altitude of 593.8 m above the mean sea level. A total of 594.4 mm rainfall was received during the cropping period of 2020-21 from April 2020 to March 2021. July and September months were the wettest. The total rainfall and number of rainy days were highest in the month of September. The experimental soil is clay loam in texture with 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 experiment comprising 11 treatments was laid out in randomized complete block design with three replications. The treatments were consisted of $T_1$: FYM @ 3 t $ha^{-1}$; $T_2$: Pressmud @ 3 t $ha^{-1}$; $T_3$: Spentwash @ 5 ml $kg^{-1}$ 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 (T), Bagalkot (D). 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) [3].

## Results and Discussion

### Effect of FYM and distillery byproducts on LCC and SPAD meter readings

Data presented in Table 2 represents the relative greenness (LCC value) and the amount of Chlorophyll content (SPAD value) of the sorghum leaves. The relative greenness (LCC value) and the amount of Chlorophyll content (SPAD value) of sorghum leaves were high when combined application 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 either FYM or pressmud applied alone and similar trends were followed at 24, 48 and 72 DAS. Highest LCC and SPAD value of sorghum leaves were observed where spentwash at 5 ml $kg^{-1}$ of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers (25% & 31%) applied followed by the combinations of FYM + spentwash (14.3% & 22%) and pressmud + spentwash (9% & 15.1%) both were cured and mixed at 3:1 ratio for 25 days in conjunction with recommended dose of fertilizers over control at 24 DAS and similar trend were recorded at 48 DAS and 72 DAS of the sorghum crop. Lowest LCC and SPAD value of sorghum leaves were observed in absolute control.

Chlorophyll plays a significant role in the process of photosynthesis because of its ability to absorb light and it play a very essential role in plant development. Since, it helps the plant to have its green coloring and also helps the plant to absorb solar light, which therefore break water and carbon to carbohydrates and oxygen. The diluted/less concentrated at rate of 5 ml $kg^{-1}$ of soil application of DSW can reduce the membrane roots injury that helps in the uptake of available nutrients such as N, Fe and Mg that improves the greenness/chlorophyll content of the leaves of the crop. The increase in chlorophyll content may be due to lack of heavy metals in the effluent and probably the availability of Fe and Mg which are necessary for the synthesis of chlorophyll (Rath *et al.*, 2011) [8]. Some of the possible reasons for the decrease of pigment in other manures (FYM and Pressmud) alone and their combinations (FYM + DSW and PM + DSW each cured at 3:1 ratio for 25 days) contents may be due to the formation of enzyme chlorophyllase which is responsible for chlorophyll degradation. The increase in total chlorophyll content by the application of DSW may be due to the high availability of $Mg^{+2}$ is the central atom of chlorophyll molecule which is required for structural integrity of chloroplast (Akhtar *et al.*, 2018) [1]. The synthesis of chlorophyll accelerated at lower concentration of DSW this might be due to the increased activity of catalase enzyme and reduced availability of toxic metals at lower concentration. Similar findings (Jain and Srivastava, 2012) [5] reported that application of very low rate of crude spentwash (CSW) and DSW at 5 ml $kg^{-1}$ soil showed the highest chlorophyll a and b contents while minimum contents were observed at higher rate of application of CSW at 100 ml $kg^{-1}$ soil.

**Effect of FYM and distillery byproducts on growth parameter**

Data presented in Table 5 revealed that plant height (cm), Ear head length (cm), Ear head girth (cm), Test weight (g), grain yield (kg $ha^{-1}$) and stover yield (kg $ha^{-1}$) of sorghum on a various levels and combinations of FYM and distillery byproducts. The growth attributes were highest when combined application 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 applied FYM or pressmud alone. Highest plant height (cm), Ear head length (cm), Ear head girth (cm), Test weight(g), grain yield (kg $ha^{-1}$) and stover yield (kg $ha^{-1}$) were observed where spentwash at 5 ml $kg^{-1}$ of soil (1:10 spentwash and water dilution) applied in conjunction with recommended dose of fertilizers (20.6%, 21.6%, 20.2%, 17.5%, 65.8% & 39.4%) applied followed by combined application of spentwash with FYM (9.6%, 17.7%, 16.8%, 10.9%, 62.5% & 35.4%) and pressmud (7.3%, 14.3%, 14%, 10.3%, 50.4% & 33.4%) both were cured and mixed at 3:1 ratio for 25 days in conjunction with fertilizer over control at harvest of the crop. Lowest growth attributes were observed in absolute control.

This increase in growth and yield attributes might be due to the addition of increase plant nutrients (N, P, K Ca and S and it also contain sufficient amount of micro-nutrients) to the sorghum crop through the DSW. Increase in plant height by the application of DSW may be attributed to promotion of metabolic activity and cell division. (Sukanya and Meli, 2005) [10] findings showed that 50 percent N through distillery effluent and remaining 50 percent N through inorganic fertilizers to the soil increases the availability of nutrients resulted in a higher growth attribute. DSW application increases overall growth and yield of sorghum crop might be due to the easy availability of nutrients leading to balanced C: N ratio which enhances overall growth resulting in high photosynthetic activity. Applied DSW might have undergo nutrient mineralization resulting in supply of all essential nutrients and supply of nutrients through DSW resulted in increased rate of photosynthesis coupled with efficient translocation of photosynthesis to different plant part (Malagi *et al.*, 2013) [6].

The use of DSW remarkably increased seed germination, subsequent growth and yield of sorghum crop. Application of diluted DSW improved the productivity and enhanced the growth, yield, and nutrient contents of the sorghum crop. (Sukanya and Meli, 2004) [9] reported that maize grain yield of 76.83 g $ha^{-1}$ was recorded with the lower dilution as compared to the higher dilution. Findings of (Hati *et al.*, 2007) [4] reported that higher yield of both soybean and wheat crop with the application of distillery effluent may be due to the enhanced fertility status of soil and improved soil physical environment, which might have promoted better germination, root proliferation, nutrient and water uptake by the crops and greater biomass production. Application of diluted or less concentrated DSW increases the growth and yield of sorghum crop by reducing BOD and COD level in DSW that may be ascribed to the nutritional balance and increase in the availability of plant nutrients. This can be due to the reduced osmotic potential as a result of the less concentrated DSW application. And also increase in mitotic and metabolic activities by the diluted DSW application which results in increase in the growth and quality of sorghum crop.

**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 | 6.90 | 6.50 | 4.20 | 6.50 | 6.00 | 6.80 |
| 2. | EC (dS $m^{-1}$) | 1.08 | 0.34 | 30.50 | 5.50 | 20.02 | 20.12 |
| 3. | OC (%) | 22.25 | 35.08 | 35.50 | 28.12 | 33.20 | 22.21 |
| 4 | C:N ratio. | 15.10 | 19.44 | 15.8 | 28.12 | 17.47 | 21.77 |
| II | Major Nutrients (%) | | | | | | |
| 4. | Nitrogen | 0.76 | 1.80 | 2.00 | 1.00 | 1.90 | 1.02 |
| 5. | Phosphorus | 0.25 | 1.02 | 0.23 | 0.36 | 0.75 | 0.18 |
| 6. | Potassium | 0.68 | 1.28 | 9.60 | 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 | 1.70 | 0.62 | 2.82 | 0.72 |
| 9. | Sulphur | 0.28 | 6.99 | 3.20 | 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 | 119.40 | 17.00 | 55.12 | 100.00 | 6.01 |
| 13 | Iron | 1230.00 | 1202 | 54.14 | 1120.21 | 1025.30 | 21.20 |
| 14 | Copper | 18.10 | 77.40 | 0.90 | 16.21 | 69.20 | 0.51 |
| 15 | Manganese | 424.40 | 253.20 | 9.85 | 400.32 | 214.20 | 3.30 |
| 16 | BOD (mg $L^{-1}$) | | | 5500 | | | |
| 17 | COD (mg $L^{-1}$) | | | 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 LCC and SPAD meter readings

| Treatments | 14-12-2020 | | 14-01-2021 | | 16-02-2021 | |
|---|---|---|---|---|---|---|
| | 24 DAS | | 48 DAS | | 72 DAS | |
| | SPAD | LCC | SPAD | LCC | SPAD | LCC |
| $T_1$:$T_1$: FYM @ 3 t ha$^{-1}$ | 32.0 | 3.3 | 33.2 | 3.5 | 32.9 | 3.3 |
| $T_2$:$T_2$: Pressmud @ 3 t ha$^{-1}$ | 32.2 | 3.0 | 32.2 | 3.0 | 29.1 | 3.0 |
| $T_3$:$T_3$: Spentwash @ 5 ml kg$^{-1}$ of soil * | 41.1 | 3.5 | 40.2 | 4.0 | 39.9 | 3.5 |
| $T_4$:$T_4$: 3 t ha$^{-1}$ (Spentwash + FYM)** | 35.4 | 3.3 | 36.9 | 3.5 | 34.3 | 3.3 |
| $T_5$:$T_5$: 3 t ha$^{-1}$ (Spentwash + Pressmud)** | 32.6 | 3.3 | 33.3 | 3.2 | 33.4 | 3.3 |
| $T_6$: $T_1$ + 100% RDF | 35.4 | 3.5 | 37.2 | 3.8 | 35.7 | 3.5 |
| $T_7$: $T_2$ + 100% RDF | 31.0 | 3.5 | 36.6 | 3.5 | 34.2 | 3.5 |
| $T_8$: $T_3$ + 100% RDF | 41.4 | 4.0 | 41.0 | 4.5 | 40.8 | 4.0 |
| $T_9$: $T_4$ + 100% RDF | 36.7 | 3.5 | 36.6 | 4.0 | 34.8 | 3.5 |
| $T_{10}$: $T_5$ + 100% RDF | 33.7 | 3.3 | 36.3 | 3.5 | 35.5 | 3.3 |
| $T_{11}$: Absolute control | 28.6 | 3.0 | 30.5 | 3.0 | 24.9 | 3.0 |
| CD @ 5% | 3.4 | 0.3 | 2.2 | 0.2 | 3.2 | 0.3 |
| S.Em. ± | 1.14 | 0.10 | 0.74 | 0.07 | 1.06 | 0.10 |

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

**Table 3:** Effect of FYM and distillery byproducts on growth and yield of *rabi* sorghum

| Treatments | Plant height (cm) | Ear head length (cm) | Ear head girth (cm) | Test wt. (g) | Grain yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$: FYM @ 3 t ha$^{-1}$ | 179.7 | 10.7 | 10.3 | 44.7 | 1005.9 | 2310.0 |
| $T_2$: Pressmud @ 3 t ha$^{-1}$ | 174.7 | 10.5 | 9.9 | 42.7 | 872.9 | 2010.0 |
| $T_3$: Spentwash @ 5 ml kg$^{-1}$ of soil * | 199.3 | 12.6 | 12.0 | 48.0 | 1699.1 | 3035.2 |
| $T_4$: 3 t ha$^{-1}$ (Spentwash + FYM)** | 180.3 | 12.2 | 11.7 | 46.7 | 1572.7 | 2826.4 |
| $T_5$: 3 t ha$^{-1}$ (Spentwash + Pressmud)** | 176.7 | 11.4 | 10.9 | 43.3 | 1171.2 | 2576.7 |
| $T_6$: $T_1$ + 100% RDF | 183.7 | 11.0 | 10.6 | 47.3 | 1057.6 | 2326.7 |
| $T_7$: $T_2$ + 100% RDF | 180.0 | 10.9 | 10.0 | 45.3 | 959.1 | 2110.0 |
| $T_8$: $T_3$ + 100% RDF | 211.7 | 12.8 | 12.4 | 49.7 | 1842.7 | 3072.4 |
| $T_9$: $T_4$ + 100% RDF | 186.0 | 12.4 | 11.9 | 46.0 | 1678.8 | 2879.5 |
| $T_{10}$: $T_5$ + 100% RDF | 181.3 | 11.9 | 11.5 | 45.7 | 1269.7 | 2793.3 |
| $T_{11}$: Absolute control | 168.0 | 10.2 | 9.9 | 41.0 | 630.1 | 1860.0 |
| CD @ 5% | 10.45 | 0.20 | 0.36 | 1.73 | 44.8 | 43.13 |
| S.Em. ± | 3.51 | 0.06 | 0.12 | 0.57 | 15.1 | 14.52 |

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

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