Research Article

doi:10.19071/jpc.2016.v44.i2.3102
Journal of Plantation Crops, 2016, 44(2): 85-89

Influence of organic sources of nutrients on vanilla (*Vanilla planifolia*) as an intercrop in coconut garden

H.P. Maheswarappa*, V. Krishnakumar[1], Alka Gupta and A. Geetha Kumari

ICAR-Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, India
[1]ICAR-Central Plantation Crops Research Institute, Regional Station, Kayamkulam-690 533, Kerala, India

(Manuscript Received: 04-01-16, Revised: 23-05-16, Accepted: 23-06-16)

Abstract

Performance of vanilla, as influenced by organic source of nutrition when grown as intercrop in coconut garden, was studied in sandy loam soil at ICAR-CPCRI, Kasaragod, Kerala for seven years. Field experiments were carried out with different sources of organic manures, recommended NPK fertilizer and no fertilizer treatments. Application of cow dung slurry (6 tonnes ha^{-1}) resulted in vigorous growth of vine (vine length of 5.5 m) and higher number of beans per vine (208) and a significantly higher mean fresh yield of bean (1.87 kg vine^{-1}). Application of vermicompost (5 kg plant^{-1}) + biofertilizers (*Bacillus* and *Azospirillum*) and vermiwash were on par and recorded mean fresh yield of 1.47 kg vine^{-1} and 1.30 kg vine^{-1}, respectively. Control treatment without fertilizer application recorded significantly lower fresh bean yield (0.55 kg vine^{-1}) due to lower number of beans per vine (72 nos.). In the rhizosphere of vanilla, no significant difference for either bacterial or actinomycetes population was noticed among the treatments. The fungal population differed significantly among the treatments and the highest population level was found with application of biogas slurry (62.1x10^{3} cfu g^{-1} soil),which was on par with application of cow dung slurry (59x10^{3} cfu g^{-1} soil). Among the function specific microbial communities, the highest population of P-solubilisers (98x10^{3} cfu g^{-1} soil) was recorded in the biogas slurry treatment, and it was the lowest in control and vermiwash application treatments. The average coconut yield realized during experimental period (2004-05 to 2009-10) was 136 nuts per palm, recording 53 per cent increase in yield compared to pre-experimental yield (89 nuts per palm).

Keywords: Coconut, intercropping, organic nutrient source, vanilla

Introduction

Vanilla, the second most expensive spice traded in the world market, is the fully-grown fruit of the orchid. and is used extensively in food and beverage industries, as well as, in the perfumery and to a small extent in medicine also. Though synthetic vanillin is much cheaper than the natural vanilla, the flavor of vanilla beans is far superior to that of former, due to the presence of other flavour compounds in the natural product. The important vanilla growing countries are Madagascar, Indonesia, Mexico, Comoros and Reunion. In India, vanilla cultivation is taken up in Kerala, Tamil Nadu and Karnataka states.

In perennial crops like coconut, where the land is occupied by the same crop for several decades, one of the feasible ways of increasing the production is to utilize the interspaces for cultivation. In a coconut plantation, each palm occupies an area of 56.3 m^2 (at 7.5 m x 7.5 m spacing), the spread of active root zone for individual palms is restricted to 2 m radius from the bole (covers only 12.6 m^2 or 22 per cent area) and leaving 78 per cent of the land not effectively utilized by coconut (Maheswarappa *et al*., 2000). Several viable multiple cropping patterns have been suggested for coconut plantations and by judicious selection of compatible intercrops, proper manuring and adoption of scientific management practices, the total productivity could be improved leading to additional benefit to farmers (Maheswarappa *et al*., 2013). Vanilla, a climbing orchid and shade loving

*Corresponding Author: maheshcpcri@gmail.com

spice crop, can be successfully cultivated as intercrop in coconut and arecanut plantations. Importance of vanilla as one of the component crops in coconut production system was highlighted by Nybe *et al.* (2004) and according to Nybe and Miniraj (2007), providing irrigation makes cultivation an economically viable proposal. As the global demand for natural vanillin is still on the higher side due to its beneficial effects compared to synthetic vanillin, Indian farmers can take up its cultivation as an intercrop. As there is higher demand for organically produced vanilla, the present study was carried out to evaluate the growth and yield of intercropped vanilla as influenced by different sources of organic manures in coconut garden and its effect on the productivity of coconut.

Materials and methods

The field experiment was conducted during 2003 to 2010 at ICAR-Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, India, which is situated at 12°30' N latitude and 75°00' E longitude at an elevation of 10.7 m above mean sea level. The mean annual rainfall during 2003 to 2010 was 3370 mm, the mean maximum temperature was 33.6 ^{0}C, while minimum temperature was 25.3 ^{0}C. The experiment was conducted in a 45 years old coconut garden of West Coast Tall variety spaced at 7.5 m x 7.5 m. Vanilla vines with five nodes were planted during June 2003 in the centre of two rows of coconut with a spacing of 1.5 m x 1.5 m leaving 2.25 m from the base of palms on either side at the base of *Glyricidia* standards, which were established before planting vanilla cuttings. Coconut husks were incorporated in the rhizosphere of vanilla plants. The nutrient treatments for vanilla as detailed below were imposed from 2005 onwards.

- T_1: Control (no fertilizers)
- T_2: Application of vermicompost (VC) @ 5 kg plant^{-1} year^{-1} (two splits)
- T_3: Application of VC @ 5 kg plant^{-1} year^{-1} (two splits) + Application of biofertilizers (Phosphate- solubilizing *Bacillus* sp. and nitrogen fixing *Azospirillum* sp. @ 25 g plant^{-1} year^{-1})
- T_4: Vermiwash application: (1:10 dilution) (twice a year @ 2 L plant^{-1})
- T_5: Application of cow dung slurry @ 6 t ha^{-1} (two splits) (1:10 dilution)
- T_6: Biogas slurry application: 6 t ha^{-1} (two splits)
- T_7: Soil application of 40, 20, 60 g NPK plant^{-1} year^{-1} (N in two splits)

The treatments were replicated four times in a RBD with nine vanilla plants per treatment.

Recommended dose of fertilizers was applied for coconut in two splits in the basins (pre-monsoon and post-monsoon periods) and irrigation for coconut + vanilla system was provided by microjet method with IW/CPE of 1.0. The organic manures were applied as per the treatments during May-June and September-October months. The *Azospirillum* and *Bacillus* cultures were obtained from rhizosphere of healthy coconut palms (WCT variety). The population count of these cultures at the time of application was 1x10^8 cfu per gram of carrier material. The vanilla plants, coiled on the branches of *Glyricidia,* started flowering during January. The flowers were artificially hand pollinated between 6 am to 9 am on the day of opening. The vanilla beans were harvested when the distal end turned slight yellow. The annual yield of coconut was recorded during each year. *Glyricidia* branches were pruned thrice in a year (April, August and December) and the biomass was recorded and applied to the rhizosphere of vanilla crop. Soil from the rhizosphere of vanilla at 0-30 cm depth collected during April 2009 was used for studying general and function-specific communities of microbes. The soil samples were serially diluted (10 folds) in sterile water blanks to produce several dilutions. One mL of aliquot from these dilutions was pour plated in different media. Three sets of samples were drawn from each treatment. Three replications for each group of microorganisms were maintained. Total number of culturable bacteria were counted on nutrient agar (Allen, 1959) after incubating for 24-48 h at 28±2 °C, actinomycetes on Ken Knights and Munaier's agar (Allen, 1959) counted after 5-7 days incubated at 28±2 °C, fungi on Martin's rose Bengal agar (Martin, 1950) counted after 2-4 days incubated at 28±2 °C. The nitrogen fixing bacteria were counted after 4 days on N-free Jensen's agar medium (Becking, 1959), phosphate solubilizers were enumerated by locating the clear halo formed around the colonies on Pikovskaya agar

(Pikovskaya, 1948). King's B agar medium (King *et al*., 1954) was used for fluorescent *Pseudomonas* spp., producing green or greenish blue fluorescence, and the colonies were counted under UV light after incubation for 24 to 48 h at 28±2°C. The results of the microbial analyses were given as CFU g^{-1} of dry soil. Each CFU value was the average of 4x3 sample replicates. Statistical analysis was done using standard analysis of variance (ANOVA) technique (Panse and Sukhatme, 1985).

Results and discussion

Growth and yield parameters of vanilla

The length of vine differed significantly among the treatments during 2008 (Table 1). Application of cow dung slurry produced significantly higher vine length (5.5 m $vine^{-1}$) compared to the other treatments. The length of vine recorded with applications of vermiwash (T_4) and biogas slurry (T_6) were on par, each recording length of 4.9 m $vine^{-1}$, whereas, the control (without fertilizer application) recorded the lowest length (2.8 m $vine^{-1}$). Internodal length of vanilla vines was not influenced by any of the treatments. Number of beans per plant was significantly higher (208) with application of cow dung slurry (T_5), but was on par with application of vermiwash (T_4) (162), whereas, control treatment recorded significantly lower number of beans per vine (72).

The fresh yield of vanilla beans over the years as well as the mean (2007 to 2009) differed significantly among the treatments. Application of cow dung slurry recorded significantly the highest mean bean yield (1.87 kg $vine^{-1}$) compared to the other treatments (Table 1). This was followed by application of vermicompost + biofertilizers (T_3) and vermiwash (T_4), which were on par with each other (1.47 and 1.30 kg $vine^{-1}$, respectively) whereas, control treatment recorded significantly the lowest fresh bean yield (0.55 kg $vine^{-1}$). Higher yield under treatments with organic sources (T_5, T_4 and T_3) might be due to the slow and steady supply of nutrients apart from very low nutrient loss and the availability of micronutrients coupled with the added advantage of improving soil biological properties (Table 3). Sadanandan and Hamza (2006) also indicated that organics are effective compared to recommended inorganic NPK fertilisers in increasing the yield of vanilla.

Biomass of *Glyricidia*

The quantity of fresh biomass of *Glyricidia* prunings (mean of 2007 to 2009) significantly differed among the treatments (Table 2) and it was the highest (12.4 kg $plant^{-1}$) with the application of biogas slurry, however, being on par with all other treatments except control, which recorded significantly the lowest biomass yield (7.9 kg $plant^{-1}$).

Table 1. Growth and yield characters of vanilla as influenced by different treatments

Treatments	Length (m $vine^{-1}$) (2008)	Inter nodal length (cm) (2008)	No. of beans $vine^{-1}$ (Mean of 2008-09)	Fresh bean yield (kg $vine^{-1}$)			Pooled data of fresh bean yield* (kg $vine^{-1}$)
				(2007)	(2008)	(2009)	
T_1	2.8	10.1	72	0.72	0.62	0.30	0.55
T_2	4.5	11.2	120	1.32	1.12	0.85	1.10
T_3	4.6	11.5	144	1.67	1.47	1.27	1.47
T_4	4.9	11.8	162	1.60	1.20	1.10	1.30
T_5	5.5	11.3	208	2.00	1.82	1.80	1.87
T_6	4.9	11.4	135	1.20	1.10	1.00	1.10
T_7	4.2	10.5	89	1.10	0.90	0.85	0.95
CD (P=0.05)	0.1	NS	55	0.18	0.18	0.28	0.31

*Mean values of fresh bean yield recorded during the period 2007 to 2009

[T_1: Control (No fertilizers); T_2: Application of vermicompost (VC) @ 5 kg $plant^{-1}$ $year^{-1}$ (two splits); T_3: Application of VC @ 5 kg $plant^{-1}$ $year^{-1}$ (two splits) + Application of biofertilizers (Phosphate solubilizing *Bacillus* sp. and nitrogen fixing *Azospirillum* sp. @ 25 g $plant^{-1}$ $year^{-1}$); T_4: Vermiwash application: (1:10 dilution) (twice a year) (2 L $plant^{-1}$); T_5: Application of cow dung slurry @ 6 t ha^{-1} (two splits) (1:10 dilution); T_6: Biogas slurry application: 6 t ha^{-1} (two splits); T_7: Soil application of 40, 20, 60 g NPK $plant^{-1}$ $year^{-1}$ (N in two splits)]

Table 2. Fresh biomass of *Gyricidia* prunings as influenced by different treatments (Mean of 2007 to 2009)

Treatments	Fresh weight (kg plant^{-1})
T_1	7.9
T_2	11.8
T_3	12.1
T_4	11.7
T_5	12.0
T_6	12.4
T_7	11.2
CD (P=0.05)	3.2

The fresh prunings were recycled in the root region of vanilla, resulting in addition of organic matter to soil and thereby improving the soil biological properties. In arecanut garden, Sujatha and Bhat (2010) have reported production of 6 to 8 kg *Glyricidia* prunings per plant and upon its incorporation giving positive effect on soil properties.

Soil microbial population

In the case of general microbes, no significant difference for either bacterial or actinomycetes population was noticed among the treatments (Table 3). The fungal population differed significantly among the treatments and the highest population level was found with application of biogas slurry (62.1x10^3 cfu g^{-1} soil), which was on par with application of cow dung slurry (59x10^3 cfu g^{-1} soil). Lower fungal population was recorded in the control or plants applied with chemical fertilizers (soil application) or with vermiwash (foliar application) treatments.

Among the function specific microbial communities, the highest population of P-solubilisers (98x10^3 cfu g^{-1} soil) was recorded in the biogas slurry treatment (Table 3), and it was the lowest in control, vermiwash application treatments. The population level of N-fixers differed among the treatments and application of vermicompost resulted in significantly higher population (11.6x10^2 cfu g^{-1} soil), whereas, control recorded the lowest population (4.9x10^2 cfu g^{-1} soil). Both nitrogen and phosphorus are key minerals in soils responsible for proper growth and development of crops. The major portion of applied inorganic N is lost through leaching and phosphorus is generally present as non-available fixed insoluble inorganic phosphates, which needs to be solubilized/mineralized in order to be absorbed by the plants as orthophosphates. Solubilization of insoluble inorganic phosphates by several soil microorganisms and yield increases and higher phosphorus content of the crop plants due to inoculation with mineral phosphate solubilisation (MPS) microbes have been reported (Viruel *et al*., 2014). Application of vermicompost along with biofertilizers and cow dung slurry recorded significantly higher population of fluorescent pseudomonads as compared to other organic treatments, whereas the microbes could not be detected in the case of control and inorganic fertiliser application indicating organic nutrition could supplement good microbial population. Fluorescent pseudomonads are an important component of soil microbiota as they are implicated both in plant growth promotion and disease control (Gupta *et al*., 2000).

Table 3. General microbial population and function-specific microbial communities (cfu g^{-1} soil) as influenced by different treatments

Treatments	Bacteria (x10^5)	Fungi (x10^3)	Actinomycetes (x10^4)	Fluorescent Pseudomonads	P-Solubilisers (x10^3)	N-fixers (x10^2)
T_1	5.9	24.7	62.2	ND	12.0	4.9
T_2	31.6	32.5	77.7	55.0	41.0	11.6
T_3	8.3	29.8	77.3	268.0	38.0	9.3
T_4	21.3	15.1	52.0	91.0	17.0	6.2
T_5	20.2	59.0	94.7	130.0	12.0	6.2
T_6	28.9	62.1	32.1	64.0	98.0	9.0
T_7	23.1	25.7	69.6	ND	20.0	8.7
CD (P=0.05)	NS	18.8	NS	105.3	37.0	1.1

ND: Not detected; NS: Not significant

Table 4. Yield of coconut (WCT var.)

Period	**(nuts palm^{-1} year^{-1})**
2000-2002 (Pre expt.)	89
2004-05	120
2005-06	148
2006-07	137
2007-08	127
2008-09	120
2009-10	168
Average (2004-05 to 2009-10)	136

Thus, it could be inferred that application of organic manures helps in increasing the microbial population in soil, particularly the beneficial ones. Beneficial microorganisms will help to increase the productivity of crops by supplying plant nutrients directly or indirectly promoting growth.

Coconut yield

An improvement in coconut yield over the years was observed with vanilla intercropping under different nutrient sources (Table 4). The average yield realized during experimental period (2004-05 to 2009-10) was 136 nuts per palm, recording 53 per cent increase in coconut yield compared to pre-experimental yield (89 nuts palm^{-1}). This clearly indicated additive advantage of growing vanilla as intercrop in coconut garden wherein it was managed with nutrient and water requirement. The results are in conformity with that of Nayar and Suja (2004), who have reported no reduction in the yield of main crop (coconut) when the base crop and intercrops were adequately fertilized. Maheswarappa *et al.* (2013) also reported the trend of positive influence of organic treatment in sustaining the productivity in the coconut based cropping system.

Thus, from the study it can be concluded that, intercropping of vanilla in coconut garden with the application of cowdung slurry (6 tonnes ha^{-1}) in two splits or vermicompost 5 kg plant^{-1} year^{-1} in two splits along with bio-fertilisers (Phosphate solubilizing *Bacillus* sp. and nitrogen fixing *Azospirillum* sp. @ 25 g plant^{-1} year^{-1}) resulted in higher fresh bean yield and increase in the microbial population in the rhizosphere and overall increase in the nut yield of coconut.

References

Allen, O.N. 1959. *Experiments in Soil Bacteriology*, 3rd Edn. Minneapolis, MN, USA, Burgess, 117 p.

Becking, J.H. 1959. Nitrogen fixing bacteria of the genus *Beijerinckia* in South African soils. *Plant and Soil* **11**: 193-206.

Gupta, A., Gopal, M. and Tilak, K.V.B.R. 2000. Mechanism of plant growth promotion by rhizobacteria. *Indian Journal of Experimental Biology* **38**: 856-862.

King, E.O., Ward, M.N. and Raney, D.E. 1954. Two simple media for the demonstration of pyocyanin and fluorescin. *Journal of Laboratory Clinic and Medicine* **44**: 301-307.

Maheswarappa, H.P., Subramanian, P. and Dhanapal, R. 2000. Root distribution pattern of coconut (*Cocos nucifera* L.) in littoral sandy soil. *Journal of Plantation Crops* **28**(2): 164-166.

Maheswarappa, H.P., Dhanapal, R., Subramanian, P. and Palaniswami, C. 2013. Evaluation of coconut based high density multi-species cropping system under organic and integrated nutrient management. *Journal of Plantation Crops* **41**(2): 130-135.

Martin, J.P. 1950. Use of acid, rose Bengal and streptomycin in the plate method for estimating soil fungi. *Soil Science* **69**: 215-232.

Nayar, T.V.R. and Suja, G. 2004. Production potential of root and tuber crops in multiple cropping systems involving plantation crops. *Journal of Root Crops* **30**(2): 93-100.

Nybe, E.V. and Miniraj, N. 2007. Vanilla. In: *Spices*. (Ed.) Peter, K.V., vol. 5. Horticulture Science Series. New India Publishing Agency, New Delhi, pp. 114-130.

Nybe, E.V., Peter, K.V. and Miniraj, N. 2004. Integrated cropping in coconut involving spice crops. *Indian Coconut Journal* **34**(10): 3-9.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*. 4th Edn. Indian Council of Agricultural Research, New Delhi.

Pikovskaya, R.I. 1948. Mobilization of phosphorus in soil in connection with vital activity of some soil microbial species. *Mikrobiologiya* **17:** 362-370.

Sadanandan, A.K. and Hamza, S. 2006. Effect of organic farming on soil quality, nutrient uptake, yield and quality of Indian Spice. In: *18th World Congress on Soil Science.* July 9-15, 2006, Philadelphia, PA, USA.

Sujatha, S. and Bhat, R. 2010. Response of vanilla (*Vanilla planifolia* A.) intercropped in arecanut to irrigation and nutrition in humid tropics of India. *Agricultural Water Management* **97**: 988-994.

Viruel, E., Erazzú, L. E., Martínez Calsina, L., Ferrero, M. A., Lucca, M. E. and Siñeriz, F. 2014. Inoculation of maize with phosphate solubilizing bacteria: Effect on plant growth and yield. *Journal of Soil Science and Plant Nutrition* **14**(4): 819-831.