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Effect of organics on growth, yield and economics on summer groundnut

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Abstract
An experiment was conducted during summer-2019 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar having loamy sand soil to study the nutrient management in summer groundnut (*Arachis hypogaea* L.) under organic farming. The experiment was laid out in randomized block design and replicated four times with ten treatments. Application of 1.0 t/ha castor cake + Rhizobium + PSB being at par with FYM 5 t/ha + castor cake 0.5 t/ha + Rhizobium + PSB recorded significantly higher plant height at 60 DAS (28.9 cm) and at harvest, number of branches per plant, dry matter per plant over rest of the treatments. Further, it also significantly increased pod yield/plant, pod (1687 kg/ha) and haulm yield (2285 kg/ha), shelling percentage but was at par with the treatments FYM 5 t/ha + castor cake 0.5 t/ha + Rhizobium + PSB and FYM 10 t/ha + Rhizobium + PSB. Plant height at 30 DAS and number of kernels/plant didn't differ significantly Rhizobium + PSB. Maximum net realization and benefit: cost ratio (BCR) were registered with castor cake 1.0 t/ha + Rhizobium + PSB. Higher yield and net realization can be secured with the application of either 1 t/ha castor cake or 5 t/ha FYM + castor cake 0.5 t/ha along with inoculation of Rhizobium + PSB under organic farming.

Keywords: Economics, Agronomy Instructional Farm, summer-2019

Introduction
Groundnut (*Arachis hypogaea* L.) is considered one of the most important leguminous crops, cultivated in diverse climatic conditions around the country. It is low price commodity, but valuable source of all the nutrients. It contains 48 to 50 per cent of oil and 26 to 28 per cent of protein and also rich source of dietary fibres, minerals and vitamins. Almost every part of groundnut is commercially valued. Groundnut seeds are consumed directly as raw, roasted or boiled (meal) and the oil extracted from the seeds is used as culinary oil. The oil is used in making margarine, crackers/cookies, candy, salted groundnut, salad oils, nut chocolates, sandwiches and soaps. About two thirds of world production crushed groundnut for oil. Furthermore, groundnut plants as haulm and deoiled cake are used as animal feed. The optimization of the mineral nutrition is the key to optimize the production of groundnut, as recently released high yielding groundnut varieties remove still more nutrients from the soil. On contrary, groundnut farmers, most part of semi-arid region use very less fertilizer and same time only one or two nutrient fertilizers (straight fertilizers) resulting in severe mineral nutrient deficiencies due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. India is the world's largest producer of groundnut where nutritional disorders cause yield reduction from 30 to 70 per cent depending upon the soil types. This, it is high time to look into the mineral nutrition aspects of groundnut for achieving high yield and advocate the suitable package of practices for optimization of yield (Singh, 2004). The term "organic farming" refers to produce a farm product with excluding use of agrochemicals and seeds of genetically modified organism. So, that eliminate any harmful residual effect occurred after consuming organic food. Organically produced groundnut contained less cholesterol than conventionally produce groundnuts which is good for heart patient. Study also showed that organically produced groundnut consumed in daily food improves vitamins (Vitamins 'E' and 'B' Complexes), polyphenols and micronutrients (iron and zinc) and also not any adverse effect on digestion system. The holistic analyses showed that the protein (29.6 g/100 g), fat (48 g/100 g) and iron (2.6 mg/100 g) content in organic groundnut was higher than inorganic groundnut (Venkatasubramanian, 2011) [20]. The application of organic manures *viz.*, FYM and castor cake may serve the source of major (N, P and K) and micronutrients (Fe, Mo and Zn *etc*.). Addition of organic manure in the soil is not only act as source of nutrient, but also influences its availability.

It improves physical and chemical properties and health of soil such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients, increase in Cation Exchange Capacity (CEC), stimulation of soil flora and fauna *etc*. On an average, FYM contains 0.5% N, 0.17% P_2O_5 and 0.55% K_2O. Castor cake is not used as animal feed as it contains a toxic alkaloids ricinine and ricin. It widely used as concentrated organic manure. Castor cake also supply micronutrients, improve physical properties of soil, immobilize toxic elements like Al and promote Mo activity (Lima *et al.*, 2011) [11]. Bio-fertilizers are inexpensive and eco-friendly. It is a long-term sustainable perspective and should not be thought for a short-term gain. Application of effective and competent strains of bio-fertilizers can improve the yield of groundnut on a sustainable basis by improving the nutrient supply, creating healthy soil environment and suppressing soil-borne pathogen.

Material and Methods

An experiment was conducted during summer-2019 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar having loamy sand soil to study the nutrient management in summer groundnut (*Arachis hypogaea* L.) under organic farming. The experiment was laid out in randomized block design and replicated four times with ten treatments *viz*., T_1: FYM 5 t/ha, T_2: FYM 5 t/ha + *Rhizobium* + PSB, T_3: castor cake 0.5 t/ha, T_4: castor cake 0.5 t/ha + *Rhizobium* + PSB, T_5: FYM 10 t/ha, T_6: FYM 10 t/ha + *Rhizobium* + PSB, T_7: castor cake 1.0 t/ha, T_8: castor cake 1.0 t/ha + *Rhizobium* + PSB, T_9: FYM 5 t/ha + castor cake 0.5 t/ha and T_{10}: FYM 5 t/ha + castor cake 0.5 t/ha + *Rhizobium* + PSB. Groundnut variety TG-37 was used as test crop. The soil of experimental field was loamy sand in texture, low in organic carbon (0.23%) and available nitrogen (142.5 kg/ha), medium in available phosphorus (43.41 kg/ha) and available potash (253.02 kg/ha) with soil pH of 7.70. Groundnut seeds (120 kg/ha) were sown at a row distance of 45 cm and 10 cm plant to plant distance. Various growth and yield attributing characters of the crop were measured and studied during the course of investigations. Other management practices were followed as recommended.

Results and Discussion

Growth parameters

Plant Height (cm)

Plant height measured at 30 and 60 DAS and at harvest of the crop significantly influenced by nutrient management treatments and presented in Table 1. Plant height at 30 DAS was found non-significant due to different organic sources for nutrients in groundnut. However, numerically an application of FYM 5 t/ha + castor cake 0.5 t/ha + *Rhizobium* + PSB recorded tallest plant (17.1 cm) at 30 DAS. An application of FYM or castor cake at lower dose with or without bio-fertilizers recorded statistically similar plant height at 60 DAS. Similarly, at higher dose of FYM (10 t/ha) with or without inoculation of Rhizobium + PSB (26.1 and 23.5 cm) recorded statistically equal plant height at 60 DAS. Though, at higher dose of castor cake (1.0 t/ha) with inoculation of *Rhizobium* + PSB proved significantly effective in increasing plant height at 60 DAS (28.9 cm). Integration of FYM + CC either with or without bio-fertilizers recorded statistically equal plant height at 60 DAS (27.3 cm and 25.4 cm).

Similarly, addition of FYM at 5 t/ha and castor cake 0.5 t/ha either with or without bio-fertilizers recorded statistically equal plant height at harvest (40.9 cm and 38.0 cm). An application of FYM and CC at higher rate *i.e.*, 10 t/ha and 1.0 t/ha, respectively, along with inoculation of *Rhizobium* + PSB produced statistically equal plant height at harvest except CC 1 t/ha + *Rhizobium* + PSB. Though, integration of FYM 5 t/ha and CC 0.5 t/ha along with *Rhizobium* + PSB recorded significantly higher plant height (40.9 cm) of groundnut at harvest and at par with FYM 5 t/ha + CC 0.5 t/ha (38.0 cm). Among all the treatments application of CC 1.0 t/ha + *Rhizobium* + PSB produced tallest plant at harvest (43.4 cm) and was at par with FYM 10 t/ha + *Rhizobium* + PSB (35.3 cm) and FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (40.9 cm). This indicated that bio-fertilizers play significant role in increasing plant height of groundnut at harvest. Rhizobium bacteria have the capacity to fix atmospheric nitrogen to soil and make it available to plant. Phosphorus solubilizing microorganisms reserved in available form of readily hydrolyzes organic phosphate and degrade them in the soil through production of organic acids. Seed inoculation with *Rhizobium* + PSB increased plant height.

Table 1: Effect of different treatments on plant height of groundnut

Treatments			Plant height (cm)		
			At 30 DAS	At 60 DAS	At harvest
T_1	:	FYM 5 t/ha	16.1	22.0	33.0
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	16.6	23.1	34.7
T_3	:	Castor cake 0.5 t/ha	16.7	22.9	34.4
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	16.7	23.	35.5
T_5	:	FYM 10 t/ha	16.5	23.5	35.3
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	16.9	26.1	39.6
T_7	:	Castor cake 1 t/ha	16.6	24.6	36.9
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	17.0	28.9	43.4
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	16.8	25.4	38.0
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	17.1	27.3	40.9
		S.Em. (±)	0.75	0.88	1.60
		C.D. at 5%	NS	2.6	4.6
		C.V. %	9.0	7.13	8.62

It might be attributed to multifarious role of castor cake and FYM in terms of nutrients supply as well as improvement in physical, chemical and biological properties of soil which finally reflected on growth of plant. The PSB like *Pseudomonas* and *Bacillus* also enhances the availability of phosphorus to the plant by converting inherent insoluble phosphorus into soluble form. Phosphorous also helpful for root setting in early stage of plants leads to more nutrients availability resulted in better growth. The better growth of plant resulted into increased in plant height. The findings are

in agreement with those reported by Zalate and Padmini (2009) [21], Akbari *et al*. (2011) [1], Sharma *et al.* (2013) [18], Kumar *et al.* (2012) [10], Chaudhary *et al*. (2015) [7], Alsamowal *et al*. (2016) [2] and Bhutadiya *et al*. (2019) [4] in groundnut.

Number of branches per plant at harvest

Data presented in Table 2 revealed that application of FYM and CC at lower rate either with or without bio-fertilizers did not differ significantly among each other with respect to number of branches per plant. On the other hand, an application of FYM and CC at higher rate with and without bio-fertilizers (8.3 and 7.8) also did not differ significantly among each other except CC 1.0 t/ha + *Rhizobium* + PSB. Combined application of FYM and CC at lower dose with or without bio-fertilizers recorded statistically similar number of branches per plant of groundnut crop. Though, among all the treatments, CC 1 t/ha + *Rhizobium* + PSB produced significantly maximum number of branches per plant (9.3) and at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (8.3).

Integration of FYM 5 t/ha + CC 0.5 t/ha + Rhizobium + PSB secured 6.41 per cent number of branches per plant than that of FYM 5 t/ha + CC 0.5 t/ha. Application of CC 1 t/ha + *Rhizobium* + PSB increase 20.77 and16.25 per cent more number of branches per plant as compared to CC 1 t/ha and FYM 10 t/ha + *Rhizobium* + PSB.

Table 2: Effect of different treatments on number of branches/plant at harvest

Treatments			Number of branches/plant
T_1	:	FYM 5 t/ha	6.7
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	7.2
T_3	:	Castor cake 0.5 t/ha	7.0
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	7.2
T_5	:	FYM 10 t/ha	7.3
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	8.0
T_7	:	Castor cake 1 t/ha	7.7
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	9.3
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	7.8
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	8.3
		S.Em. (±)	0.35
		C.D. at 5%	1.0
		C.V. %	9.3

This might be happened due to the crop accumulates more amount of constituent and nutrients from organic manures (FYM + castor cake). Some beneficial microorganisms (Rhizobium) fixed atmospheric nitrogen which readily available to plant and from this plant can easily uptake of nitrogen which results to stimulate the cell division in meristem tissue and an increase in the number of branches per plant. This was confirmed with the findings of the findings are in agreement with those reported by Zalate and Padmani (2009) [21], Akbari *et al*. (2011) [1], Sajid *et al*. (2011) [17], Sharma *et al*. (2013) [18], Chaudhary *et al*. (2015) [7], Alsamowal *et al*. (2016) [2] and Bhutadiya *et al*. (2019) [4] in groundnut.

Dry matter per plant at harvest (g)

Dry weight per plant of groundnut influenced significantly due to various organic treatments are showed in Table 3. An application of FYM at 5 t/ha and CC at 0.5 t/ha either with or without bio-fertilizers recorded significantly lower dry matter/plant than its higher rate of application except FYM 10 t/ha + *Rhizobium* + PSB. Application of FYM 10 t/ha + *Rhizobium* + PSB (36.10 g) recorded statistically equal dry matter/plant as produced by CC 1 t/ha (34.20 g). Similar trends observed in case of FYM 5 t/ha + CC 0.5 t/ha (34.70 g) and FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (37.75 g). Significantly the highest dry matter/plant (41.75 g) was recorded by CC 1 t/ha + *Rhizobium* + PSB and at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (37.75 g).

Dry matter per plant increased by 15.65 and 22.07 per cent with application of CC 1 t/ha + *Rhizobium* + PSB over FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha. Application of FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB increased dry matter per plant by 8.79 per cent than same treatment, but without *Rhizobium* + PSB.

Table 3: Effect of different treatments on dry matter/plant at harvest

Treatments			Dry matter/ plant (g)
T_1	:	FYM 5 t/ha	29.34
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	30.63
T_3	:	Castor cake 0.5 t/ha	29.83
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	31.30
T_5	:	FYM 10 t/ha	32.00
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	36.10
T_7	:	Castor cake 1 t/ha	34.20
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	41.75
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	34.70
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	37.75
		S.Em. (±)	1.58
		C.D. at 5%	4.6
		C.V. %	9.3

Castor cake and Rhizobium enhance nitrogen uptake by the plant and this resulted into more synthesis of nucleic acid and amino acid which improve chlorophyll content in plant which induces photosynthesis ultimately helpful into various growth factors and development of plant. PSB (phosphate solubilizing bacteria) convert fix phosphorous in available form for plant which is very essential during early growth stage of crop and for root establishment. More absorption of nutrients including micronutrients favored in increasing total dry matter per plant (g) at harvest. These findings match with the findings of Chandrasekharan *et al*. (2007) [6], Mathivanan *et al*. (2014) [13], Singh *et al*. (2014) [21] in chickpea and Patil and Udmale (2016) [16] in soybean.

Effect on yield attributes and yield

Number of pods per plant at harvest

Number of pods per plant at harvest showed significant variations due to different organic sources which are outline in Table 4. An application of FYM 5 t/ha as well as CC 0.5 t/ha either alone or with bio-fertilizers recorded statistically equal value of number of pods/plant. Though, application of FYM at 10 t/ha (11.0) as alone and with bio-fertilizers (12.0) did not differ significantly each other in producing number of pods/plant. But when CC at 1.0 t/ha applied as alone, it produced significantly lower number of pods/plant (11.6) as compared to applied with bio-fertilizers (13.7). Integration of FYM and CC at lower rate either with or without bio-fertilizers produced statistically similar number of pods/plant. Significantly maximum number of pods/plant was obtained with CC 1 t/ha + *Rhizobium* + PSB (13.7) was at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (12.5). It indicates that bio-fertilizers play significant role in producing higher number of pods/plant than without bio-fertilizers.

Application of FYM and CC at lower rate, but along with bio-fertilizers increased 6.83 per cent more number of pods per plant as compared to FYM 5 t/ha + CC 0.5 t/ha. Number of pods per plant increased 14.16 and 18.10 per cent with CC 1 t/ha + *Rhizobium* + PSB over FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha.

The higher value of number of pods per plant under the high dose of castor cake might be due to favorable effect of castor cake on growth in term of dry matter accumulation in plant due to better translocation of photosynthesis toward sink. *Rhizobium* and PSB increase the availability of nitrogen and phosphorus. The present findings are closely associated with Zalate and Padmani (2009) [21], Sajid *et al*. (2011) [17], Mathivanan *et al*. (2014) [13], Chaudhary *et al*. (2015) [7], Birla *et al*. (2018) [5] in cowpea and Bhutadiya *et al*. (2019) [4].

Table 4: Effect of different treatments on number of pods per plant at harvest

Treatments			Number of pods/ plant
T_1	:	FYM 5 t/ha	10.0
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	10.8
T_3	:	Castor cake 0.5 t/ha	10.5
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	10.8
T_5	:	FYM 10 t/ha	11.0
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	12.0
T_7	:	Castor cake 1 t/ha	11.6
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	13.7
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	11.7
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	12.5
		S.Em. (±)	0.51
		C.D. at 5%	1.47
		C.V. %	8.82

Pod yield/plant (g)

Pod yield/plant was significantly influenced due to various organic sources for nutrient management in summer groundnut. The data related to pod yield/plant are presented in Table 5. An application of FYM and CC at higher and lower rate either with or without bio-fertilizers recorded statistically equal pod yield/plant except FYM and CC when applied at higher rate with bio-fertilizers. Significantly the highest pod yield/plant was obtained with an application of CC 1 t/ha + *Rhizobium* + PSB (11.8 g) and at par with FYM 10 t/ha + *Rhizobium* + PSB (11.0 g) and FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (11.2 g). Pod yield per plant increased 7.27 and 24.21 per cent with the application of CC 1 t/ha + *Rhizobium* + PSB than application of FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha. Combined application of CC and FYM at lower rate, but along with *Rhizobium* + PSB increased pod yield per plant 14.28 per cent as compared to FYM + CC at lower rate, but without bio-fertilizers.

Increase in pod yield per plant at higher rate of CC and FYM or its combination with *Rhizobium* and PSB is might be due to balanced nutrition and favorable soil environment, better plant growth and ultimately photosynthesis increase which leads to maximum pod yield per plant. The increase in pod yield/plant of crop due to application of organic manure is not only because of improved nutrient availability, but also its beneficial effect on physical and biological environment. This has special reference in groundnut crop as pod setting and development take place in sub-surface soil and the crop is mainly grown in arid and semi-arid climate were water storage capacity plays vital role. These results are in agreements with earlier worker Chandrashekharan *et al*. (2007) [6], Zalate and Padamini (2009) [21], Kumar *et al*. (2012) [10], Chaudhary *et al*. (2015) [7] and Bhutadiya *et al*. (2019) [4].

Table 5: Effect of different treatments on pod yield/plant in groundnut

Treatments			Pod yield/ plant (g)
T_1	:	FYM 5 t/ha	8.4
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	9.0
T_3	:	Castor cake 0.5 t/ha	8.7
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	9.2
T_5	:	FYM 10 t/ha	9.3
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	11.0
T_7	:	Castor cake 1 t/ha	9.5
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	11.8
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	9.8
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	11.2
		S.Em. (±)	0.47
		C.D. at 5%	1.4
		C.V. %	9.6

Pod yield (kg/ha)

Pod yield of groundnut crop significantly influenced due to various nutrient management treatments under organic farming, data presented in Table 6. An appraisal of data shown in Table 6 revealed that application of FYM 5 t/ha recorded significantly the lowest pod yield/ha (1231 kg/ha), but at par with FYM 5 t/ha + *Rhizobium* + PSB (1342 kg/ha) and CC 0.5 t/ha (1307 kg/ha). Application of FYM at 10 t/ha as alone (1496 kg/ha) or in combination with bio-fertilizers (1655 kg/ha) produced statistically equal pod yield/ha which indicate that there is no role of bio-fertilizers in producing significantly higher pod yield with FYM. Similar trend was observed in CC at lower dose in producing pod yield in groundnut. Combined application of FYM + CC at lower rate (5 t/ha and 0.5 t/ha) recorded statistically equal yield either alone (1500 kg/ha) or in combination with bio-fertilizers (1663 kg/ha). Overall, significantly maximum pod yield (1687 kg/ha) of groundnut produced by application of castor cake 1 t/ha + *Rhizobium* + PSB and was at par with FYM 10 t/ha + *Rhizobium* + PSB (1655 kg/ha) and FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (1663 kg/ha). This clearly indicate that bio-fertilizers play significant role in producing higher pod yield when either CC or FYM applied at higher

dose as well as both source combinedly used at lower rate.
Lower pod yield of groundnut at lower rate of FYM and CC might be due to both at lower rate may not full fill nutrient requirement of groundnut for growth and development.
Pod yield per hectare recorded under CC 1 t/ha + *Rhizobium* + PSB increased to the tune of 12.09 and 1.93 per cent over CC 1 t/ha and FYM 10 t/ha + *Rhizobium* + PSB. Increased in pod yield per hectare due to application of FYM + CC at lower rate with *Rhizobium* + PSB is 10.87 per cent higher as compared to its application without *Rhizobium* + PSB.
Significantly higher pod yield of groundnut obtained with higher rate of organic sources *viz.*, castor cake (1 t/ha) and FYM (10 t/ha) provide essential nutrients to crop for growth and development. Though, organic manures having low content of nutrients, but when applied them with higher dose they are able to fulfill required major and minor nutrients. Supplementation of nutrients along with better soil physical condition at higher rate of both organic manure increased number of pods/plant and pod yield per plant which resulted into higher pod yield per hectare. Inoculation of *Rhizobium* + PSB either at higher or lower rate of FYM and CC recorded significantly higher pod yield might be due to *Rhizobium* bacteria has very important role in fixed atmospheric nitrogen and make available to plants and PSB also provide readily available phosphorous by solubilizing fixed form of P and make it available to plant. The findings closely followed the results of Solanki *et al.* (2006), Zalate and Padmani (2009) [21], Kumar *et al*. (2012) [10], Mathivanan *et al*. (2014) [13], Chaudhary *et al*. (2015) [7], Birla *et al*. (2018) [5] in cowpea and Bhutadiya *et al*. (2019) [4].

Haulm yield (kg/ha)
An application of FYM 5 t/ha (1660 kg/ha) and CC 0.5 t/ha (1764 kg/ha) recorded lower haulm yield as compared to FYM 10 t/ha and CC 1.0 t/ha either with (2236 and 2285 kg/ha) or without bio-fertilizers (2012 and 2030 kg/ha). Higher dose of FYM (10 t/ha) with or without bio-fertilizers produced statistically similar haulm yield. But higher dose of castor cake with *Rhizobium* + PSB recorded significantly higher haulm (2285 kg/ha) yield of groundnut than no bio-fertilizers. Combined application of FYM and CC at its lower rate with and without bio-fertilizers produced statically similar haulm yield of groundnut. Though, significantly the highest haulm yield recorded with CC 1 t/ha + *Rhizobium* + PSB (2285 kg/ha) and at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (2254 kg/ha) and FYM 10 t/ha + *Rhizobium* + PSB (2236 kg/ha). Inoculation of bio-fertilizers increased haulm yield with both the organic source at both the rate as well as its combined application.
The major role in producing significantly higher haulm yield of groundnut with inoculation of *Rhizobium* + PSB might be due to unavailable nutrients made in available form to crops along with fixing the atmospheric nitrogen and ultimately increase growth of crop resulted into higher yield under inoculated treatments.

Table 6: Effect of different treatments on pod yield and haulm yield in groundnut

Treatments			Pod yield (kg/ha)	Haulm yield (kg/ha)
T_1	:	FYM 5 t/ha	1231	1660
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	1342	1819
T_3	:	Castor cake 0.5 t/ha	1307	1764
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	1428	1928
T_5	:	FYM 10 t/ha	1496	2012
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	1655	2236
T_7	:	Castor cake 1 t/ha	1505	2030
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	1687	2285
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	1500	2024
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	1663	2254
		S.Em. (±)	61.82	86.91
		C.D. at 5%	179	252
		C.V. %	8.3	8.7

Haulm yield of groundnut increased by 2.19 and 2.46 per cent higher with the application of CC 1 t/ha + *Rhizobium* + PSB than FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha. Combined application of FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB produced 11.36 per cent higher haulm yield than FYM 5 t/ha + CC 0.5 t/ha.
Increase in haulm yields was mainly because of increase in plant height, number of branches per plant at harvest and dry matter per plant at harvest which resulted from of castor cake and *Rhizobium* and PSB that provided balanced nutrition, favourable soil environment and ultimately leads to maximum haulm yields. *Rhizobium* bacteria fix atmospheric nitrogen to soil and make it available to plant. PSB make insoluble phosphorus to soluble phosphorus and also synthesize growth promoting substance which augment plant growth. The findings closely followed the results of Zalate and Padmani (2009) [21], Balakrishnan *et al*. (2010) [3], Kumar *et al*. (2012) [10], Mathivanan *et al*. (2014) [13], Chaudhary *et al.* (2015) [7] and Bhutadiya *et al*. (2019) [4].

100-kernels weight
The data exhibited in Table 7 showed that among all sources of organic manures application of CC at 1.0 t/ha with bio-fertilizers recorded significantly maximum value of 100-kernel weight (48.9 g) and at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (47.3 g). Application of FYM at 5 t/ha or 10 t/ha and castor cake at 0.5 or 1.0 t/ha with or without *Rhizobium* + PSB recorded statistically equal value of 100 kernel weight except FYM 10 t/ha and CC at 1.0 t/ha along with bio-fertilizers. Though, combined application of FYM + CC at lower rate with or without bio-fertilizers produced significantly equal value of 100-kernel weight. Inoculation of bio-fertilizers increased weight of 100-kernel with both the organic manures.
100-kernel weight increased 6.07 and 9.64 per cent with the application of CC 1 t/ha + *Rhizobium* + PSB than application of FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha. Combined application of CC and FYM at lower rate, but along with *Rhizobium* + PSB increased 100-kernel weight 4.18 per cent as compared to FYM + CC at lower rate, but without bio-

fertilizers.

This might be due to beneficial effect from organic manures along with bio-fertilizers. They enhance translocation of photosynthates towards sink. Organic manures like FYM and CC (higher dose) reduces bulk density of soil that promote favorable soil condition for groundnut pod which enhancing kernel size. PSB also has a vital role by providing available phosphorous for seed development in groundnut. Results match with findings of Kumar *et al*. (2012) [10], Mathivanan *et al*. (2014) [13] and Mavarkar *et al*. (2016) [14].

Table 7: Effect of different treatments on 100-kernel weight and shelling percentage in groundnut

Treatments			100-kernels weight (g)	Shelling percentage
T_1	:	FYM 5 t/ha	42.0	55.1
T_2	:	FYM 5 t/ha + *Rhizobium* + PSB	43.1	57.8
T_3	:	Castor cake 0.5 t/ha	42.9	57.3
T_4	:	Castor cake 0.5 t/ha + *Rhizobium* + PSB	43.7	59.1
T_5	:	FYM 10 t/ha	43.5	59.5
T_6	:	FYM 10 t/ha + *Rhizobium* + PSB	46.1	63.4
T_7	:	Castor cake 1 t/ha	44.6	60.1
T_8	:	Castor cake 1 t/ha + *Rhizobium* + PSB	48.9	66.4
T_9	:	FYM 5 t/ha + Castor cake 0.5 t/ha	45.4	60.3
T_{10}	:	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	47.3	64.1
		S.Em. (±)	0.92	2.04
		C.D. at 5%	2.7	5.9
		C.V. %	4.1	6.8

Shelling percentage

The results indicated that statistically equal shelling percentage was recorded with an application of FYM at 5 and 10 t/ha and CC 0.5 and 1.0 t/ha with or without *Rhizobium* + PSB except FYM 10 t/ha and CC 1.0 t/ha with bio-fertilizers (63.4 and 66.4). Application of FYM and CC at higher rate with bio-fertilizers recorded more shelling percentage than without bio-fertilizers. Integration of FYM + CC at lower rate with bio-fertilizers (64.1) recorded more shelling percentage than without bio-fertilizers (60.3). While, application of CC 1.0 t/ha + *Rhizobium* + PSB recorded significantly highest (66.4) shelling percentage and at par with FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (64.1) and FYM 10 t /ha with *Rhizobium* + PSB (63.4). Inoculation of bio-fertilizers to seeds of groundnut gave higher value of shelling percent with both the organic manures.

Application of FYM and CC at lower rate, but along with bio-fertilizers increased 6.30 per cent more shelling percentage as compared to FYM 5 t/ha + CC 0.5 t/ha. Shelling percentage increased by 4.73 and 10.48 per cent with CC 1 t/ha + *Rhizobium* + PSB over FYM 10 t/ha + *Rhizobium* + PSB and CC 1 t/ha.

Castor cake provides a favourable condition for the extraction of nutrients from the soil. In presence of both the organic manures, *Rhizobium* and PSB provide essential nutrients to plant resulted in better growth and development of crop and finally increases filled pods with bolded kernel lead to an increase in shelling percentage. These finding match with Malligawad (2010), Kumar *et al*. (2012) [10], Kamdi *et al*. (2014) [9], Chaudhary *et al*. (2015) [7] and Moinuddin and Kaleem (2019) [15].

Economics

A perusal of data on gross realization is exhibited in Table 8. The highest gross realization of ₹95,775/ha was accrued with application of castor cake 1 t/ha + *Rhizobium* + PSB followed by FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (₹94,420/ha) and FYM 10 t/ha + *Rhizobium* + PSB (₹93,930/ha). The lowest gross realization (₹69,850/ha) was noticed with FYM 5 t/ha. Maximum net realization of ₹49,407/ha was recorded with castor cake 1 t/ha + *Rhizobium* + PSB followed by FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (₹45,272/ha). The lowest net realization of ₹24,250/ha was noticed with FYM 5 t/ha. Application of castor cake at higher dose along with *Rhizobium* + PSB resulted in similar yield levels as compared to FYM + *Rhizobium* + PSB, but due to their lower cost, net realization is considerably higher than the groundnut produced with FYM. Examination of data on benefit: cost ratio (BCR) for different nutrient management practices under organic farming are given in Table 8. The highest benefit: cost ratio (BCR) of 2.07 was obtained with castor cake 1.0 t/ha + *Rhizobium* + PSB followed by FYM 5 t/ha + CC 0.5 t/ha + *Rhizobium* + PSB (1.92). The lowest benefit: cost ratio (BCR) of 1.53 was noted with FYM 5 t/ha. This could be due to higher pod and haulm yield received under treatments. Results corroborated with the results of Sharma *et al*. (2013) [18], Chaudhary *et al*. (2015) [7], Diwedi *et al*. (2018) [8] and Bhutadiya *et al*. (2019) [4].

Table 8: Economics of groundnut as influenced by different treatments

Treatments		Yield (kg/ha)		Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
		Pod	Haulm				
T_1	FYM 5 t/ha	1231	1660	69,850	45,600	24,250	1.53
T_2	FYM 5 t/ha + *Rhizobium* + PSB	1342	1819	76,195	45,888	30,307	1.66
T_3	Castor cake 0.5 t/ha	1307	1764	74,170	43,080	31,090	1.72
T_4	Castor cake 0.5 t/ha + *Rhizobium* + PSB	1428	1928	81,040	43,368	37,672	1.87
T_5	FYM 10 t/ha	1496	2012	84,860	51,600	33,260	1.64
T_6	FYM 10 t/ha + *Rhizobium* + PSB	1655	2236	93,930	51,888	42,042	1.81
T_7	Castor cake 1 t/ha	1505	2030	85,400	46,080	39,320	1.85
T_8	Castor cake 1 t/ha + *Rhizobium* + PSB	1687	2285	95,775	46,368	49,407	2.07
T_9	FYM 5 t/ha + Castor cake 0.5 t/ha	1500	2024	85,120	49,120	36,000	1.73
T_{10}	FYM 5 t/ha + Castor cake 0.5 t/ha + *Rhizobium* + PSB	1663	2254	94,420	49,408	45,012	1.91

Selling price: (1) Pod: ₹50 per kg and **(2) Haulm:** ₹5 per kg.

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