Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 7 [SPL 1] 2018 : 129-133

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Effect of Integrated Nutrient Management On Yield And Profitability of Cocoa (*Theobroma Cacao* L.) Grown Under Alluvial Soil Conditions of Andhra Pradesh

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ABSTRACT
An experiment was conducted during 2016 and 2017 to investigate the impact of integrated nutrient management on yield and profitability of cocoa at existing coconut gardens, Horticultural Research Station, Ambajipeta. The study was laid out in randomized block design with ten treatments replicated thrice. The yield characters like number of healthy pods (55.84), weight of the pod (485.26 g), wet bean weight per pod (135.58 g), dry bean weight per pod (66.60 g), single bean weight (1.57 g) and total dry bean yield per tree (3.57 kg) were recorded highest in the trees treated with 75% RDF + 25% RDN through composted coir pith+ 50g Azospirillum + 50g PSB.In the present investigation the B:C ratio ranged from 1.58 to 4.85 was observed and the highest benefit cost ratio of 4.85 was obtained in the treatment 75% RDF + 25% RDN through composted coir pith+ 50g Azospirillum + 50g PSB followed by 75% RDF + 25% RDN through composted coir pith (4.61) and 50% RDF + 50% RDN through composted coir pith (3.69).The results obtained in the present investigation concluded that application of 75% RDF + 25% RDN through composted coir pith+ 50g Azospirillum + 50g PSB had recorded highest yield and profitability among the different INM treatment application under coastal ecosystem of Andhra Pradesh.
***Key words**: Cocoa, INM,Yield, Profitability, Alluvial soil condition, Coastal ecosystem*

Received 22.05.2018 Revised 13.06.2018 Accepted 19.07.2018

INTRODUCTION

Cocoa (*Theobroma cacao* L.) the 'Food of Gods' is a tree originated from the neo-tropical rainforests of the Amazon basin and Guyana Plateau of South America belong to the family Malvaceae (Alverson*et al*., 1999 and Bayer *et al*., 1999). It is a diploid species with 20 chromosome in the somatic cells (2n=20). One of the most important plantation crops consumed worldwide and around 40-50 million people depend on cocoa for their livelihood. In India, it is cultivated as component crop in arecanut, coconut and oilpalm plantations and accounted to an area of 83,000 hectares with a production of 19,000 MT (NHB, 2016-17). The productivity of cocoa in terms of dry bean yield is very low due to improper management. Balanced nutrition ensures efficient use of all nutrients by the plant. Imbalanced nutrition results in low yield, low fertilizer- use efficiency and low farmer profit, besides depletion of the deficient nutrients of the soil. There is a need for reduced consumptions of chemical fertilizers and increased use of organic manures and biofertilizer for sustainability. In order to meet balanced nutrient supply in cocoa, integrated nutrient management is the important alternative source, which is not only beneficial to maintain the soil health but also to sustain the pod production (Sharma *et al*., 2013). However, so far, information about the use of organic manures alone or in combination with inorganic fertilizers to fulfill the nutrient need of cocoa trees is very scarce.Keeping this in view, the present study is undertaken to study the effect of integrated nutrient management on yield and profitability of cocoa as intercrop in coconut in coastal Andhra Pradesh under alluvial soil conditions.

MATERIAL AND METHODS

The experiment site was located at Horticultural Research Station, Ambajipeta, East Godavari District, Andhra Pradesh.Thelocation falls under Agro-climatic zone-10, humid, East Coast Plain and Hills(Krishna-Godavari zone) with an average rainfall of 900 mm, located at an altitudeof 34 m above mean sea level. The geographical situation is 16.83^0 N latitude and81.5^0 E longitude. It experiences hot humid summer and mild winters. Fourteen year old cocoa trees were selected for the study. In coconut plantation of thirty year old with spacing of 8 × 8 m, the cocoa plants are intercropped with a spacing of 3 × 3 m. The study was laid out in randomized block design with ten treatments. The treatment details were 75% RDF + 25% RDN through composted coir pith (T_1), 75% RDF + 25% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB (T_2), 50% RDF + 50% RDN through composted coir pith (T_3), 50% RDF + 50% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB (T_4), 75 % RDF + 25% RDN through FYM (T_5), 75% RDF + 25% RDN through FYM + 50g *Azospirillum* + 50g PSB (T_6), 50% RDF + 50% RDN through FYM (T_7), 50% RDF + 50% RDN through FYM+ 50g *Azospirillum* + 50g PSB (T_8), 100% RDF (T_9) and Control (T_{10}). The recommended dosage of N, P and K for cocoa is 100:40:140g/tree/year. In inorganic fertilizer treatments (50%, 75% and 100% recommended dose of fertilizers) nitrogen, phosphorus and potassium nutrients were applied in the form of urea, single super phosphate and muriate of potash respectively. Nitrogen, Phosphorus and Potash was applied in two equal split doses i.e., first split during August (2016) and second split in November (2016).The *Azospirillum*and PSB @ 50 g/tree was inoculated with the respective organic manures thoroughly and incorporated in the soil. All the treatments were imposed to the cocoa trees timely and maintained. The observations on yield parameters of cocoa were recorded as per standard procedures laid out by ElainAphsara*et al*., (2008) and analysis carried out as per Panse and Sukhatme (1978). The total number of healthy pods and damaged pods /diseased pods were harvested in each treatment and numbered in the field itself.The pod weight and wet bean weight per pod were measured randomly from six selected trees of each treatment and expressed in gram (g).The single dry bean weight was measured by weighing one hundred dried beans after fermentation. The average dry bean weight per pod was worked out and expressed in grams (g).The average dry bean yield per tree was calculated from the mean dry weight of the beans per pod and the total number of pods in each treatment. The cost of cultivation and gross returns per hectare in each treatment were calculated based on the prices of inputs and outputs that were prevailing at the time of their use during the period of experimentation. The net returns per ha was calculated by deducting the total cost of cultivation from the total monetary value of the produce. To know the rate of return per rupee invested, benefit-cost ratio was worked out by using the formula,Gross income (Rs ha^{-1})/Total cost of cultivation (Rs ha^{-1}).Net profit was calculated by subtracting cost of cultivation from gross returns.

Table 1: Effect of INM treatments on yield characters of cocoa (*Theobroma cacao* L.)

Treatments	Healthy pods	Damaged pods	Weight of the pod (g)	Wet bean weight (g)	Dry bean weight/ pod (g)	Single bean dry weight (g)	Total dry bean yield/tree (kg)
T_1	51.43	0.78	448.91	126.91	63.28	1.49	3.03
T_2	55.84	0.37	485.26	135.58	66.60	1.57	3.57
T_3	43.33	0.97	438.03	107.83	62.05	1.48	2.48
T_4	44.54	0.59	398.90	105.55	52.39	1.41	2.13
T_5	43.59	0.44	398.49	93.77	56.83	1.39	2.26
T_6	45.58	0.49	410.00	103.96	54.18	1.45	2.34
T_7	44.49	0.44	401.91	98.02	60.56	1.44	2.48
T_8	43.17	0.93	410.36	101.59	55.88	1.42	2.25
T_9	40.65	0.74	390.56	100.99	61.07	1.45	2.26
T_{10}	26.03	1.21	329.50	58.20	44.09	1.21	0.97
SE m ±	**1.06**	**0.05**	**21.52**	**12.10**	**1.79**	**0.04**	**0.11**
CD(P=0.05)	**3.17**	**0.15**	**64.44**	**36.23**	**5.38**	**0.13**	**0.34**
CV (%)	**4.18**	**12.61**	**9.06**	**20.30**	**5.39**	**5.52**	**8.26**

T_1: 75% RDF + 25% RDN through composted coir pith
T_2: 75% RDF + 25% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB
T_3: 50% RDF + 50% RDN through composted coir pith
T_4: 50% RDF + 50% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB
T_5: 75 % RDF + 25%RDN through FYM
T_6: 75% RDF + 25%RDN through FYM+ 50g *Azospirillum* + 50g PSB
T_7: 50%RDF + 50%RDN through FYM
T_8: 50%RDF + 50%RDN through FYM+ 50g *Azospirillum* + 50g PSB
T_9: 100%RDF
T_{10}: Control
RDF- Recommended dose of fertilizers
RDN-Recommended dose of nutrients
CCP- Composted coir pith
FYM- Farm yard manure
PSB-Phosphate solubilizing bacteria

RESULTS AND DISCUSSION

The results varied significantly among the INM treatments. The number of healthy pods of 55.84 was recorded highest in 75 % RDF + 25 % RDN through CCP + 50 g *Azospirillum* + 50g PSB (T_2). The pod weight of 485.26 g was recorded highest in 75% RDF + 25% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB treated trees (Table 1). The highest wet bean weight of 135.58 g was recorded in T_2 (75 % RDF + 25 % RDN through CCP+ 50 g *Azospirillum* +50g PSB) (Table 1).The pod weight was mainly dependent on growth characters of the plant. The greater accumulation of dry matter conferred greater ability to give higher pod weight. This was obviously due to vigorous plant growth characters might have increased the photosynthetic activity resulting in higher translocation of carbohydrates in the trees. Relatively higher amount of carbohydrates could have promoted the growth rate and in turn increased the pod weight. In addition, application of biofertilizers and composted coir pith along with the recommended dose of NPK might have supplied all the micronutrients along with major nutrients which might have helped the plant to increase the chlorophyll content of leaves, photosynthetic efficiency, translocation of metabolites from the source to sink as and when needed by the crop and it might be responsible for retaining more number of pods, increase in weight of pods and wet bean weight. The results were also reported by Noordiana*et al.* (2007),Thondaiman*et al*. (2013), Dutta*et al*. (2010) and Minimal *et al*. (2015) in cocoa.On an average, the total damaged or diseased pods harvested were significantly differed among the treatments. The highest total damaged pods harvested (1.21) was recorded with T_{10} (control). Rodents are serious vertebrate pests damaging the pods at mature stages. Most common rodents damaging cocoa pods are rats and squirrels. The damage is mainly during the peak harvesting season. There was no influence of either season or a nutrient which clearly indicates that problem of rodents could be solved easily through management practices. On an average, the highest single bean dry weight of 1.55 g was recorded with T_2 (75 % RDF + 25 % RDN through CCP+ 50 g *Azospirillum* +50g PSB) and lowest single dry bean weight (1.10 g) in T_{10} (control) (Table 1). The highest dry bean weight of 63.72 g was recorded with T_2 (75 % RDF + 25 % RDN through CCP+ 50g *Azospirillum* +50g PSB) and lowest dry bean weight (37.38 g) in control (T_{10}) (Table 1). This increase in dry weight of beans is due to integration of inorganic and organic sources of nutrient maximized supply of nutrients during entire period of pod growth, ultimately resulting in accumulation of more photosynthates leading dry weight and yield. Armando *et al.* (2001) and Sanjay *et al.* (2016) also reported similar results. The highest dry bean yield per tree of 3.57 kg was recorded in 75% RDF + 25% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB (T_2) and the lowest of 0.97 kg in control (Table 1). Yield is a complex trait and is a product of several other yield attributing characters. The increase in dry bean yield per tree could be attributed to increased rate of photosynthesis which could have further led to the better partitioning of assimilates. Higher values observed for these traits might be due to higher fertilizer use efficiency and higher uptake of macro and micronutrients supplied through composted coir pith and biofertilizers. These findings are in agreement with that ofKrishnamoorthy and Rajamani (2014) in cocoa. The data on cost and return for each treatments, the highest gross returns of Rs. 3,12,018 and highest net profit of Rs. 2,07,322 were obtained by the application of 75 % RDF + 25 % RDN through CCP+ 50 g *Azospirillum* +50g PSB (T_2). The treatment 75 % RDF + 25 % RDN through CCP+ 50 g *Azospirillum* +50g PSB (T_2) had resulted in a higher benefit cost ratio of 4.85 followed by T_1 (4.61) (75% RDF + 25 % RDN through CCP) and T_3 (50 % RDF + 50% RDN through CCP) (3.69), whereas the lowest benefit cost ratio (1.58) was recorded in T_{10} (control) (Table 1). More gross returns were obtained due to higher dry bean yield in the treatments containing inorganic fertilizers, organic sources of nutrients along with biofertilizers. However, applications of recommended dose of fertilizers in the form of organic and inorganic sources of nutrients along with bio fertilizers were found economical despite its higher cost of cultivation. The results were also reported by Kalpana*et al*. (2008), Dhomane and Kadam (2013) and Bhuyan*et al*. (2016).

Table 2: Benefit cost ratio for different INM treatments

Treatments	Cost of cultivation (Rs. ha^{-1})	Yield (kg/ha)	Gross Returns (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	B:C ratio
T_1: 75 % RDF + 25 % RDN through CCP	57500	1393.8	264822	207322	4.61
T_2: 75 % RDF + 25 % RDN through CCP + 50g *Azospirillum*+ 50g PSB	64300	1642.2	312018	247718	4.85
T_3: 50 % RDF + 50 % RDN through CCP	58800	1140.8	216752	157952	3.69
T_4: 50 % RDF + 50 % RDN through CCP + 5og *Azospirillum* + 50g PSB	65600	979.8	186162	120562	2.84
T_5: 75 % RDF + 25 % RDN through FYM	67000	1039.6	197524	130524	2.95
T_6: 75 % RDF + 25 % RDN through FYM + 50g*Azospirillum* + 50g PSB	73800	1076.4	204516	130716	2.77
T_7: 50 % RDF + 50 % RDN through FYM	77800	1140.8	216752	138952	2.79
T_8: 50 % RDF + 50 % RDN through FYM + 50g *Azospirillum* + 50g PSB	84600	1035	196650	112050	2.32
T_9: 100 % RDF	56070	1039.6	197524	141454	3.52
T_{10}: Control	53500	446.2	84778	31278	1.58

CONCLUSION

The present study represents the positive response of organic, inorganic manures and bio-fertilizers application to increase the yield and profitability of cocoa. The combined use of organic manures, bio-fertilizers and chemical fertilizers has been found not only in maintaining higher productivity but also in providing stable crop yields for sustainable crop production through integrated nutrient use. The above results indicated that there is ample scope for substitution of inorganic fertilizers with INM treatments, by keeping the higher production and productivity in view, application of 75% RDF + 25% RDN through composted coir pith+ 50g *Azospirillum* + 50g PSB were recommended in black alluvial soilsof Andhra Pradesh for higher returns.

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