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Influence of BBF and soil amendments on physical properties of soil and yield of soybean in Purna valley of Vidarbha region

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Abstract
A field experiment was undertaken in the six farmer's fields of Purna valley with soybean crop during Kharif, 2015-16 in randomized block design, replicated six times, with four treatments comprised of only BBF, BBF + FYM @ 5 t ha^{-1}, BBF + gypsum @ 2.5 t ha^{-1} and BBF + FYM @ 2.5 t ha^{-1} + gypsum @ 1.25 t ha^{-1} combined. It was found that lowest bulk density recorded under combined application of FYM and gypsum in BBF (1.53 Mg m^{-3}) While, highest in control (1.65 Mg m^{-3}) where, only BBF was followed. The hydraullic conductivity was 13.55 % more in combined application of FYM and gypsum over control where only BBF is followed. The mean weight diameter was highest (0.73 mm) with application of sole gypsum and the lowest (0.68 mm) in control. The highest soybean yield (14.03 q ha^{-1}) was obtained with the combined application of gypsum + FYM on BBF. Similarly considerable amount of yield was noticed in other treatments.
Based on the data obtained during experimentation, it is concluded that, the integration of land configuration technique and different soil amendments found beneficial for improving physical, chemical, biological properties of soil. Similarly it also supports in maximize the yield of soybean in sodic vertisols.

Keywords: BBF (broad bed furrow), gypsum, farm yard manure, amendments

1. Introduction
The Purna valley is the unique tract of Vertisols in Vidarbha region (Maharashtra state) of India having combination of three fold problems, the native salinity, poor drainability and poor quality of ground water. These soils of are developed on basaltic alluvium under arid and semi-arid conditions have clay mineralogy. The salts have varying degree of deterioration i.e. salinity or sodicity and salinity-sodicity (Anonymous, 2010) [1]. These soils are having high swell-shrink potential, slow permeability with very low hydraulic conductivity and poor drainage conditions. Taxonomically these salt affected soils are classified as SodicHaplusterts and SodicCalciusterts (Padole *et al*., 1998) [18]. These soils affect the plant growth and development, causing yield loss in many crop species (Qadir *et al*., 2007) [24]. The major reasons for this low productivity of crops grown on these soils are the salt toxicity and poor soil properties (Gao *et al*., 2008). Efficient treatment strategies to reduce the salt toxicity of soils are combined application of inorganic, for instance gypsum, and organic amendments, like farm manure improves their effectiveness for increasing soil properties (Ullahand Bhatti 2007; Ipsita and Singh, 2014; Verma *et al*., 2015) [27, 9, 28] in turn increase the crop yields. Hussain *et al*., 2001 [8] reported the Physical properties like bulk density, hydraulic conductivity and mean weight diameter were significantly improved when FYM (10 t ha-1) was applied in combination with chemical amendments resulting enhanced rice and wheat yields in salt affected soils. Hence, the present investigation was taken up with the objective to examine the effect of gypsum (G) and farm yard manure (FYM) application on physical properties of salt affected (saline sodic) soil, seed and starw yield of soybean (*Glycine max* L.). Soybean (*Glycine max*. L.) is one of the important oil seed as well as leguminous crop. It is originated in Eastern Asia/China.It is second largest oilseed crop in India after groundnut. Soybean as a miracle "Golden bean" of the 21st century mainly due to its high content protein 40%, oil 20%,carbohydrates-30%, fibre-0.5%, lecithin - 0.5% and saponins - 4%, and it is now making headway in Indian Agriculture. In India, it is mainly grown as oil seed as well as pulse crop. It is the cheapest and richest source of high quality protein. It supplies most of the nutritional constituents essential for human health. Soybean occupies an intermediate position between legumes and oilseeds.

2. Material and Methods

The experiment was conducted on six farmer's field with soybean crop in Ramagad located at Daryapur tehsil of Amravati district of Vidarbha region of Maharashtra during kharif, 2015-16. The design of experiment was randomized block design (RBD), replicated six times, where each farmer was treated as one replication with four treatments comprised of only BBF, BBF + FYM @ 5 t ha^{-1}, BBF + gypsum @ 2.5 t ha^{-1} and BBF + FYM @ 2.5 t ha^{-1} + gypsum @ 1.25 t ha^{-1} combined. Characteristics of the soils are comprised of clayey montmorillonitic, deep with soil order Vertisols. The initial physical and chemical properties of the experimental soils were analyzed and presented in table 1. Soil samples were collected before sowing and after harvest of soybean and analyzed for the soil bulk density, hydraulic conductivity and mean weight diameter. Soil bulk density was determined by clod coating technique as described by Blake and Hartge (1986) [3]. Hydraulic conductivity of soil was determined by constant head method as described by Klute and Dirksen (1986) [11]. Mean weight diameter of soil was determined by Yoder's apparatus method as per Kempen and Rosenau (1986) [10]. Similarly Seed yield and straw yield of soybean were also recorded during the field experimentation. The data on different parameters were tabulated and analyzed statistically by the methods described by Panse and Sukhatme (1971) [19].

Table 1: Initial physical and chemical properties of soil

S. No	Parameter	Site I	Site II	Site III	Site IV	Site V	Site VI
1	pH (1:2.5)	8.33	8.35	8.31	8.37	8.39	8.37
2	Ec (dSm^{-1})	0.19	0.21	0.20	0.23	0.21	0.20
3	OC (gkg^{-1})	4.1	4.3	4.4	4.7	4.4	4.6
4	Inorganic Carbon (g kg^{-1})	6.5	6.4	6.6	8.1	8.2	8.1
5	Total carbon (g kg^{-1})	10.6	10.7	11	12.8	12.6	12.7
6	B D (Mgm^{-3})	1.86	1.80	1.84	1.92	1.78	1.9
7	HC ($cmhr^{-1}$)	0.49	0.53	0.50	0.47	0.56	0.49
8	MWD (mm)	0.62	0.66	0.64	0.58	0.68	0.60
10	CEC ($cmol(p^+)kg^{-1}$)	49.67	50.98	49.87	47.27	52.10	49.14
11	ESP	13.72	12.20	13.52	14.61	11.72	14.68

3. Result and Discussion

The important physical properties of soil viz., bulk density, hydraulic conductivity and mean weight diameter are generally considered as criteria for governing soil quality. These physical properties are sensitive to management practices which include inorganic and organic amendments which have ability to improve these properties.

Bulk density of soil

The data in respect of bulk density is presented in Table 2 and depicted in Fig1.The bulk density of soil varied from 1.72 to1.84 Mg m^{-3} under various treatments. The lowest bulk density was recorded under combined application of farm yard manure and gypsum in BBF (1.72 Mg m^{-3}).However, it was found highest in control (1.84 Mg m^{-3}) where only BBF was followed. The slight reduction in bulk density was recorded under the treatments where sole farm yard manure (T_2) and sole gypsum (T_3) was applied. The results indicated the potential benefit of BBF, farm yard manure and application of gypsum. The rate of decrease in bulk density was comparatively less in all treatments. It must be because of high clay content and high plasticity of soil.

The reduction in bulk density caused due to addition of FYM and gypsum may be attributed to better aggregation, increased porosity and improvement in soil structure. The slight reduction in bulk density was also recorded with sole use of gypsum which can be attributed to addition of calcium causing flocculation which favours improvement in bulk density of soil. The results are in conformity with the findings of Pathak *et al*. (1991) [21] compared and reported that the bulk density was lower under BBF and flat seed bed. The results clearly showed that the bulk density of 0-15 cm soil layer was significantly lower in BBF than the flat bed treatment throughout the growing season. The differences in bulk density persisted between the treatments at all the stages. Even near the harvest, it was found that the bulk density of the 0-15 cm layer was significantly less in BBF (1.47 M gm^{-3}). Thus BBF has a clear advantage over flat seed bed in keeping top-soil loose. Choudhary *et al*. (2011) [4] also confined that, physical properties of soil change very slowly and showed gradual variations during short period.

Table 2: Influence of BBF and soil amendments on physical properties of soil.

T. No.	Treatments	BD	HC	MWD
		Mgm^{-3}	$cmhr^{-1}$	Mm
T1	BBF	1.84	0.53	0.67
T2	BBF+ FYM @ 5 tha^{-1}	1.79	0.59	0.74
T3	BBF+ Gypsum @ 2.5 tha^{-1}	1.78	0.62	0.75
T4	BBF+ FYM @ 2.5 t ha^{-1} + Gypsum @1.25 tha^{-1}	1.72	0.61	0.76
SE(m) ±		0.02	0.01	0.01
CD at 5 %		0.06	0.03	0.03
Initial status		1.88	0.51	0.65

Hydraulic conductivity

The data generated in respect of hydraullic conductivity is presented in Table 3 and depicted in Fig 2. The hydraulic conductivity of the experimental soil showed slight improvement in treatments where gypsum @ 2.5 t ha^{-1}(0.62 cm h^{-1}) was used followed by treatment where farm yard manure @ 2.5 t ha^{-1} in combination with gypsum @ 1.25 t ha^{-1} were used (0.61 cm h^{-1}).The hydraullic conductivity was 13.55% more in treatment T_4 where FYM and gypsum were integrated over treatment $T_1$where only BBF was followed.

The significant change in hydraulic conductivity was attributed to the reclamation of soil. Replacement of sodium by calcium due to addition of gypsum gradually helps in flocculation process resulting in better aggregation, which have resulted in to decrease in bulk density and improvement in hydraulic conductivity (Patel and Suthar, 1993) [20]. This lead to further regeneration of soil structure and reduction in bulk density leading to improvement in hydraulic conductivity. Although the hydraulic conductivity showed significant variation and numerical increase from the initial 0.51 cm hr^{-1} to 0.62 cm hr^{-1} (FYM+Gypsum) indicates the potential of these amendments in improving soil physical environment in long run.

The use of sole FYM (T_2) recorded increase in hydraulic conductivity over only BBF (T_1).The application of gypsum @ 2.5 t ha^{-1} and integration of both gypsum @ 1.25 t ha^{-1} FYM @ 2.5 t ha^{-1} showed the higher hydraulic conductivity to the extent of 0.62 and 0.61 cm hr^{-1}respectively.The reduction in bulk density and increase in porosity has been reported by Bharambe *et al.* (2001) [2]. Gill *et al.* (2009) [7] in their studies on soil physical properties in dense sodic sub soil incorporated organic amendments (Lucerne pallets) in Australia and reported 50 fold increase in hydraulic conductivity in Australian sodic soils after four years. Haynes and Naidu (1998) also reported that the additions of organic manures into soil result in increased water holding capacity, porosity, infiltration capacity, hydraulic conductivity and water stable aggregation and decreased bulk density and surface crusting. Soil compactibility also was decreased by the incorporation manure into soil.

Increase in the rate of hydraullic conductivity due to incorporation of gypsum (Dubey and Mondal 1994) [4] stressed that, gypsum is more effective in ameliorating the sodic soils by improving infiltration rate. Gypsum incorporation reduces soluble salt content and ESP which resulted into increasing hydraullic conductivity of sodic soils (Chauhan and Tripathi 1983). Maximum increase in hydraulic conductivity of sodic Vertisols was estimated due to interactive effect of BBF and amendments.

Mean weight diameter

The sodic soils are characterized by their poor structural stability, which is usually correlated with comparatively large amount of Na associated with clay particles. The mean weight diameter is an important indicator of soil aggregation and quality. Considering the significance of mean weight diameter, it was studied in this experiment and the generated data is placed in Table 3 and same has been depicted in Fig 3.The mean weight diameter of soil varied from 0.67 mm to 0.76 mm under various treatments and showed slight variation. The mean weight diameter was highest (0.76 mm)with integrated application of gypsum @ 1.25 t ha $^{-1}$ and FYM @ 2.5 t ha^{-1} (T_4) followed by gypsum 2.5 t ha^{-1} (T_3) (0.75 mm).The lowest mean weight diameter 0.67 mm in treatment $T_1$was noted where no amendments were used. The mean weight diameter was recorded in treatment T_4 6.84% more over T_1. Similarly it was resembles with the values where farm yard manure and gypsum were given. The results are in conformity with the findings of Mosaddeghi *et al*. (2000) [15], where he stated that soil physical structure improvement caused by the manure application may be a result of increase organic matter content which has a dilution effect on the soil, by bonding particles, increasing soil aggregation. Gypsum has been the most popular calcium compound useful for amelioration of soil structure.

Soil Moisture

Soil moisture is important physical property because several chemical and biological processes depend upon it. Cultivation practices like BBF and soil amendments helps to improve the moisture status of soils by improving structure of soils. The data generated in respect of soil moisture at 30,60,90 days after sowing is presented in Table 4 and depicted in Fig 4.

Table 3: Influence of BBF and soil amendments on soil moisture.

T. No.	Treatments	Soil moisture (%)		
		30 DAS	60 DAS	90 DAS
T1	BBF	25.83	20.63	17.12
T2	BBF+ FYM@5 tha^{-1}	27.73	23.61	19.9
T3	BBF+ Gypsum 2.5 tha^{-1}	35.96	31.83	23.60
T4	BBF+ FYM @ 2.5 tha^{-1} + Gypsum @ 1.25 tha^{-1}	37.5	34.46	25.94
SE(m) ±		0.47	0.54	0.62
CD at 5 %		1.43	1.62	1.86

Treatment T_4 where gypsum @ 1.25 t $ha^{-1}$and FYM@ 2.5 t ha^{-1}were used showed improvement in soil moisture to the extent of 37.5, 34.46 and 25.94 % at 30, 60 and 90 days after sowing respectively followed by treatment T_3 where gypsum @ 2.5 t ha^{-1} was given showed improvement in soil moisture to the extent of 35.96, 31.83 and 23.60 % at 30,60 and 90 days after sowing respectively. The soil moisture was 31.12, 40.13 and34 % at 30 DAS, at 60 DAS and at 90 DAS more in treatment T_4 where FYM and gypsum was integrated over treatment $T_1$where only BBF followed.

The use of sole FYM (T_2) recorded increase in soil moisture over only BBF (T_1).Similar result were reported Mosaddeghi *et al*. (2000) [16] additions of organic manures into soil result in increased soil moisture contain, porosity, infiltration capacity, hydraulic conductivity and water stable aggregation and decreased bulk density and surface crusting.

Seed and straw yield of soybean

In respect of yield of soybean as influenced by various treatments, the highest soybean yield (18.13 q ha^{-1}) in treatment T_3 BBF+ Gypsum @ 2.5 t ha^{-1} and which was at par with T_4 –BBF+ FYM @ 2.5 t ha^{-1} + Gypsum @ 1.25 t ha^{-1} and significantly superior over rest of the treatment. The results are in conformity with the findings of Ravindar J. *et al*. (2015). Similar results have also been reported by Sagare *et al.* (2000) [25] the application of gypsum @ 50% GR in combination with FYM @ 5 t ha^{-1} enhanced the grain yield of crop.

Table 4: Influence of BBF and soil amendments on yield of soybean

T. No.	Treatments	Grain	Straw
		q ha^{-1}	
T1	BBF	13.42	18.93
T2	BBF+ FYM @ 5 t ha^{-1}	15.60	22.44
T3	BBF+ Gypsum @ 2.5 t ha^{-1}	18.13	27.09
T4	BBF+ FYM @ 2.5 t ha^{-1} + Gypsum @ 1.25 t ha^{-1}	17.38	25.74
SE(m) ±		0.48	0.90
CD at 5 %		1.41	2.64
C.V		6.01	7.72

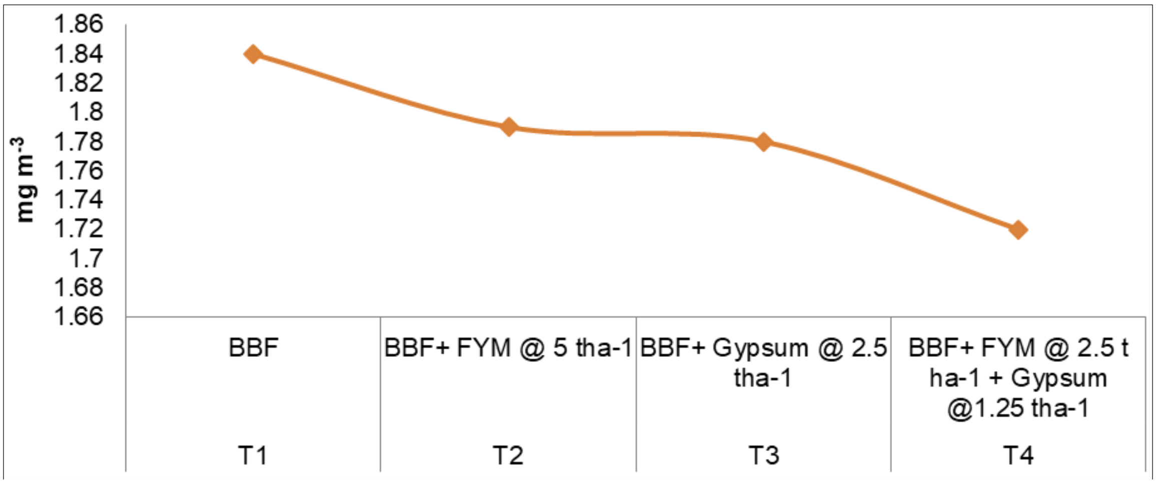

Fig 1: Influence of BBF and soil amendments on bulk density

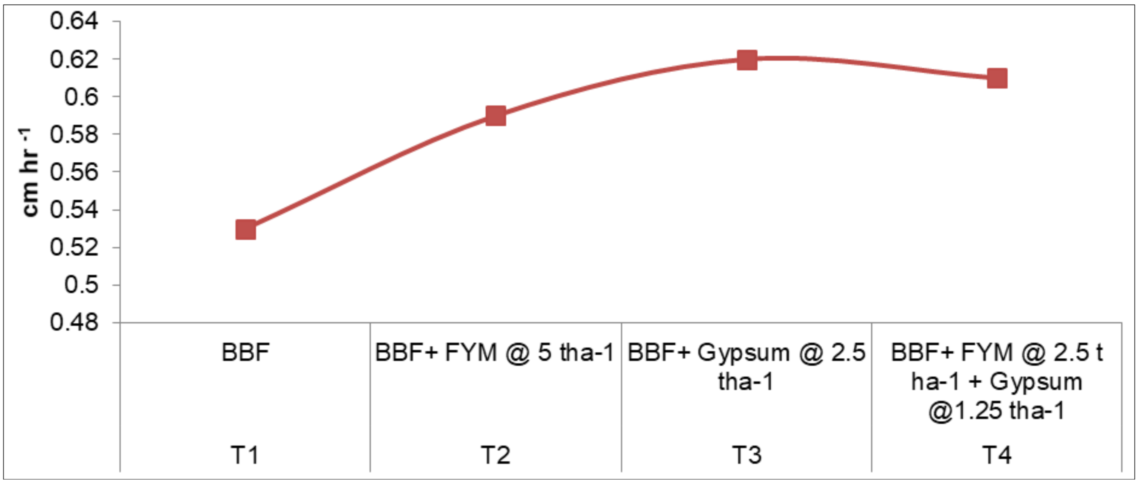

Fig 2: Influence of BBF and soil amendments on hydraulic conductivity

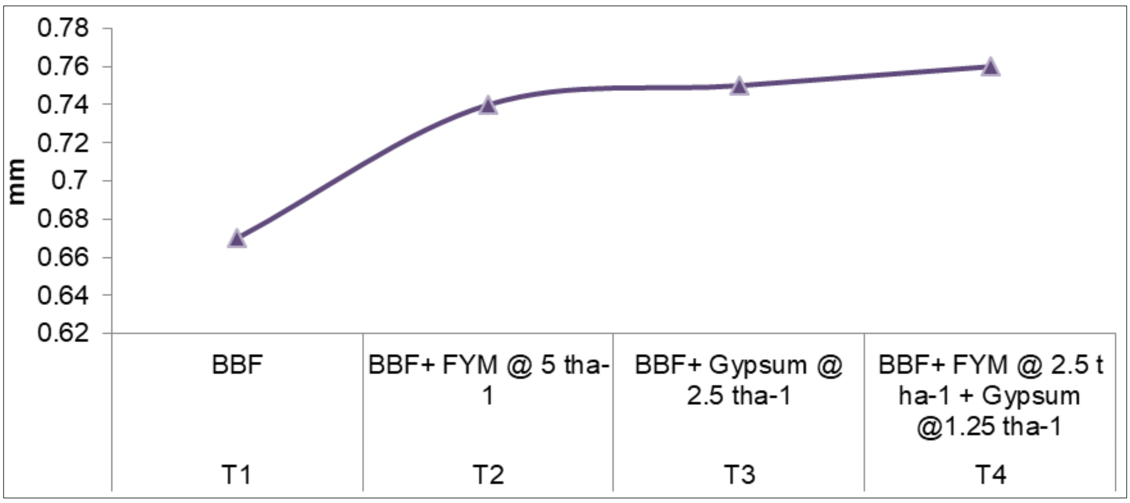

Fig 3: Influence of BBF and soil amendments on mean weight diameter

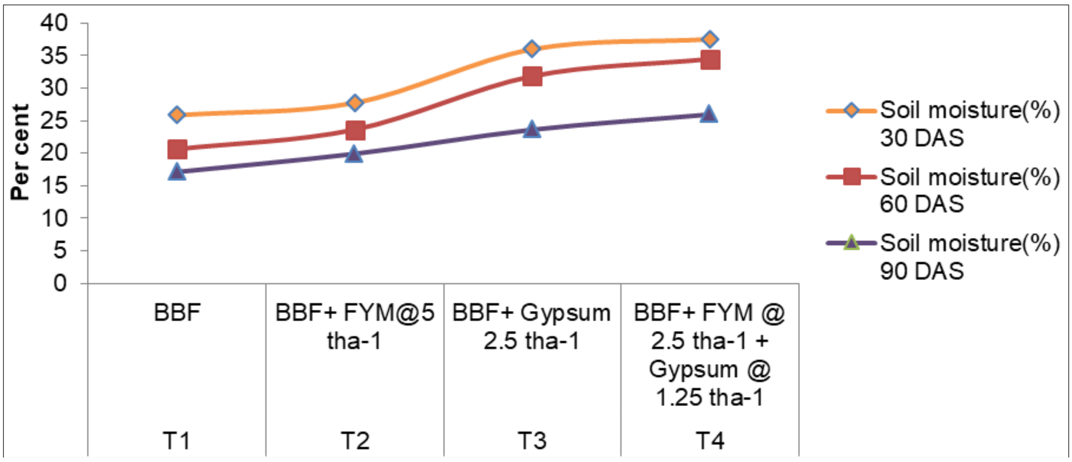

Fig 4: Influence of BBF and soil amendments on soil moisture

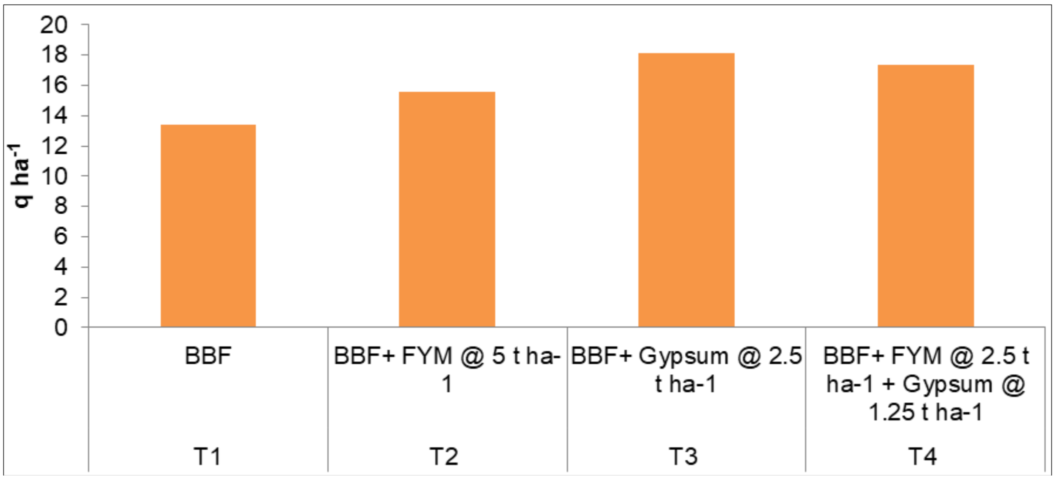

Fig 5: Influence of BBF and soil amendments on grain yield of soybean

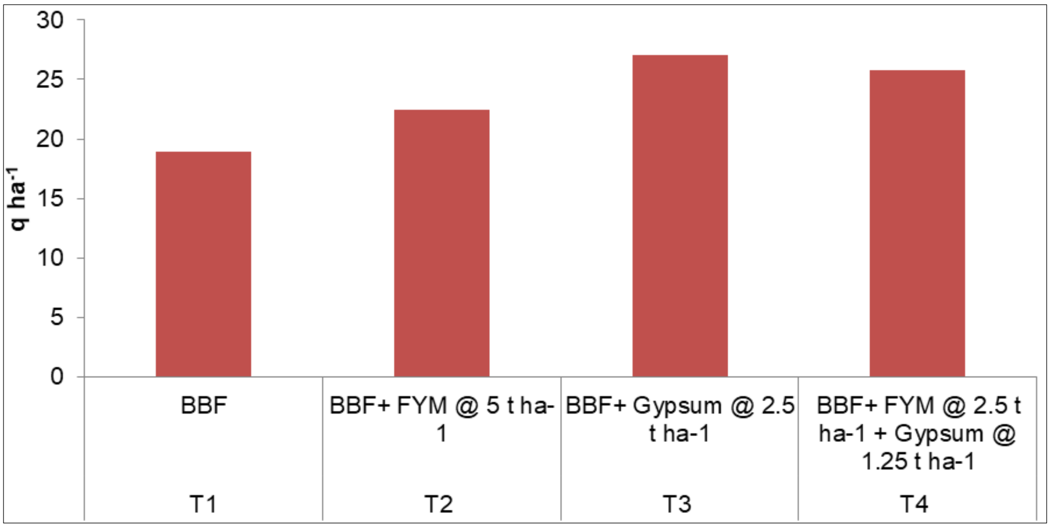

Fig 6: Influence of BBF and soil amendments on straw yield of soybean

This is due to significant reduction in pH, ECe and ESP at Ca^{+} ion that exchange with Na^{+} of clay complex leading to creation of favourable environment for microbial activity which results in improvement at soil health(Rao and Pathak, 1996) [21].

4. Conclusion

- The land configuration technique along with application of farm yard manure @ 2.5 t ha^{-1} + gypsum @ 1.25 t ha^{-1} was found beneficial for improvement in physical, chemical and biological properties of sodic soil.
- The integration of BBF and soil amendments was found beneficial for better amelioration and more grain and straw yield of soybean in sodic Vertisols of Purna valley.

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