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Effect of Beer Factory Sludge (BFS) With or Without Farm Yard Manure (FYM) on the Yield, Soil Physico Chemical Properties in *Spinacia Oleracia and Capsicum Annum L*

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Abstract: **In this study the effect of beer factory sludge (BFS) on soil physico chemical properties were evaluated during the growth of two plants i.e., Spinacia oleracia and Capsicum annum L. Two different combinations were studied; the first one is BFS + FYM mixture, the second one is BFS and was mixed with soil in different proportions. A separate category was maintained in which the soil was amended with inorganic fertilizer (INF) for a comparative study between BFS and INF on growth parameters of plants. The physical properties such as pH, EC, OC, available nitrogen, available phosphorous, available potassium and micro nutrients (Zn, Cu, Fe, Mn) were characterized. Bio chemical properties of plant like plant height, plant dry weight, fruit weight and BFS parameters like COD, BOD, heavy metals, WRC were determined. The soil parameters were analysed for 0thday, mid day and final day of plant harvesting. The BFS treated plants exhibited faster growth when compared with control soil and inorganic fertilizer. Among the two treatments in two categories, FYM amended with BFS (category-1) the growth rate was higher followed by Category-2. But no significant difference in growth was obtained between the two categories. The high COD, BOD content was observed and the heavy metal content in BFS was found to be in below detectable levels. The results of this experiment revealed that BFS consists of high organic loading and nutrients due to which it can be applied as fertilizer and BFS can be directly applied to soil without any further treatments as the heavy metals were below detectable levels.**

Keywords: **Beer Factory Sludge, *Capsicum Annum,* Farmy Yard Manure, *Spinacia Oleracia* and Soil Amendment.**

I. Introduction

Soil is one of the precious resources which facilitate sustainable life style. Enormous growth of industrialization resulted in highest usage of aromatics in explosives, pesticides and pharmaceuticals which has been led to serious environmental pollution. The soil thus lost its fertility and remained as poor soil less in major macro and micro nutrients required for plant growth. To improve soil fertility bioremediation is to be followed which relies on soil microorganisms and organic amendments [10]. The treatment of this waste has become a stringent process and a costly affair to follow government rules and regulations. Chemical analysis on this sludge revealed that it has high nitrogen, potassium, BOD and COD which can improve plant growth [7]. Generally the major problem arising in using of different types of sludge as fertilizer for land application is the presence of heavy metals. Though sewage sludge consists of high amounts of N, P, K and benefits the usage as fertilizer but heavy metals in them limits their usage [13]. Beer factory sludge consists of very low amount of heavy metals and even in below detectable levels which recommends its usage as fertilizer [11].

The organic carbon, Available nitrogen, Available potassium, Electrical conductivity were very high in BWS when compared with soil, sludge wastes are a very attractive source of many valuable compounds like Nitrogen, Phosphates and Organic matter. Ramana opine that brewery effluent is a good source of nitrogen which helped in the increased growth and yield of groundnut during their study [22]. M.A.Sanchez-Monedero revealed that nitrification is responsible for falling pH and increasing O.C. [24]. According to the micro nutrients can be supplied through organic wastes and they help in improving soil fertility resulting in sustaining plant life. Amir hossein suggested that application of organic amendments corrects micro nutrient deficiency as deficit of micro nutrients has become a limiting factor in crop productivity [2]. As beer factories produces more amounts of sludge for production of beer resulting in disposal problems. Converting sludge into fertilizer is the best and alternative way for disposal which does not create environmental problems. According to Mohimi, using of sludge as soil conditioner is the most acceptable way for disposal of industrial sludge [16]. Babel suggested that BFS can be applied for land treatment as lots of sludge is produced during manufacturing of beer [3]. Senthilraja, concluded that beer is the fifth consumed beverage in world and large amounts of sludge is produced and used as fertilizer [25]. Lots of sludge is produced everyday causing disposal problems. Beer factory sludge is a dark grey coloured solid substance possessing high COD, BOD, water retention capacity (WRC), micro organisms and many essential macro and micro nutrients useful for crop productivity. Sun dried BFS can be amended with soil directly in powder form.

II. Materials and Methods

A. Study area

The beer factory sludge (BFS) was collected from the united millennium breweries Ltd. (UMBL) is at Ranasthalam mandal,Srikakulam district, Andhra Pradesh.

Approximately 3-4 litres of sludge will be produced per one litre of beer production. In order to assess the efficiency of beer factory sludge (BFS) for the crop growth, a pot culture experiment was carried out by using different ratios of the beer factory sludge with or without farmy yard manure (FYM) at GITAM University. After characterization of beer factory sludge, then it was mixed with soil and applied to the pots at different ratios. The beer factory sludge was amended with soil at nine rates, ie, 9:1, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8, 1:9, 10:0 and soils with inorganic fertilizer (Table -1). Respective controls were also maintained to compare the results for each treatment. All the (24) pots of two categories (ie. BFS with FYM and without FYM) were allotted for two types of seeds viz., *Spinacia oleracia* and *Capsicum annum L.* In the category-1, BFS was mixed with FYM in equal parts and applied to the soil by different ratios. In the category-2, BFS was applied to soil by different ratios. One set (24 pots) were sown with *Spinacia oleracia,* 5seeds in each pot. Likewise the other set with *Capsicum annum,* 5 seeds in each pot. For irrigation equal amounts of water given to each pot at every day. 50 *(Spinacia oleracia)* and 90 (*Capsicum annum)* days were elapsed as growing period under the controlled conditions. All sets were maintained triplicates. The pots were separately maintained in which inorganic fertilizer were applied to soil in recommended proportions by the Agricultural research centre, Anakapalli, Andhra Pradesh.

B. Analysis of physico - chemical properties

The test soil samples were collected from the experimental pots during decomposition on the days of Initial 0^{th} day (before sowing of seeds), 45^{th} day and 90^{th} day (after harvesting of plants) for *Capsicum annum,* Initial 0^{th} day (before sowing of seeds), 25^{th} day and 50^{th} day (after harvesting of plants) *L.* for *Spinacia oleracia.* The test soil samples were air dried, sieved to pass through 2mm screen and stored at room temperature ($30\pm{}^{0}C$) until use. Physicochemical properties of test soil like pH, EC, OC, N, P, K (available), micro nutrients like Zn, Cu, Fe, Mn were determined by Jackson [9]. Physicochemical properties of BFS as pH, EC, OC, N, P, K (available), Zn, Fe, Cu, Mn along with COD, BOD and WRC were also determined.

C. Heavy metal analysis

The BFS was analyzed for the presence of heavy metals by using Atomic absorption spectrophotometer. The heavy metals were determined according to the standard procedures.

D. Growth and bio chemical parameters

In order to assess the effect of different amendments (BFS with or without FYM) on plant growth, plant height (root and shoot), fruit weight at harvest was measured and chlorophyll content was determined.

E. Dry weight measurement

Plants were removed carefully from the soil and the roots were washed thoroughly with tap water and dried at 105°C (WTC Binder-7200 Oven, Tuttlingen, Germany) until a constant weight was obtained.

F. Statistical analysis

All the data obtained from the treatments were applied for statistical analysis using one way analysis of variance (ANOVA) using the computer package MINITAB 12.0 on LSD 0.5% probability.

III. Results and Discussion

The present investigation has been carried out to assess the effect of different ratios of BFS with or without FYM on two plants ie, *Spinacia oleracia* (leafy vegetable) & *Capsicum annum* (vegetable). The plants were cultivated in soil along with BFS and FYM mixture (category-1), BFS (category-2) as an amendment. In experimental pots during decomposition of the BFS while plant grows indicates its utilization by the cultivated plants. The results were summarized in Table 2&3. The pH of the BFS was neutral towards alkali where as both types of categories and also in both plants also appeared neutral in different intervals. This could be mainly due to the addition of FYM in the category -1. The electric conductivity of both categories was diverse in different time intervals of decomposition. The organic carbon and nitrogen content of BFS with FYM was higher than that of BFS (Table-2&3). It has been established that many micro organisms can take up organic nutrients directly from soil and play vital symbiotic roles in plant nutrition and ecosystem functioning. Thus BFS and FYM could be a better alternative for in-organic fertilizers in agricultural applications. The total phosphorous content of the BFS with FYM was almost the same as in BFS. Furthermore, potassium and the micronutrients manganese, copper and zinc were low in BFS with FYM compared to the BFS treatment studied.

The pH of brewery waste sludge was almost neutral and it suggests that BFS can be safely applied to soil as it is the suitable pH for crop production. According to Luque, the pH of the sludges ranges from 6.5 to 11.5 [14]. Kanagachandran revealed that the differences in pH are due to raw waters [11]. Erdem have found that the BWS amendment improved pH of acidic soils and enhanced O.C, NH4+ and cation exchange capacity [17]. The pH of brewery sludge ranges between 7.12 to 7.17, which indicate its suitability as a fertilizer [19]. One of the main hurdles in the agricultural application of BFS has been the presence of heavy metals and the consequent toxic effects on crops and soil, and the leaching of heavy metals into nearby water sources. The results revealed that mercury and cadmium were well below the detection level. Water retention is a valuable property and important in soil for releasing the humidity to the plants as needed. Thus water retention of BFS was compared with BFS + FYM, and soil. During a period of fifty days, BFS demonstrated the highest water retention capacity followed by soil. This property of BFS has been linked to the high content of organic matter, the high cationic exchange capacity and other nutrients as documented by Luque [14]. Analysis of BWS recorded that it is rich in Micro nutrients like Cu, Fe, Zn, Mn. Micro nutrients in soil improves soil fertility. This report agrees with Nino [18]. Kanagachandran have found high micro nutrient level in BFS. The BWS has high water retention capacity, BOD and COD and described that BWS amended soils demonstrated the higher water retention capacity and Organic matter [11]. High rates of BOD and COD in BWS was observed by Babel [2].The results showed variations in the different BFS and FYM amendments because of the addition of stabilized manure to soil can affect soil fertility by modifying the physical, chemical and biological properties of the soil [8].

The plants cultivated in untreated control (without BFS & FYM , only soil) showed some slight deficiencies of Nitrogen, Chlorophyll during the intervals of cultivation period and these plants had lower concentrations of several minerals in comparison with plants grown in BFS &FYM amended soil. Application of BFS & FYM as soil amendment, improves the organic content and plant nutrient concentrations, which lead to increase in plant growth. There was a remarkable difference between the values of these parameters from control to test samples with different ratios of soils and beer factory waste. Amending BFS along with or without FYM in all the two categories increased available nitrogen, O.C, available potassium, EC in the soil by comparing the control soil. Contrary to this the BFS, BFS with farmyard manure amending with soil decreased the phosphate content of the soil, The increase in nitrogen and potassium may have a competitive effect against phosphorous resulting in the decrease of phosphorous. This result coincides with Ahmadi, who reported that application of high rates of nitrogen decreased the phosphorous in spinach plants [1].

Application of BFS with or without FYM also improved the plant nutrient status and growth yield. The various growth parameters (morphometrical properties) of two plants, like root length, shoot length, plant dry weight values were presented in (Fig.1). The application of brewery factory sludge with FYM had a marked difference in *Spinacia oleracia,* the plant height but in case of sole BFS showed non-significant result. The maximum plant height (50cm) was recorded in the A3 treatment (category -1) and 48cm (C3 treatment) was recorded in category -2. The minimum plant height (22 cm) was recorded in control (A10, C10treatment) of both categories. The highest value of chlorophyll content of leaves (1.768 Ug/ml) was recorded in the A3 treatment that received from mixture of brewery factory waste, FYM and brewery factory waste (1.767 Ug/ml) at the ratio 7:3 (C3 treatment). The lowest of chlorophyll content of leaves (0.314Ug/ml) was recorded in the A10, C10 treatment (control soil) of both categories. The dry weights of *Spinacia oleracia* plants cultivated in BFS with / without FYM mixture were recorded. The maximum plant dry weight (3.2gm) was recorded in the A3 treatment (category -1) and 3.0gm (C3 treatment) was recorded in category -2. The minimum plant dry weight (1.0 cm) was recorded in control (A10s, C10s treatment) of both categories.

The application of brewery factory sludge with FYM had a marked difference in *Capsicum annum,* the plant height but in case of sole BFS showed non-significant result. The maximum plant height (74cm) was recorded in the B3 treatment (category -1) and 69cm (D3 treatment) was recorded in category -2. The minimum plant height (52 cm) was recorded in control (B10, D10treatment) of both categories. The highest value of chlorophyll content of leaves (0.998Ug/ml) was recorded in the B3 treatment that received from mixture of brewery factory waste, FYM and brewery factory waste (0.996 Ug/ml) at the ratio 7:3 (D3 treatment). The lowest of chlorophyll content of leaves (0.424Ug/ml) was recorded in the B10, D10 treatment (control soil) of both categories. Senthilraja observed increase in chlorophyll content in sunflower and sesame leaves by the usage of BWS as fertilizer [25]. The dry weights of *Capsicum annum* plants cultivated in BFS with / without FYM mixture were recorded. The maximum plant dry weight (21.2gm) was recorded in the A3 treatment (category -1) and 19.3gm (C3 treatment) was recorded in category -2. The minimum plant dry weight (15.0 cm) was recorded in control (A10s, C10s treatment) of both categories.

The maximum fruit weight (1.8) of chilly plant was observed in plants cultivated in the treatment of B3 (7:3) with BFS + FYM mixture and minimum fruit weight (0.6) in the control soil (Table 2). Addition of FYM to BFS had a positive effect on weight of chilly plant as well as BFS to BFS alone did not demonstrate any significant improvements in these parameters. Previous work by Luque also demonstrated a significant correlation between the applied dose of BWS and yields in corn, sorghum and peanuts grown on test areas [14]. The analysis of selected content of nutrients in chili plants cultivated with BFS alone was almost the same as with the category -1 studied. The overall findings demonstrated that BFS on its own can also be utilized as a fertilizer. The core purpose for studying soil fertility dynamics under amendments and cropping systems is to minimize nutrient losses to the environment and allow more accurate recommendations for sustainable plant production, thereby increasing the productivity of vegetables (both leafy vegetables and vegetables). Soil fertility plays such a key role in tropical cropping systems that its study with respect to management practices has become necessary. Thus the present study revealed that the crop growth with brewery factory waste with farmyard manure improved the performance of crop up to vegetative stage than the BFS alone. Similar observations were reported by Orhue [20].

The physico-chemical properties of soil and plant biomass of the soil treated with inorganic fertilizer have shown better results than control soil and the amendments at lower amounts of BFS+FYM, BFS, i.e., upto 20% by volume. The treatments above 20% by volume have showed good results in comparison with inorganic fertilizers in all the three categories. Keith Paustian studied the effects of organic manures and fertilizer additions on soil dynamics [12]. Organic amendments had strongly influenced 'N' uptake and crop productivity than inorganic fertilizer additions. Ortas used organic and inorganic fertilizers for production of pepper, wheat and maize [21]. The biomass production increased as soil organic carbon increased with the application of organic fertilizers than inorganic fertilizers.

In category-1, BFS along with farmyard manure influenced the plant growth. Sajid masood revealed that application of farmyard manure to soil helped in increasing plant height, root and shoot yield [23]. Blum found increased grain yield in sorghum with farmyard manure treated soil [4]. Enhanced growth in rice was obtained by addition of farmyard manure along with inorganic fertilizer. In Category-2, BWS alone treated with soil and the increment levels in plant biomass has been observed in comparison with control soil. Senthilraja described that a positive effect was found on growth and physiological changes in Maize, Sunflower and Sesame [25]. Cihat Kutuk applied beer factory sludge to sugar beet crops [5] [6]. Leaf and root yield has been increased by the macro and micro nutrient value of beer factory sludge. Ajmal yielded significant results in agricultural crop plants by amending brewery sludge with soil [15]. In comparison of the biomass of two plant varieties of the 2 categories, Category-1 showed enhanced growth followed by Category-2. But significant differences have not been observed. So, brewery sludge can be directly applied as fertilizer. This result agrees with Kanaga chandran, who reported that addition of BWS with FYM compost did not demonstrated any significant improvement in yield parameters [11].

IV. Conclusion

The results presented in this work have shown that BFS with FYM can be a valuable source of nutrients for plants than the BFS alone. From the detailed analyses and interpretation of data on soil fertility parameters (with reference to OC, N, P & K) under BFS amended soils in this study, the following conclusions can be drawn. Efficient nutrient management in BFS with FYM could lead to buildup of soil nutrients over time. Another beneficial characteristic of BFS is pH buffering. Through repeated applications, a pH of 7.0 is in reach of nearly any soil. Soil organic carbon content gives a picture of large changes in soil fertility over long term. BFS has shown to improve the growth of all the plants under test, as well as resulted in increase yields. BFS not only increased yields but also improves soil quality, and reduces soil acidity. The research provided a systematic monitoring of soil physico-chemical properties as affected by specific nutrient management practices in BFS amended soils. Brewery sludge can be directly amended with soil without any further treatment. Composting and Co-Composting is also not required for BFS. Sun dried BFS can be directly applied to soil as it is a high source of nutrients and no detrimental effects in soil and plant because the heavy metals were below detectable levels in the present study.

Table -2 Comparison of fruit weight of chilly plant under two categories

Category 1(BFS+FYM)	Fruit weight(gm)	Category 2(BFS)	Fruit weight(gm)
B1	1.0	D1	0.9
B2	1.6	D2	1.2
B3	1.8	D3	1.6
B4	1.0	D4	0.9
B5	-	D5	-
B6	-	D6	-
B7	-	D7	-
B8	-	D8	-
B9	-	D9	-
B10	0.6	D10	0.6
B11	-	D11	-
BI	1.6	DI	1.6

Table – 1 Pattern of arrangement of test pots of Spinacia oleracia & Capsicum annum L

Treatment	Sample code	Category -1		Sample code	Category-2	
		Soil (gm)	BFS+FYM (gm)		Soil (gm)	BFS (gm)
T1(9:1)	A1, B1	2700	300	C1, D1	2700	300
T2(8:2)	A2, B2	2400	600	C2, D2	2400	600
T3(7:3)	A3, B3	2100	900	C3, D3	2100	900
T4(6:4)	A4, B4	1800	1200	C4, D4	1800	1200
T5(5:5)	A5, B5	1500	1500	C5, D5	1500	1500
T6(4:6)	A6, B6	1200	1800	C6, D6	1200	1800
T7(3:7)	A7, B7	900	2100	C7, D7	900	2100
T8(2:8)	A8, B8	600	2400	C8, D8	600	2400
T9(1:9)	A9, B9	300	2700	C9, D9	300	2700
T10(Control soil)	A10, B10	3000	-	C10,D10	3000	-
T11(0:10)	A11, B11	-	3000	C11, D11	-	3000
Control+INF)	AI, BI	3000+INF	-	CI, DI	3000+INF	-

Bfs-Beer Factory Sludge, Fym-Farmyard Manure, Inf-Inorganic Fertilizer, A& C-Spinacia Oleracia, B&D- Capsicum Annum L

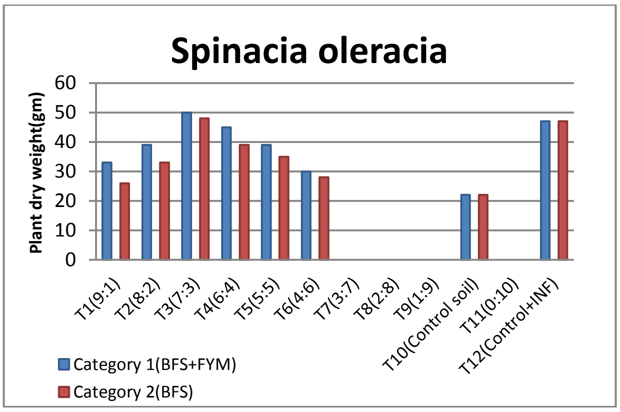


Fig.1(a)

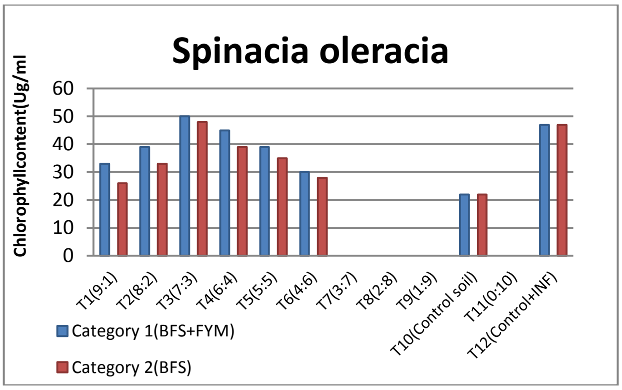


Fig.1(b)

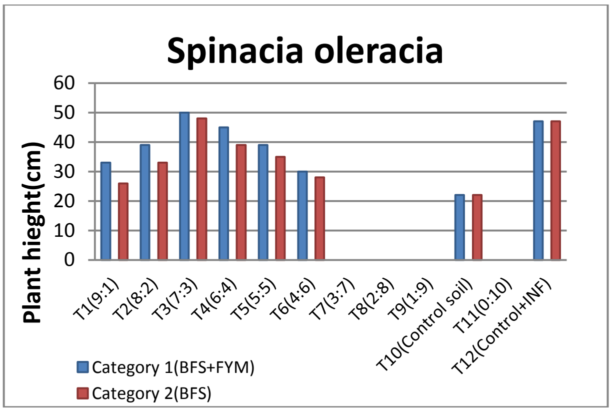
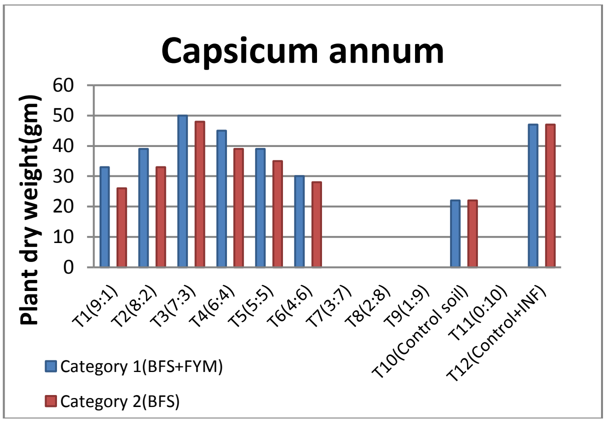


Fig.1(c)



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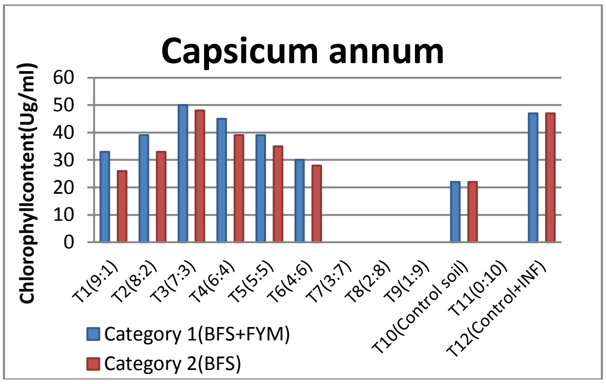

Fig.1(e)

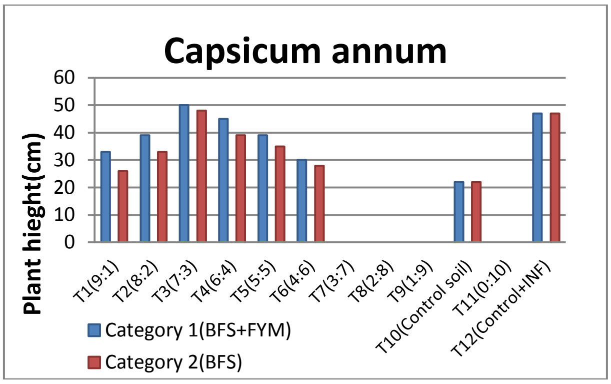

Fig.1(f)

Fig.1 Summary of results of germinated Spinacia oleracia and capsicum annum seeds in experimental pots

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