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Performance of Rooted Cuttings of Black Pepper (*Piper nigrum* L.) with Organic Substitution of Nitrogen

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ABSTRACT

Black pepper (*Piper nigrum*), known as "King of spices", is a perennial export oriented cash crop in India. With organic spice being the latest demand by the health conscious people throughout the globe, organic substitution of nitrogenous fertilizers in black pepper is becoming relevant day by day. An investigation was carried out to study the influence of different organic substitution of nitrogenous fertilizers in nutrient schedule on different growth parameters of the black pepper cultivar Panniyur-1. Recommended dose of P and K in the form of SSP and MoP was given to the vines. The plants were allowed to grow for upto 36 months of age for taking observations on different growth parameters. Considering the realization of highest response for four important growth parameters viz., plant height (269.37 cm), plant fresh weight (533.80 g), plant dry weight (178.01 g) and relative growth rate, RGR (5.10 g g^{-1} day^{-1}) after 36 months of planting, it may be concluded that the organic matter supplementation by 25% farm yard manure along with 75% urea) may be the best nutrient schedule under this agro-climatic condition.

Key words: Black pepper, spice, nutrition, nitrogen, organic, growth

INTRODUCTION

Black pepper (*Piper nigrum*), of the family Piperaceae, is a perennial export oriented spice crop in India. It is gaining popularity worldwide as an indispensable food adjunct due to its unique pungency and associated flavor. It is regarded as "King of spices" and "Black gold" (Parthasarathy *et al*., 2008) and having great socio-economic importance. The increasing reliance and demand of organic spices throughout the world provides ample scope to go for organic substitution of nitrogen in black pepper too (Stephen and Nybe, 2003). Sharangi *et al*. (2010) worked on the survivability of black pepper (*Piper nigrum* L.) cuttings from different portions of vine and growing media in India.

The productivity of black pepper in India is being challenged by countries like Malayasia and it is ascribed basically to improper management practices (Hamza and Sadanandan, 2005). Nutrition, the most important management option, is often neglected or not taken into account properly. Many researchers have reported on the need of integrated plant nutrition management for soil fertility and crop production (Ayeni, 2011; Singh *et al*., 2011; Aticho *et al*., 2011; Parthasarathy *et al*., 2010). Peter *et al*. (2000) documented that less fertilizer use, low fertilizer use efficiency and micronutrient deficiency are the major reasons for the low productivity of all the spices grown in India including black pepper. With soil degradation and decline in crop yields at its alarming limits, sustainability in crop production with respect to maintenance of soil fertility is the major concern. People used to go with the chemical fertilizers as these are cheaper, easily available and required in lesser quantity compared with their organic counterparts disregarding their deleterious effects on soil environment (Chamle *et al.*, 2010). The placement and dose of inorganic fertilizers are also decisive in some cases (Sharangi and Sahu, 2009). In spite of this, inorganic fertilizers alone are no more reliable to ensure productivity and quality and organic management is being welcomed particularly when the sustainability is taken into account (Shashidhar *et al.*, 2009; Onwudike, 2010; Berova *et al.*, 2010; Tena and Beyene, 2011). Even other organic options like allelopathy are becoming popular on spice crops for managing weeds (Sharangi, 2011). Use of organic manures solely or as a supplement of the inorganic fertilizer management schedule would be an inevitable practice in years to come for sustainable crop production. The present study was, therefore, undertaken to evaluate the influence of different organic substitution on growth parameters of black pepper cv. Panniyur-1.

MATERIALS AND METHODS

An investigation was carried out during the period of 2007 to 2010 at the Horticulture Research Station, Bidhan Chandra Krishi Viswavidyalaya (Agricultural University) to study the influence of different organic substitution of nitrogenous fertilizers in nutrient schedule on different growth parameters of the black pepper cultivar Panniyur-1 collected from Central Plantation Crop Research Institute (CPCRI), Mohitnagar, India. Geographical location of the experimental site is 23.5°N latitude and 80°E Longitude with average altitude of 9.75 m above the mean sea level and the average temperature ranges from 25-36.5°C during summer months and between 12 and 25°C during winter months with average annual rainfall being about 1500 mm. The nutrient schedule employed in this experiment was (T_1), 25% Mustard Cake (MC) +75% urea, (T_2), 50% MC + 50% urea, (T_3), 25% Neem Cake (NC) + 75% urea, (T_4), 50% NC+ 50% urea, (T_5), 25% Groundnut Cake (GC) + 75%urea, (T_6), 50% GC+ 50%urea, (T_7), 25% Farm Yard Manure (FYM) + 75% urea (T_8), 50%FYM + 50% urea and (T_9), the recommended dose (NPK at 100:40:140 g/vine). Rooted black pepper cuttings of cv. Panniyur-1 were planted in the field and nutrients were supplied as per the schedule. The plants were allowed to grow for upto 36 months of age for taking observations on different growth parameters. To determine LAI, leaves area upon samples were estimated by leaf area meter before placing in oven and then determined LAI in each sampling stage. The RGR was determined by the following formulas (Farahani *et al.*, 2009):

$$RGR = (LnW_2-LnW_1)/(T_2-T_1)$$

Statistical analysis: Field data taken at periodic intervals were analysed by statistical analysis software (SAS version 12) and their means were separated by Least Significant Difference (LSD 0.05 test). The correlation coefficients among the growth characters and parameters of rooted black pepper cuttings were calculated (Minitab version 16) and regression curve alongwith equations were made (MS Excel). The correlation analysis is performed to all the growth parameters of black pepper. The estimation curve was created to determine the relationships of vigour characteristics especially of Leaf Area Index (LAI) and Relative Growth Rate (RGR) with other growth parameters.

RESULTS

Organic substitution of nitrogenous fertilizers: All the plant growth parameters except plant height, number of primary branches and leaf area (Table 1) were recorded to be the lowest in the plants which received the recommended doses of N, P, K nutrients through inorganic fertilizers (T_9). However, the vines responded differently to the different organic substitution of nitrogen for the manifestation of the growth characters. It is evident that T_5 exhibited the maximum plant height (269.83 cm), number of nodes (148.39) and number of leaves per plant (164.99). The minimum plant height (208.83 cm), number of nodes (137.13) and number of leaves per plant (152.00) was observed in T_3, T_9 and T_9, respectively. Plant fresh and dry weight was found maximum (533.80 g and 178.01 g, respectively) with T_7 and minimum (475.13 g and 158.01 g, respectively) with T_9. However, considering the realization of highest response for four important growth parameters viz., plant height (269.37 cm), plant fresh weight (533.80 g), plant dry weight (178.01 g) and relative growth rate, RGR (5.10 gg^{-1} day^{-1}) after 36 months of planting, the organic matter supplementation treatment, T_7 (25% Farm Yard Manure (FYM) + 75% urea) emerged as the best nutrient schedule under this agro-climatic condition.

Plant species vary widely in their potential growth rate. Generally, the technique of growth analysis is employed to analyze the causes of inherent variation in growth rate. Hence, growth analysis is a widely used analytical tool for characterizing plant growth. However, in the present investigation these analytical tools for growth analysis have been determined from the varied response of the vines to different nutrient schedules as organic supplementation of nitrogen (T_1 to T_9) to compare growth differences that arise from experimental treatments.

Correlation among the growth characters and parameters: Data recorded on different growth characters and parameters periodically starting from 14 months upto 36 months after cutting at two months interval from the sampled vines received the nine different nutrient schedules as organic supplementation of nitrogen (T_1 to T_9) were employed to determine the

Table 1: Effect of organic substitution of nitrogen on black pepper plants*

Treatment	Height of plant (cm)	Number of nodes	Inter-nodal length (cm)	Number of leaves per plant	Number of primary branches	Base vine girth (mm)	Plant fresh weight (g)	Plant dry weight (g)	Leaf area (cm^2)	LA I	L AR (cm^2 g^{-1})	NAR (g cm^{-2} day^{-1})	RGR (gg^{-1} day^{-1})
T_1	249.40	139.14	12.08	155.45	17.32	15.29	497.13	165.34	94.52	0.17	0.57	8.79	5.03
T_2	260.70	144.27	13.13	157.43	16.93	16.64	507.47	168.90	119.48	0.21	0.71	7.14	5.05
T_3	208.83	141.77	13.09	156.97	17.86	16.99	515.13	171.34	108.86	0.19	0.64	7.97	5.06
T_4	259.97	143.46	13.17	163.61	17.37	16.80	509.80	169.68	118.38	0.21	0.70	7.24	5.05
T_5	269.83	148.39	13.45	164.99	17.56	16.28	512.47	170.46	118.64	0.21	0.70	7.27	5.06
T_6	267.13	147.74	14.53	159.48	17.61	16.56	523.47	174.46	111.16	0.19	0.64	7.97	5.08
T_7	269.37	144.70	14.22	160.75	16.31	16.31	533.80	178.01	118.87	0.21	0.67	7.63	5.10
T_8	259.23	140.37	12.93	156.50	17.60	16.08	531.47	176.79	116.00	0.20	0.66	7.76	5.09
T_9	235.03	137.13	11.43	152.00	16.54	15.14	475.13	158.01	100.35	0.18	0.64	7.84	4.98
SEM(±)	32.908	1.263	0.570	1.194	0.604	0.527	2.115	0.659	1.026	0.002	0.007	0.089	0.004
CD (p = 0.05)	10.976	0.421	0.190	0.398	0.201	0.176	0.706	0.220	0.342	0.001	0.003	0.030	0.002

*age 36 months. T_1 = 25% MC + 75% Urea ; T_2 = 50% MC + 50% Urea ; T_3 = 25% NC + 75% Urea ; T_4 = 50% NC + 50% Urea ; T_5 = 25% GC + 75% Urea; T_6 = 50% GC + 50% Urea ; T_7 = 25% FYM + 75% Urea ; T_8 = 50% FYM + 50% Urea; T_9 = Recommended dose (NPK at 100:40:140 g/vine)

Table 2: Correlation among the growth characters and parameters of rooted black pepper cuttings*

Treatment	Height of plant (cm)	Number of nodes	Inter-nodal length (cm)	Number of leaves per plant	Number of primary branches	Base vine girth (mm)	Plant fresh weight (g)	Plant dry weight (g)	Leaf area (cm^2)	LA I	L AR ($cm^2 g^{-1}$)	NAR ($g cm^{-2}$ day^{-1})	RGR (gg^{-1} day^{-1})
Height of plant (cm)	1.000												
Number of nodes	0.590	1.000											
Internodal length (cm)	0.514	0.862	1.000										
Number of leaves per plant	0.568	0.823	0.668	1.000									
Number of primary branches	-0.224	0.231	0.156	0.233	1.000								
Base vinegirth (mm)	0.024	0.633	0.700	0.592	0.416	1.000							
Plant fresh weight (g)	0.409	0.562	0.828	0.507	0.247	0.607	1.000						
Plant dry weight (g)	0.416	0.567	0.837	0.508	0.232	0.606	0.830	1.000					
Leaf area (cm^2)	0.520	0.677	0.667	0.705	0.005	0.721	0.653	0.653	1.000				
LA I	0.520	0.677	0.664	0.701	0.007	0.717	0.651	0.652	0.841	1.000			
L AR ($cm^{-2} g^{-1}$)	0.426	0.549	0.388	0.614	-0.116	0.585	0.277	0.277	0.909	0.909	1.000		
NAR ($g cm^{-2} day^{-1}$)	-0.370	-0.497	-0.324	-0.557	0.145	-0.544	-0.196	-0.197	-0.869	-0.870	-0.994	1.000	
RGR ($gg^{-1} day^{-1}$)	0.415	0.575	0.840	0.517	0.245	0.616	0.93	0.96	0.656	0.655	0.281	-0.201	1.000

*age 36 months. Correlation coefficient r>0.66 and r>0.798 are significant at p = 0.05 and p = 0.01, respectively

correlation coefficients among growth characters and parameters. The correlation coefficients emanated from different plant growth characters and parameters of the final stage of documentation are shown in Table 2. The results are presented and discussed hereunder.

Number of nodes has positive and significant correlation with internodal length (r = 0.862), number of leaves per plant (r = 0.823), leaf area (r = 0.677) and LAI (r = 0.677), so, also the internodal length with number of leaves per plant (r = 0.668), plant fresh weight (r = 0.828) and RGR (r = 0.840). Base vine girth is found to be significantly correlated with leaf area (0.721) and LAI (0.717), respectively. On the other hand, NAR is negatively correlated with leaf area (-0.869), LAI (-0.870) and LAR (-0.994), respectively in a significant way.

Plant height did not register significant correlation with any growth character and parameter. Nodes per plant were correlated significantly with only internodal length and leaves/plant. Leaves/plant established positive and significant correlations with leaf area and leaf area index which was quite expected. Highly negative correlation of NAR with leaf area, LAI and LAR could not be explained.

Relationships of canopy architecture characteristics and other growth parameters: Canopy architecture characteristics, plant height, LAI and RGR are some of the major factors for determining vigour of vine crops like black pepper. Based on the statistical analysis, we found a quadratic relation between the black pepper growth parameter and its vigour. Figure 1 and 2 depict the correlation of LAI and LAR between plant height, number of nodes, number of leaves/plant, plant fresh weight and plant dry weight, respectively. It is evident from Fig. 1 that LAI was weakly but significantly associated with plant height (R^2 = 0.509), number of nodes (R^2 = 0.562), leaf number/plant (R^2 = 0.542), fresh weight (R^2 = 0.320), dry weight (R^2 = 0.322). An excellent association of LAI with leaf area (R^2 = 0.980) was observed and the graph typically denotes increased LAI with increasing values of leaf area (Fig. 1f) as compared to those with plant

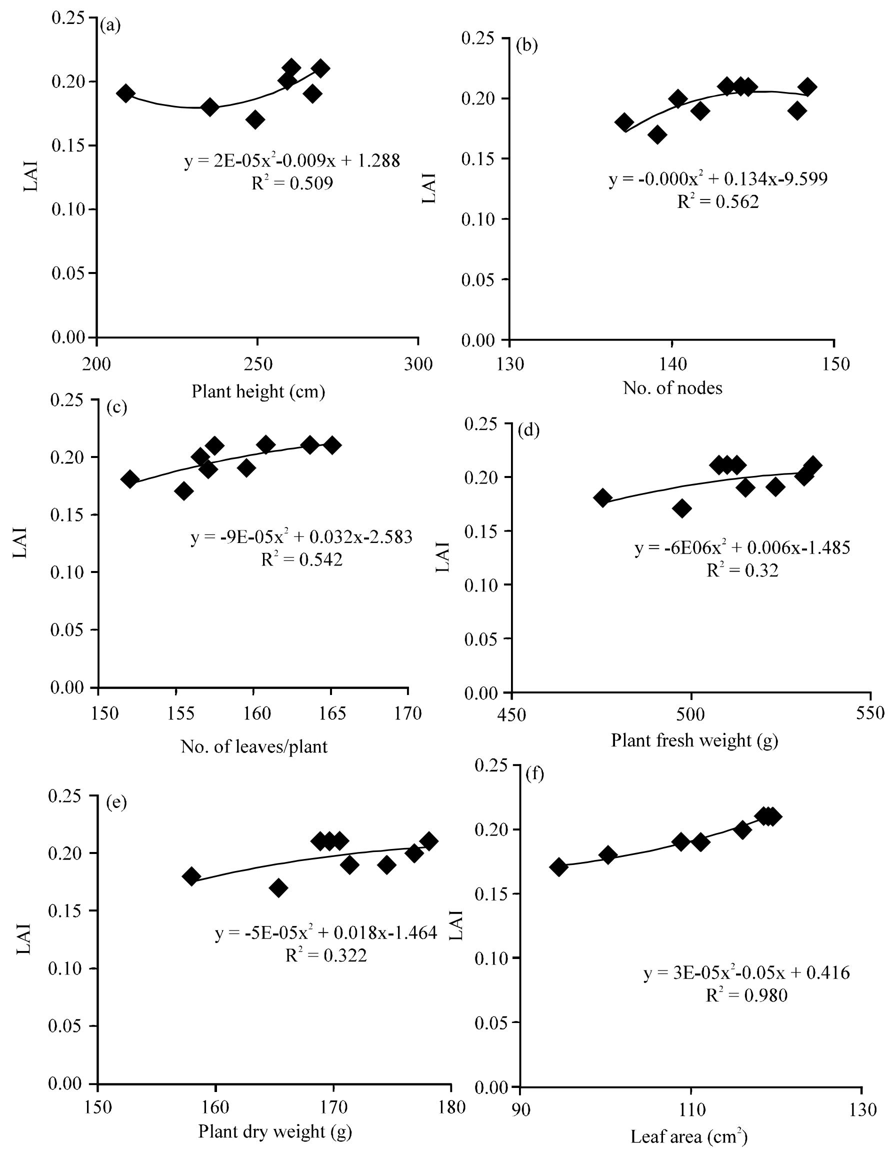

Fig. 1(a-f): Relationships of canopy architecture characteristics and other growth parameters, (a) Plant height vs LAI, (b) No. of nodes vs. LAI, (c) No. of leaves/plant vs. LAI, (d) Plant fresh weight vs. LAI, (e) Plant dry weight vs. LAI and (f) Leaf area vs. LAI

height (Fig. 1a), number of nodes (Fig. 1b), leaf number/plant (Fig. 1c), fresh weight (Fig. 1d), dry weight (Fig. 1e). However, the association of the same parameter with RGR are comparatively stronger as well as significant with R^2 values of 0.637, 0.618, 0.779, respectively in plant height (Fig. 2a), number of nodes (Fig. 2b) and leaf number/plant (Fig. 2c) excepting leaf area (R^2 = 0.434; Fig. 2f). The corresponding R^2 values of 0.996 and 0.995 in fresh weight (Fig. 2d) and dry weight (Fig. 2e), respectively are observed with typical curves depicting excellent association with RGR.

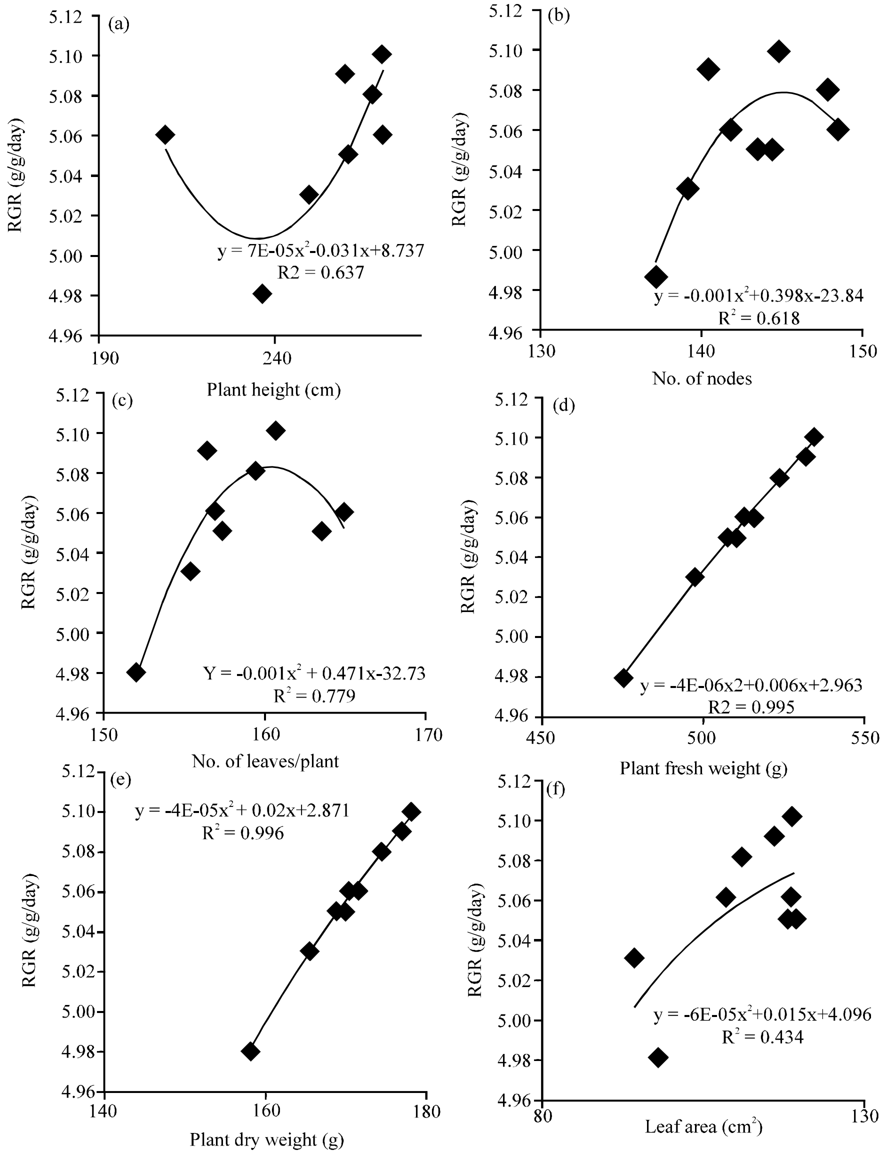

Fig. 2(a-f): Relationships of canopy architecture characteristics and other growth parameters, (a) Plant height vs. RGR, (b) No. of nodes vs. RGR, (c) No. of leaves/plant vs. RGR, (d) Plant fresh weight vs. RGR, (e) Plant dry weight vs. RGR and (f) Leaf area vs. RGR

DISCUSSION

The results of the present investigation clearly indicated the advantage of organic matter supplementation for nitrogen nutrition. It is quite justified to suggest that organic matter improved the physico-chemical characteristics of the soil by giving better aggregation, cation exchange capacity, sustained nutrient supply to the vine, enhanced water holding capacity and reduced soil erosion. It amply reflected on highly significant upgradation of all the growth parameters in the plants grown with organic matter supplementation compared to those managed with sole inorganic fertilizers. Soil organic matter decreases bulk density, increases porosity and influences chemical functions and acts as ion-exchanger and store house of nutrients (Maheswarappa *et al*., 1998, 1999). Larson and Clapp (1984) also reported the structural changes due to organic manures, through the changes in pore size both within and between the soil aggregates It also increases organic carbon content due to recycling of farm yard manure over a long period of time. This higher organic carbon status causes the increases in bacterial population to a greated extent than actinomycetes and fungi in the soil (Gaur *et al.*, 1984). The lower microbial population in the soil under inorganic fertilizer application condition was mainly attributed to suppressive effect of chemical fertilizers on microbial activity (Maheswarappa *et al.*, 1999).

Several earlier reports supported the present findings that growth and yield of black pepper were significantly enhanced by the combination of chemical fertilizer and organic manures or biofertilizers over inorganic fertilizers alone (Kanthaswamy *et al.*, 1996; Kandiannan *et al.*, 2006; Mathew and Nybe, 2002; Stephen and Nybe, 2003). According to Sangeeth *et al.* (2008), the co-inoculation of *Azospirillum* spp. (BPaz4 and BPaz9 isolates) in different combinations, under varying levels of fertilizers and organic amendments may contribute more to the growth and nutrient uptake of black pepper.

Of the parameters typically calculated, the most important is Relative Growth Rate (RGR). Relative growth rate refers to the increase in plant mass per unit of mass present and per unit of time (Van der Werf *et al.*, 1998). The relative growth rate is factorized into the growth parameters NAR (Net assimilation rate, biomass increase per unit leaf area and time) and LAR (Leaf area ratio, leaf area per unit plant mass). LAR can be further analyzed as the product of SLA (Specific leaf area, leaf area per unit leaf mass) and LMR (Leaf mass ratio, leaf mass: total plant mass). LAR, SLA and LMR are simple ratios that can be easily measured but NAR is a more complex parameter, being the net balance of C-gain in photosynthesis and C-losses in shoot and root respiration, divided by the C-concentration of the plant's newly formed biomass (Lambers *et al.*, 1989). Akinbile and Yusoff (2011) opined that the formation of canopy shading is a function of foliage (leaves) which is dependent on the accessability of plant to its uptake of nutrient and water in sufficient amount.

From such inter-relationships among the growth parameters, it was expected that RGR would establish correlations with LAR and NAR. However, such correlation coefficients was not registered in any growth stage indicating that such association ship among the growth parameters would only appear from the inherent variation in the plant species. The findings are in conformity with Ozalkan *et al.* (2010) where the highest values of LAI and LAD were recorded for the period of linear vegetative growth stage in chickpea. A highly significant ($p<0.01$) relationships between leaf area index and number of total fruit, number of bolls per plant, plant height, total dry weights and leaf dry weights was also found in cotton by Pervez *et al.* (2006).

CONCLUSION

Black pepper is gaining worldwide popularity for its unique flavour, taste and pungency alongwith the wide medicinal uses. The need of the hour is to make this spice find its position and recognition in a holistic manner. The method of propagation being simple and the growth being satisfactory under proper management condition, an organic approach of fertilization for cultivation would certainly ensure sustainability in yield and quality. Some earlier work also (Sharangi and Kumar, 2011) supported the present findings that growth and yield of black pepper were significantly enhanced by the combination of chemical fertilizer and organic manures or biofertilizers over inorganic fertilizers alone. Considering the realization of highest response for four important growth parameters viz., plant height (269.37 cm), plant fresh weight (533.80 g), plant dry weight (178.01 g) and relative growth rate, RGR (5.10 gg^{-1} day^{-1}) after 36 months of planting, the organic matter supplementation treatment, it may be concluded that 25% farm yard manure alongwith 75% urea may be the best nutrient schedule under this agro-climatic condition.

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