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Effect of Biofertilizers and different sources of organic manures on quality parameters and economics of amaranth (*Amaranthus* spp.) cv. Arka Suguna

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Abstract
A field experiment on "Effect of biofertilizers and different sources of organic manures on quality parameters and economics of amaranth (*Amaranthus* spp.) cv. Arka Suguna" was carried out during late *Kharif* season 2016 at College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat). Total fifteen treatment combinations comprising of biofertilizers *viz*. (*Azotobacter*, *PSB*, *Azotobacter* + *PSB*) and Organic manure *viz*. FYM, Vermicompost, Caster Cake, Poultry Manure, Neem Cake were tried in factorial randomized block design with four replications. The results revealed that among different biofertilizers, chlorophyll a, chlorophyll b, total chlorophyll, carotenoid content, protein Content and iron content were recorded with treatment b_3 (*Azotobacter* + *PSB*). In case of different sources of organic manures, chlorophyll a, chlorophyll b, total chlorophyll, carotenoid content, protein content and iron content were observed with treatment f_2 (Vermicompost)

Keywords: Arka Suguna, amaranth, quality, economics, Biofertilizer, organic manure

Introduction
Amaranth (*Amaranthus* spp.) originated in America and it is one of the oldest food crops in the world, with evidence of its cultivation reaching back as far as 6700 BC. The genus Amaranth consists of nearly 60 species; most of them are cultivated as leafy vegetables, grains or ornamental plants, while others are weeds. It is the most common leafy vegetable grown during summer and rainy season in India. The present production and consumption of vegetables in the country are very inadequate being only about one-fourth to one-third of requirement.

The population being increased without check is the main handicap in our progress with the result of that food shortage, malnutrition and poverty occurs. Therefore, there is an urgent need to increase the vegetable production by bringing more area under vegetable cultivation and adoption of improved technologies. However, due to heavy pressure of industrialization and urbanization, there is literally no scope to increase the area under vegetables therefore the only way is to increase the production of vegetables per unit area by scientific cultivation.

Van Soest *et al*. (1991) [15] have reported leafy vegetables to contribute significant amount of vitamins and minerals to the human diet and are also excellent sources of protein, carotene (vitamin A), iron and ascorbic acid (vitamin C) and this group of vegetables are also referred to as "mines of minerals". It is in this back drop that a field experiment was attempted to assess the performance of leafy vegetables. For maintaining proper physique, recommendation have been made by the ICMR is 300 g of total vegetables per day per head, out of which 125 g of leafy, 100 g of roots and 75 g of other vegetables. Therefore, amaranth plays an important role for continuous supply of leafy vegetables in summer. The leaves and tender stem of amaranth are rich in protein, minerals, carbohydrates, vitamin 'A' and 'C'. It is also a rich source of magnesium, phosphorus, sodium, riboflavin, potassium, sulphur and nicotinic acid. There are two varieties based on leafy colour *i.e.* green and red leaf. The most common amaranth popular in India are *A. tricolor*, *A. dubius* and *A. blitum*. Amaranth leaves as well as the softest portions of the shoots are usually boiled in water and then cooked with onions, tomatoes, oil and other additives of modern culinary delights. Its leaves are combined with condiments to prepare soup. The flavour of raw and cooked vegetable amaranth was reported as equal to or better than spinach or other similar greens.

The soil condition is one of the most important factor to improve the productivity and quality of produce. Soil must have favorable physical, chemical nutritional and biological conditions. It is worth to mention that good effect of organic nitrogen treatment as well as bio-fertilizer inoculation in increasing root growth parameters may be mainly due to improving root rhizosphere condition, *i.e.* soil structure and moisture content. In addition, adding of organic manures and bio-fertilizer had beneficial return to increase the population of microorganisms especially in the surface layer-root rhizosphere that produce substances, which stimulate plant growth. Many investigators studied the role of organic manures, which incorporated with bio-fertilizer as stimulating the plant growth, yield and quality of plant part.

Organic fertilizers also had a positive effect on soil microbial population resulting in enhanced soil biomass, carbon, nitrogen content and dehydrogenase activity. To compensate the short supply and to mitigate recent price hike in inorganic fertilizers, use of indigenous sources like farmyard manure, vermicompost, poultry manure, neem cake and castor cake, etc. should be necessary. Use of organic manures not only helps to sustain crop yields but also plays a key role in improving the physical, chemical and biological properties and also increases the efficiency of applied fertilizers (Singh and Biswas, 2000) [10].

FYM is principle source of organic matter in our country. Use of well decomposed FYM alone or in combination with Bio-fertilizer helps in proper supply of nutrition and maintaining soil health. It supplies all the essential plant nutrients, which improve the physic-chemical properties, increases water holding capacity and encourages the soil microbial activities. FYM is also advantageous for its residual value, it contains about 0.50 % N, 0.20 % P_2O_5 and 0.50 % K_2O.

Castor cake is produce by crushing castor seeds in expeller to extract oil from it in a control temperature with help of steam; it contains about 5.8 % N, 1.8 % P_2O_5 and 1.0 % K_2O.

Vermicompost is adopted as organic manure produced by use of earth worms. Earth worms play an important role in organic farming by vermin technology is a cost effective method for converting all types of bio-wastes in to nutrient rich organic manure. It modified physical, chemical and bio-chemical properties of soil. It contains about 1.60 % N, 2.20 % P_2O_5 and 0.67 % K_2O.

Poultry manure is nutrient rich organic manure, since in birds, liquid and solid excreta are excreted together resulting in a no urine loss. Poultry manure ferments very quickly. Poultry manure contains 2.87 % N, 2.93 % P_2O_5 and 2.35 % K_2O.

Neem cake is the by product obtained in the process of cold pressing of neem tree fruits and kernels and the solvent extraction process for neem oil cake. It is a potential source of organic manure, which contains 5.2% N, 1.0%P_2O_5 and 1.4% K_2O.Neem cake as organic manure protects plant roots from nematodes, soil grubs and white ants probably due to its residual limonoid content. It also acts as natural fertilizer with pesticidal properties and also reduces alkalinity in soil, as it produces organic acids during decomposition. Being totally Nautral, it is compatible with soil microbes improves and rhizospher microflora and hence ensures fertility of soil. Neem cake improves the organic matter content of the soil, helping improve soil texture, water holding capacity, and soil aeration for better root development.

Biofertilizers are carrier-based inoculants containing cells of efficient strains of specific microorganisms (namely bacteria) used by farmers for enhancing the productivity of the soil by fixing atmospheric nitrogen or by solubilizing soil phosphate or by stimulating plant growth for synthesis of growth promoting substances. In recent years, free living bacteria (*Azotobacter*), associatitve (*Azospirillum*) and symbiotic (*Rhizobium*) bacteria and phosphate solubilizing one (*Bacillus megaterium, B. polymyxa* and *Ps. striata*) are gaining much popularity. Such practices are being encouraged to save the chemical fertilizers, natural economy and the environment. Application of NPK supplemented with organic manures and Biofertilizers in adequate amounts with proper proportion is one of the factor which controls the growth and development of Amaranth.

Therefore, looking to all these factors, combinations of biofertilizer and organic manures in amaranth is the need of the time. Keeping into consideration the above facts in mind an experiment entitled "Effect of Biofertilizers and different sources of organic manures on quality parameters and economics of amaranth (*Amaranthus* spp.) cv. Arka Suguna" was planned and performed.

Materials and methods

The field experiment was conducted in Factorial Randomized Block Design as described by Panse and Sukhatme (1985) with three replication and plot size of 1.5 m^2 (Spacing 30 cm X 15 cm) on amaranth cv. Arka Suguna at College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan during late *kharif* 2016 under field condition. Total fifteen treatment combinations comprising three level of biofertilizers *viz*. (b_1) (*Azotobactor*), (b_2) (PSB) and (b_3) (*Azotobactor + PSB*) application as a seed treatments and five levels of organic manures *viz*. (f_1) (FYM 25 t/ha), (f_2) (Vermicompost 6.25 t/ha), (f_3) (Castor Cake 2.32 t/ha), (f_4) (Poultry Manure 3.48 t/ha) and (f_5) (Neem Cake 1.92 t/ha) were tried in factorial randomized block design with four replications. Observations were recorded periodically in relation to quality parameters using standard techniques.

Results and Discussion

1. Effect of Biofertilizers and different sources of organic manures on Chlorophyll a (mg/g), chlorophyll b (mg/g) and total chlorophyll (mg/g)

Influence of Biofertilizers and different sources of organic manures on chlorophyll contents in leaves are presented in table 1 graphically represented in fig. 1.

Effect of Biofertilizers on chlorophyll-a, chlorophyll-b and total chlorophyll content in leaves were found significant. Significanly maximum chlorophyll-a (0.79 mg), chlorophyll-b (0.77 mg) and total chlorophyll content (1.56 mg) was found with treatment b_3 (*Azotobactor + PSB*). The minimum chlorophyll-a (0.71mg), chlorophyll-b (0.68 mg) and total chlorophyll content (1.40 mg) in leaves was obtained with treatment b_1 (*Azotobactor*). These finding are in accordance with the findings of Singh *et al*. (2014) [9] in chilli, Hussein *et al*. (2015) [2] in dill seed and Mondal *et al*. (2017) [6] in mustard.

Influence of different sources of organic manures on chlorophyll-a was found to be not significant. The effect of different sources of organic manures on chlorophyll-b and total chlorophyll content in leaves of amaranth was found significant. The highes chlorophyll-b (0.74 mg) and total chlorophyll content (1.52 mg) was found under treatment f_2 (Vermicompost). The minimum chlorophyll-b (0.70 mg) and total chlorophyll content (1.43 mg) in leaves was observed with treatment f_3 (Caster Cake). These finding are in accordance with the findings of Tayade *et al*. (2012) [13] in amaranth, Lal *et al*. (2012) [12] in coriander, Singh *et al*.

(2014) [9] in chilli, Baliah *et al*. (2015) [1] in okra, Patidar *et al*. (2016) [8] in coriander.

The interaction effect between different biofertilizers and different sources of organic manures on chlorophyll a, chlorophyll b and total chlorophyll were found non significant.

2. Effect of bio fertilizers and different sources of organic manures on Carotenoid Content (mg/g)

Effect of biofertilizers on Carotenoid Content (mg/g) was found significant variation. The significantly maximum Carotenoid Content (2.91 mg/g) was recorded with treatment b_3 (*Azotobacter* + *PSB*) and it was found statistically superior over all other treatments. The Minimum carotenoid content was recorded with treatment b_1 (2.49 mg/g). These finding are in close accordance with the findings of Sing *et al.* (2012) [11] in kasurimethi, Kumar *et al*. (2015) [3] in cabbage and Mondal *et al.* (2017) [6] in mustard.

The effect of organic manure on carotenoid content (mg/g) was showed significant variation. The maximum carotenoid content (2.82 mg/g) was obtained with treatment f_2 (Vermicompost) and it was found statistically at par with treatments f_4 (2.76 mg/g). The minimum carotenoides content (2.65 mg) was observed under treatment f_1 (FYM). These finding are in Conformity with the findings of Upadhyay *et al.* (2012) [14] in cabbage, Singh *et al.* (2014) [9] in chilli and Baliah *et al.* (2015) [1] in okra.

In case of interaction effect of between biofertilizeres and different sources of organic manures on carotenoid Content (mg/g) could not showed significant effect.

3. Effect of biofertilizers and different sources of organic manures on protein content (%)

The influence of biofertilizers on protein content (%) was found significant. The significantly maximum Protein Content (3.07 %) was recorded with treatment b_3 (*Azotobactor* + *PSB*) and it was found significantly superior over all other treatments. The minimum protein content was found with treatment b_1 (2.90%). These findings are in close Accordance with the findings of Singh *et al*. (2012) [11] in kasurimethi, Sonali *et al.* (2012) [12] in fenugreek, Kumar *et al.* (2015) [3] in cabbage and Mondal *et al*. (2017) [6] in mustard.

The effect of organic manures on Protein content (%) was found significant. The maximum Protein content (3.16 %) was recorded with treatment f_2 (Vermicompost) and minimum protein content (%) was obtained under treatment f_3 (2.90%). These findings are in close conformity with the result reported by Mekki and Ahmed (2005) [5] in Soyabean, Upadhyay *et al.* (2012) [14] in cabbage, Singh *et al.* (2014) [9] in chilli and Baliah *et al.* (2015) [1] in okra.

In case of interaction effect between biofertilizeres and different sources of organic manures on Protein content (%) was found not significant

4. Effect of biofertilizers and different sources of organic manures on iron content (mg/100 g)

The influence of biofertilizers on iron content (mg/100 g) was found non-significant. Whereas, maximum iron content (2.91) was found in treatment b_3 (*Azotobactor* + *PSB*) treatment and minimum (2.84) was observed under b_1 (*Azotobactor*) treatment.

The influence of organic manures on iron content (mg/100 g) was found non-significant. Whereas, maximum iron content (2.91) were found in f_2 (Vermicompost) and f_4 (Poultry Manure) treatments and minimum (2.83) in f_3 (Castor cake) treatment.

In case of interaction effect between biofertilizeres and different sources of organic manures on iron content (mg/100g) was also statistically not influenced.

2 Economics

The economics indicating cost of cultivation, gross return, net return and benefit cost ratio under different biofertilizers and organic manure are furnished in Table 2.

The results revealed that among the biofertilizers, application of b_3 (*Azotobactor* + PSB) recorded maximum gross return of ₹236300 ha^{-1}, net return of ₹207840 ha^{-1} and benefit cost ratio *i.e*. 1: 8.30 whereas, control b_1 recorded minimum gross return of ₹199240 ha^{-1}, net return of ₹170960 ha^{-1} and benefit cost ratio *i.e.*1*:*7.04.

Data presented in table 2 revealed that among different organic manures treatments, application of f_2 (Vermicompost) recorded maximum gross return of ₹239180 ha^{-1}, net return of ₹179380 ha^{-1}while maximum benefit cost ratio recorded in f_4 (Poultry manure) *ie*.4.80. Whereas, minimum gross return of ₹201440 ha^{-1}recorded in f_3 (Caster cake), minimum net return of ₹154260 ha^{-1} recorded in f_1 (FYM) and benefit cost ratio *ie*.1:3.87 was observed in f_5 (neem cake).

Conclusion

The results indicated that the application of *Azotobactor* + PSB @1.5 lit./kg and Vermicompost 6.25 t/ha is beneficial for getting better quality parameters and economics of amaranth cv. Arka Suguna under North Gujarat conditions.

Table 1: Effect of biofertilizers and different sources of organic manures on chlorophyll a (mg/g), chlorophyll b (mg/g), total chlorophyll (mg/g), Carotenoid Content (mg/g), Protein Content (%) and Iron Content (mg/100 g).

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Carotenoid Content (mg/g)	Protein Content (%)	Iron Content (mg/100 g)
Biofertilizers (B)						
b_1 (*Azotobactor*)	0.71	0.68	1.40	2.49	2.90	2.84
b_2 (*PSB*)	0.74	0.72	1.47	2.73	3.01	2.87
b_3 (*Azotobactor* + *PSB*)	0.79	0.77	1.56	2.91	3.07	2.91
S Em±	0.009	0.005	0.01	0.02	0.02	0.02
CD at 5 %	0.02	0.01	0.03	0.06	0.05	NS
Organic Manures (F)						
f_1 (FYM)	0.74	0.72	1.46	2.65	2.93	2.84
f_2 (Vermicompost)	0.77	0.74	1.52	2.82	3.16	2.91
f_3 (Caster Cake)	0.72	0.70	1.43	2.64	2.90	2.83
f_4 (Poultry Manure)	0.76	0.73	1.50	2.76	3.03	2.91
f_5 (Neem Cake)	0.74	0.72	1.48	2.67	2.97	2.87
S Em±	0.01	0.007	0.02	0.02	0.02	0.02

CD at 5 %	NS	0.019	0.04	0.08	0.07	NS
Interaction (B x F)						
S Em±	0.019	0.011	0.026	0.049	0.046	0.044
CD at 5 %	NS	NS	NS	NS	NS	NS
CV %	4.47	2.73	3.1	3.14	2.64	2.67

Table 2: Economics and benefit cost ratio of amaranths for different treatments

Treatments	Yield / ha (q)	Gross returns (₹) / ha)	Total cost of cultivation (₹) / ha)	Net returns (₹)/ha)	Benefit Cost ratio
Biofertilizers (B)					
b_1(*Azotobacter*)	99.62	199240	28280	170960	7.04
b_2 (*PSB*)	106.51	213020	28280	184740	7.53
b_3 (*Azotobacter* + *PSB*)	118.15	236300	28460	207840	8.30
Organic manures (F)					
f_1 (FYM)	103.68	207360	53100	154260	3.90
f_2(Vermicompost)	119.59	239180	59350	179830	4.02
f_3 (Caster cake)	100.72	201440	45537.50	155902.50	4.42
f_4(Poultry manure)	109.54	219080	45600	173480	4.80
f_5 (Neem cake)	106.54	213080	55050	158030	3.87

The selling price of amaranth was ₹20/kg.

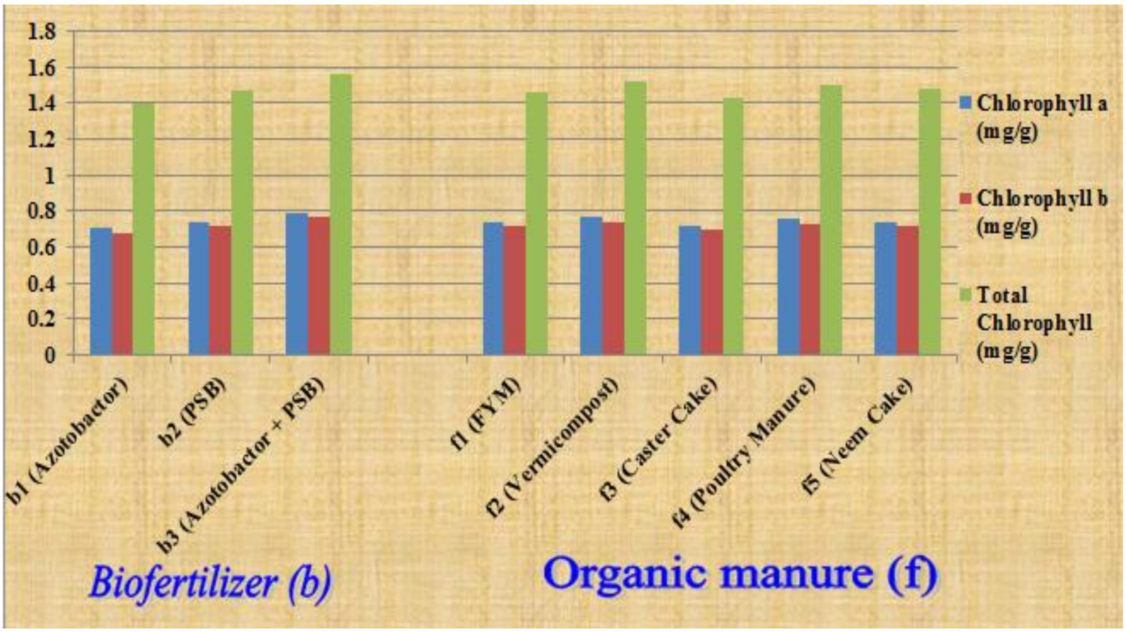

Fig 1: Effect of bio fertilizers and different sources of organic manures on chlorophyll a (mg/g), chlorophyll b (mg/g) and total chlorophyll (mg/g).

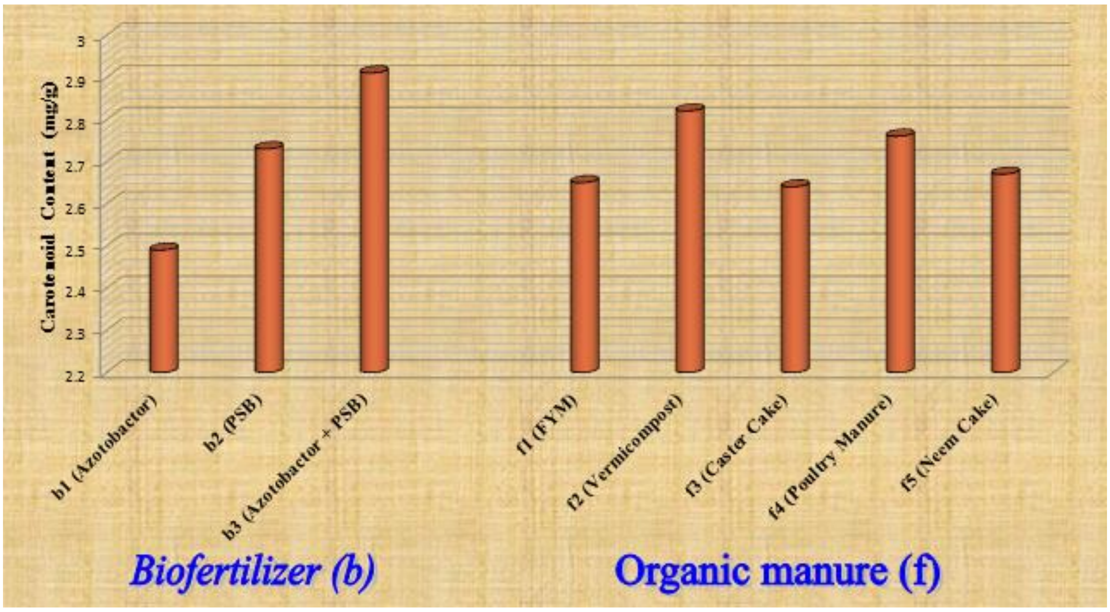

Fig 2: Effect of bio fertilizers and different sources of organic manures on carotenoid content

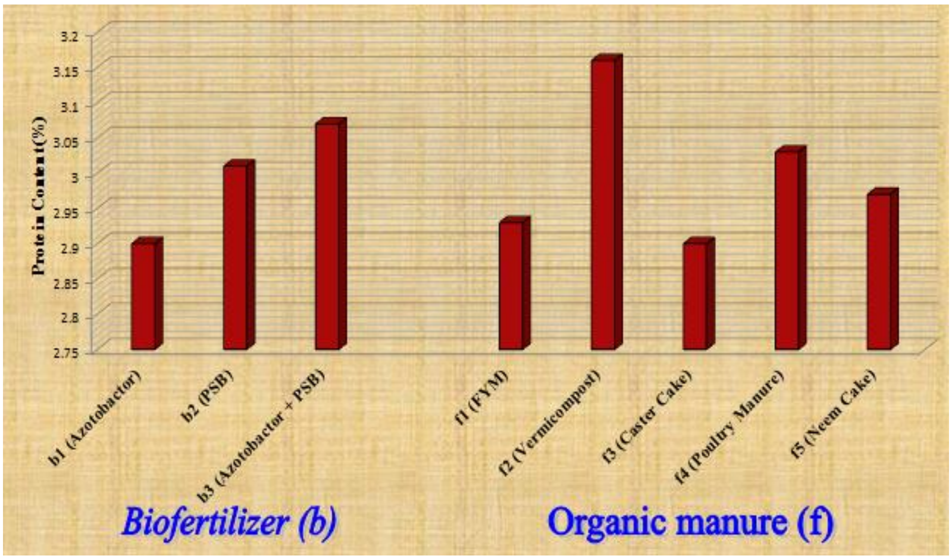

Fig 3: Effect of bio fertilizers and different sources of organic masures on protein content (%)

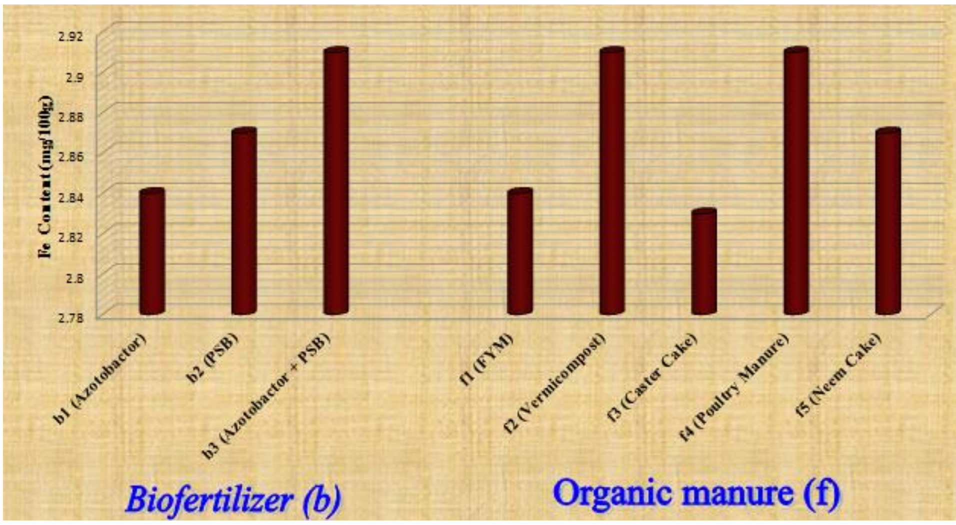

Fig 4: Effect of bio fertilizers and different sources of organic manures on Fe content (mg/100g)

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