J. Hortl. Sci.
Vol. 8(1):41-46, 2013

Effect of growth media on seed germination and seedling growth in papaya (*Carica papaya* L.) cv. Red Lady

R.L. Bhardwaj
Krishi Vigyan Kendra, Sirohi
Maharana Pratap University of Agriculture and Technology
Udaipur - 313 001, India
E-mail : rajubhardwaj3@gmail.com

ABSTRACT

The study was carried out to explore the effect of growth media on seed germination and seedling growth in papaya cv. Red Lady. Three types of media with three levels of cocopeat were studied. The experiment was laid out in Completely Randomized Design, with nine treatment combinations, and replicated thrice. Results showed that the medium Vermicompost + Sand + Pond soil (1:1:1) with 2cm cocopeat layer on top of the polybag (T_9) gave highest germination rate (92.71%), maximum speed of emergence (493.34), highest seed vigour (89.33), maximum germination index (7.18), highest germination value (25.58), the least time required for imbibition (9.37 days) and minimum time taken to germination (3.22 days). Medium T_9 was also found to be the best for growth of 'Red Lady' papaya seedlings as it gave the highest values for seedling growth parameters like seedling height (23.05cm), leaf area (339.26cm^2), number of leaves (9.84), stem diameter (3.32mm), number of roots (16.68), root length (9.93cm), total biomass (4.89g plant^{-1}) and lowest root/shoot ratio (0.21). This treatment significantly reduced seedling mortality and produced maximum number of healthy seedlings (92.69%) in minimum number of days (35.24), showing the highest net profit (Rs. 3470.65/1000 seedlings) and benefit:cost ratio (1.84) seedling production.

Key words: Papaya seedling, germination, growth media, plant growth, cocopeat, pond soil, vermicompost, propagation, Farm Yard Manure

INTRODUCTION

Papaya is an important fruit crop in India propagated by seeds only. Seed germination in papaya is reported to be slow, erratic and is also incomplete (Chako and Singh, 1966). 'Red Lady' is the choicest variety of papaya-growers due to its hermaphrodite nature and prolonged shelf-life of fruits. But, seed cost in this variety is very high (Rs. 2.0 lakh kg^{-1}). Therefore, increasing germination per cent and producing more number of healthy seedlings is a challenge for papaya growers. Papaya seeds of cv. Red Lady face some problems in germination and have high seedling-mortality due to damping-off disease in the nursery. Incomplete germination and initial mortality are the causes for reduced survival per cent of papaya seedlings. Growth media composition influences seed germination and quality of the seedlings (Wilson *et al*, 2001). Growth medium directly affects seed germination, seedling growth, development and, later, maintenance of the extensively functional rooting system. A good growth medium provides sufficient anchorage or support to the plant, serves as a reservoir for nutrients and water, allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside root substrate (Abad *et al*, 2002). Nursery potting media influences quality of seedlings produced (Agbo and Omaliko, 2006). Quality seedlings established well in the field and increased productivity of the orchard (Baiyeri, 2006). Generally, media for fruit crop seedlings are composed of soil, organic matter, pond soil and sand. Pond soil is usually used as a basic medium because it is inexpensive and easy to procure. Supplementing sand is aimed at making the medium more porous. While organic matter (Farm Yard Manure and Vermicompost) is added to enrich seedlings with adequate nutrients, cocopeat is considered as a good growth media component, with acceptable pH, electrical conductivity and other chemical attributes (Abad *et al*, 2002). Cocopeat has good physical properties, high total pore space, high water content, low shrinkage, low bulk density and is slow to biodegrade. Results of many experiments reveal that cocopeat (used alone, or as a component of soil medium), is suitable for roses, gerbera, many potted plants (De Kreij and Leeuven, 2001; Pickering, 1997), and also for vegetables.

Keeping in view influence of the medium on germination and seedling growth in papaya, present investigation was carried out to study the effect of different media, viz., sand, pond soil, Farm Yard Manure, vermicompost and cocopeat on seed germination, seedling growth and vigour of papaya seedlings.

MATERIAL AND METHODS

Seed material and treatment

Seed germination and seedling growth experiments in papaya were carried out at the Model Nursery of Krishi Vigyan Kendra, Sirohi (Rajasthan) during two successive seasons, from July to August in 2009 and 2010 under agronet (75%) house conditions. Papaya seeds of cv. Red Lady (F_1) produced by Known-You Seed Co. Ltd., Kaohsiung, Taiwan, was procured from Known you seed (India) Pvt. Ltd., Pune, in 10g polyethylene air-tight packing in cardboard boxes. Nine treatments consisted of various combination of growth media with or without cocopeat in polybags (10 x 12cm), namely, T_1 – Sand + pond soil (1:1) without cocopeat; T_2- Sand + pond soil (1:1) with 1cm cocopeat; T_3- Sand + pond soil (1:1) with 2cm cocopeat; T_4- FYM + sand + pond soil (1:1:1) without cocopeat; T_5- FYM + sand + pond soil (1:1:1) with 1cm cocopeat; T_6- FYM + sand + pond soil (1:1:1) with 2cm cocopeat; T_7- Vermicompost + sand + pond soil (1:1:1) without cocopeat; T_8- Vermicompost + sand + pond soil (1:1:1) with 1cm cocopeat and T_9- Vermicompost + sand + pond soil (1:1:1) with 2cm cocopeat. Seed-sowing was done in the month of July at about 1cm depth in different media as per treatments. The polybags were irrigated immediately after seed-sowing and irrigation was repeated daily util final emergence. After completion of germination, the bags were irrigated once every two days.

Experimental design

The experiment was laid out in Completely Randomized Design, and replicated thrice. Each treatment composed of 100 polybags. All observations on germination parameters were recorded at the time of germination, and, growth parameters from 10 randomly selected seedlings at the time of transplanting (45 days after seed-sowing). Observations on germination were recorded from the first germination until no further germination was seen, at two days' interval. Imbibition period was calculated counting number of days from sowing to commencement of germination. Speed of emergence (SE) was calculated according to Islam *et al* (2009) using the following formula;

$$\textbf{Speed of emergence} = \left[\frac{\text{No. of seedlings emerged 5 days after sowing}}{\text{No. of seedlings emerged 15 days after sowing}}\right] \text{X } 100$$

Germination percentage was calculated by number of germinated seeds divided by the total number of seeds sown in polybags, and multiplied by 100. Germination period was calculated as the difference between initial and final emergence (number of days). Seed vigour was calculated by dividing total number of healthy seedling by total number of seedlings, and multiplied by 100. Germination index was calculated as described in the Association of Official Seed Analysis (1983) using the following formula:

$$\textbf{Germination index} = \left[\frac{\text{No. of germinating seeds}}{\text{Days of first count}}\right] + \left[\frac{\text{No. of germinating seeds}}{\text{Days of final or last count}}\right]$$

Germination value (GV) was calculated according to Hossain *et al* (2005) following the formula: Germination value = (Σ DGs/N) X GP/10, Where, GP is the germination percentage at the end of experiment, DG is the daily germination speed obtained by dividing cumulative germination percentage by the number of days since sowing, Σ DGs is the total germination obtained by adding every value of DG obtained from daily counts, N is the total number of daily counts, starting from the first germination and (10) is a constant. Counting of number of leaves was done at the end of the experiment by when true leaves had emerged. Stem diameter was measured 1cm above the base of the stem, using Vernier callipers. Plant height was measured from the base of the seedling to highest tip of the plant. Leaf area was calculated by tracing the leaves on a graph paper. Number of roots and root length measurement was done by the standard method using the destructive method of uprooting the plants and taking measurement. Stem and root were weighed to record stem root fresh weight, root/shoot ratio, and, total fresh and dry weight of the plant (g) at the time of transplanting. Survival % (15 days after transplanting in the main field) was recorded using the following formula;

$$\textbf{Survival \%} = \frac{\text{Total number of surviving transplanted plants}}{\text{Total number of transplanted plants}} \text{x } 100$$

Net return was calculated by subtracting cost of each treatment from the gross returns and benefit:cost ratio was calculated as Net income/Cost of seedling production. All data were subjected to Analysis of Variance (ANOVA) to determine significant differences, followed by Tukey's test for comparison of means at 5% significance level.

RESULTS AND DISCUSSION

Results showed that growth media and cocopeat had a beneficial effect on seed germination and seedling growth in papaya cv. Red Lady.

Seed germination

Seed germination parameters in papaya as affected by growth media mixture and use of cocopeat are presented in Table 1. Treatment T_9 was found to be the best, followed by T_8 as for germination parameters, as, these media had suitable physical properties and a good water holding capacity to supports papaya seed germination (Table 1). Germination commenced at an average of 9.37 days after sowing, on Vermicompost + sand + pond soil (1:1:1) with 2cm cocopeat layer (T_9) in both the years of experimentation. Germination continued until 23.87 days from sowing, when no further germination was noticed. In both the years, maximum speed of emergence (493.34), highest germination % (92.71), highest seed vigour (89.33), highest germination index (7.18), best germination value (25.58), least time required for imbibition (9.37 days) and minimum germination period (3.22 days) were obtained in Vermicompost + sand + pond soil (1:1:1) with 2cm top-filling with cocopeat of the polybags in both the years. Sand + pond soil (1:1) without cocopeat showed least values for all the parameters compared to other treatments. This could be due to the fact that pond soil and vermicompost are high in organic matter which increases water and nutrient holding capacity of the medium for supply to the plant. Vermicompost is reported as having bioactive principles considered to be beneficial for root growth, root initiation, germination and growth of the plant (Bachman and Metzger, 2008), as also having a balanced composition of nutrients (Zaller 2007). Vermicompost, mixed with pond soil, affects physical, chemical & biological properties of the soil as the organic matter acts as a glue for soil aggregation and is a source of soil nutrients. Soil aggregation improves permeability and airflow in the polybags. Organic matter may also improve nutrient availability and improve phosphorus absorption (Karama and Manwan, 1990). All these factors are favourable for seed germination and, ultimately, increase seed germination %, speed of emergence, seed vigour, germination index, germination value, and, reduce the imbibition period. Combined application of vermicompost and cocopeat in treatment T_9 showed significant positive effect on germination, seedling growth and plant biomass, probably owing to a synergistic combination of both these factors in improving physical condition of the media and providing nutritional factors (Sahni *et al*, 2008)

Seedling growth and development

Data presented in Tables 2 and 3, and Figure 1, show significant increase in growth of papaya seedlings as affected by different growth media. Maximum number of leaves was observed in T_9 (9.84) which was at par with T_6 (9.1). Maximum seedling diameter (3.32mm), seedling height (23.05cm), leaf area (339.26cm^2), root length (9.93cm) and fresh weight of plants (4.89g) were recorded in T_9 treatment. Similarly, maximum number of roots per plant

Table 1. Effect of growth media mixture and cocopeat on germination parameters in papaya cv. Red Lady seed (pooled)

Treatment	Imbibition period	Speed of emergence	Germination %	Germination period	Seed vigour	Germination index	Germination value
T_1	15.67	127.37	59.69	8.20	55.24	2.37	1.94
T_2	13.60	169.56	67.82	6.98	64.16	3.14	3.50
T_3	12.05	226.21	80.33	5.88	75.74	4.34	6.83
T_4	15.35	154.12	70.79	7.28	64.69	3.24	3.37
T_5	13.59	277.13	81.55	4.88	76.76	4.51	7.72
T_6	11.59	325.56	85.65	3.95	82.81	5.45	12.47
T_7	13.84	252.51	77.62	6.15	73.76	3.69	5.02
T_8	11.63	430.54	87.57	4.08	83.26	5.99	14.50
T_9	9.37	493.34	92.71	3.22	89.33	7.18	25.58
SEm±	0.500	9.350	2.000	0.260	1.830	0.180	0.280
CD (*P=0.05*)	1.470	27.680	5.920	0.780	5.410	0.530	0.830

T_1 – Sand + pond soil (1:1) without cocopeat; T_2- Sand + pond soil (1:1) with 1cm cocopeat; T_3- Sand + pond soil (1:1) with 2cm cocopeat; T_4- FYM + sand + pond soil (1:1:1) without cocopeat; T_5- FYM + sand + pond soil (1:1:1) with 1cm cocopeat; T_6- FYM + sand + pond soil (1:1:1) with 2cm cocopeat; T_7- Vermicompost + sand + pond soil (1:1:1) without cocopeat; T_8- Vermicompost + sand + pond soil (1:1:1) with 1cm cocopeat; T_9- Vermicompost + sand + pond soil (1:1:1) with 2cm cocopeat

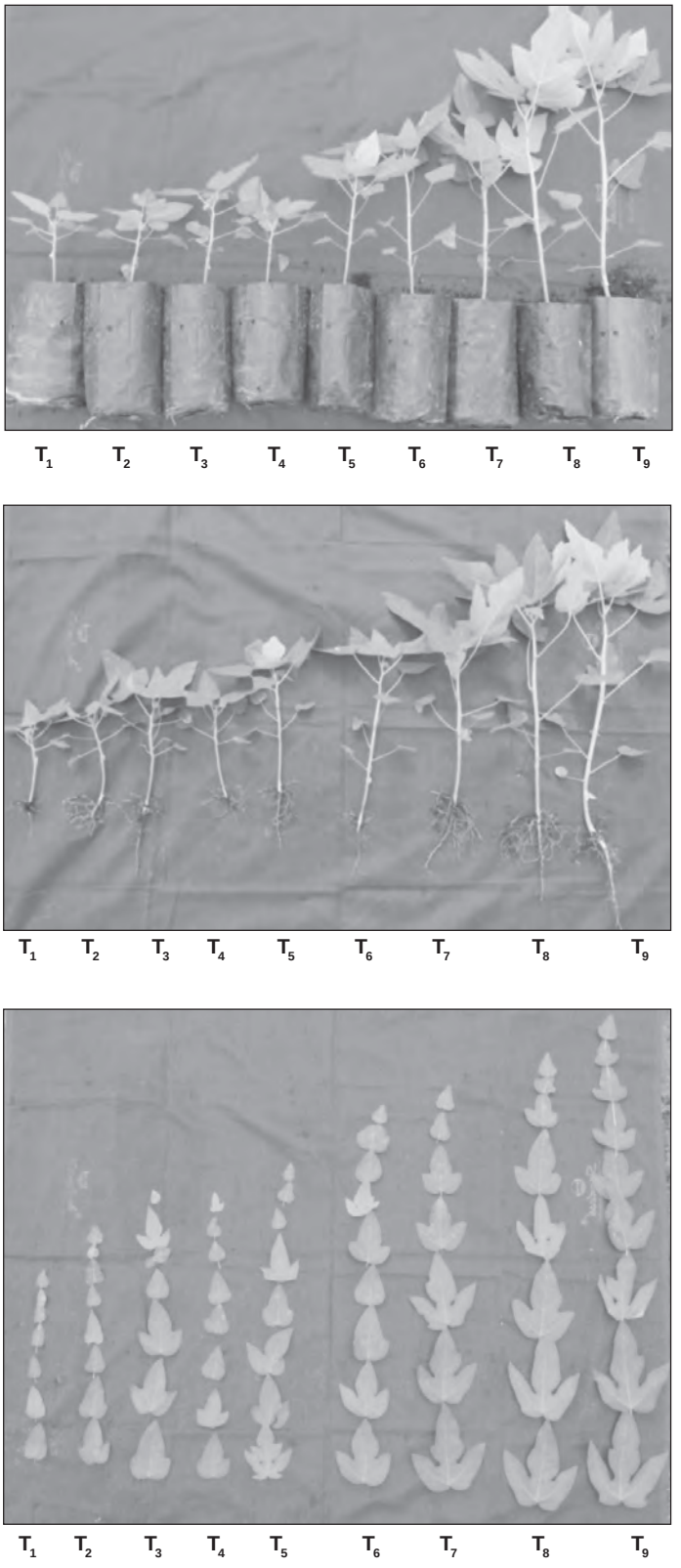

Fig. 1 Effect of growth media and cocopeat on shoot, root growth and leaf area in papaya cv. Red Lady Seedlings

was also observed in T_9 treatment (16.68) which was at par with that in T_8 (16.01). Highest fresh-weight of shoots (4.05g) roots (0.84g), and lowest root/shoot ratio (0.21) was also observed in T_9. Vermicompost provides adequate nutrients and enhances both physical properties and water-holding capacity. Combined application of vermicompost and cocopeat have too showed significant effect on seedling growth and plant biomass, perhaps due to the synergistic effect of both these factors. This result is in line with findings of Campos Mota *et al* (2009) and Abirami *et al* (2010) who suggested that since coir dust was low in nutrients, mixed with vermicompost it provides a better growth medium for plant establishment. However, air filled porosity, easily available water and aeration of vermicompost and Farm Yard Manure were not at the recommended level which, in turn, limited root growth and lowered water-holding capacity. Therefore, medium with vermicompost and cocopeat is better suited than vermicompost alone, because of its better physical properties and higher nutrient levels.

This treatment combination also helped reduce damping-off disease in the seedlings due to proper aeration of the root zone of the seedlings and produced highest survival in seedling (92.69%), which was at par with T_8 (91.70%). Due toe better physical properties and enhanced nutrient levels in T_9, seedling growth improved and attained transplantable size early (35.24 days), which was at par with T_6 (37.62 days). Improved soil permeability and air flow may have reduced damping-off disease in the nursery stage, and provided support to the fast growth of seedlings ultimately, seedlings gained transplanting-size early. It appears that good physical and biological conditions in cocopeat and vermicompost had a positive effect on root development. This is helpful in realizing increased survival % of seedlings in the main field, after transplanting. Beneficial effect of cocopeat on the root system was observed on nutmeg seedlings by Abirami *et al* (2010), in *Osteospermum* cuttings by Nowak (2004), in *Salvia* and *Viola* by Pickering (1997) and in *Impatiens* by Smith (1995). Application of vermicompost:pond soil:sand (1:1:1) with 2cm cocopeat (T_9 media) proved to be profitable and showed maximum net returns (Rs. 3470.65/1000 seedlings) and highest benefit:cost ratio (1.84) due to higher germination rate and survival % (Tables 1 and 3). This treatment was significantly superior to rest of the treatments during both years. Benefit:cost ratio, however, was at par with that in treatmentT_8.

Table 2. Effect of growth media mixture and cocopeat on growth of papaya cv. Red Lady seedlings (pooled)

Treatment	Number of leaves	Stem girth (mm)	Seedling height (cm)	Leaf area (cm^2)	Number of roots	Root length (cm)	Fresh weight of plants (g)
T_1	3.54	1.12	8.27	16.72	5.80	3.46	0.62
T_2	5.59	1.44	9.39	31.83	9.90	3.88	0.80
T_3	7.68	2.08	11.39	50.80	12.17	5.74	1.01
T_4	6.62	1.54	9.11	50.35	7.47	5.08	0.69
T_5	8.20	2.34	12.19	91.66	10.41	6.92	1.00
T_6	9.10	2.82	17.31	134.15	12.26	7.27	1.44
T_7	7.38	2.05	14.05	137.65	12.90	7.67	2.42
T_8	8.31	2.69	19.93	232.75	16.02	9.02	3.56
T_9	9.84	3.32	23.05	339.26	16.68	9.93	4.89
SEm±	0.350	0.100	0.440	3.460	0.560	0.210	0.050
CD (*P=0.05*)	1.040	0.300	1.290	10.230	1.650	0.610	0.140

T_1 – Sand + pond soil (1:1) without cocopeat; T_2- Sand + pond soil (1:1) with 1cm cocopeat; T_3- Sand + pond soil (1:1) with 2cm cocopeat; T_4- FYM + sand + pond soil (1:1:1) without cocopeat; T_5- FYM + sand + pond soil (1:1:1) with 1 cocopeat; T_6- FYM + sand + pond soil (1:1:1) with 2cm cocopeat; T_7- Vermicompost + sand + pond soil (1:1:1) without cocopeat; T_8- Vermicompost + sand + pond soil (1:1:1) with 1cm cocopeat; T_9- Vermicompost + sand + pond soil (1:1:1) with 2cm cocopeat

Table 3. Effect of growth media mixture and cocopeat on biomass production, survival rate, net returns and B:C ratio in papaya cv. Red Lady seedlings (pooled)

Treatment	Fresh weight of shoot (g)	Fresh weight of root (g)	Survival %	Root /Shoot ratio	Days required to attain transplantable size in seedlings	Net returns (Rs./1000 seedlings)	B:C ratio
T_1	0.39	0.22	77.71	0.57	46.33	780.0	1.16
T_2	0.52	0.27	81.26	0.52	43.83	980.0	1.19
T_3	0.69	0.33	85.18	0.48	41.85	1880.0	1.35
T_4	0.51	0.18	82.20	0.35	42.10	1068.0	1.20
T_5	0.78	0.23	85.77	0.30	40.00	1868.0	1.34
T_6	1.12	0.31	88.74	0.28	38.10	2368.0	1.41
T_7	1.93	0.47	85.75	0.25	40.28	2170.60	1.65
T_8	2.94	0.66	89.80	0.23	38.33	2970.40	1.78
T_9	4.05	0.84	92.69	0.21	35.24	3470.65	1.84
SEm±	0.060	0.020	1.600	0.010	1.010	52.690	0.070
CD (*P=0.05*)	0.670	0.480	4.740	0.029	2.980	155.940	0.198

T_1 – Sand + pond soil (1:1) without cocopeat; T_2- Sand + pond soil (1:1) with 1cm cocopeat; T_3- Sand + pond soil (1:1) with 2cm cocopeat; T_4- FYM + sand + pond soil (1:1:1) without cocopeat; T_5- FYM + sand + pond soil (1:1:1) with 1cm cocopeat; T_6- FYM + sand + pond soil (1:1:1) with 2cm cocopeat; T_7- Vermicompost + sand + pond soil (1:1:1) without cocopeat; T_8- Vermicompost + sand + pond soil (1:1:1) with 1cm cocopeat; T_9- Vermicompost + sand + pond soil (1:1:1) with 2cm cocopeat

On the basis of results obtained in this study, it is concluded that growth media significantly influence germination and growth in papaya seedlings. Medium with vermicompost, pond soil and sand (1:1:1) and topping of polybags with 2cm cocopeat layer was the best since germination, and, seedling growth and development parameters, were higher in this than on other media. Overall results revealed that media supplemented with cocopeat resulted in higher rate of germination and better growth and development of papaya seedlings, compared to media without cocopeat. Therefore, it is suggested that vermicompost, pond soil and sand with cocopeat may be used as growth media for achieving higher germination rate and faster seedling growth in 'Red Lady' papaya seedlings.

REFERENCES

Abad, M., Noguera, P., Puchades, R., Maquieira, A. and Noguera, V. 2002. Physico-chemical and chemical properties of some coconut dusts for use as a peat substitute for containerized ornamental plants. *Biores. Technol.*, **82**:241-245

Abirami, K., Rema, J., Mathew, P.A., Srinivasan, V. and Hamza, S. 2010. Effect of different propagation media on seed germination, seedling growth and vigour of nutmeg (*Myristica fragrans* Houtt.). *J. Med. Pl. Res.*, **4:**2054-2058

Agbo, C.U. and Omaliko, C.M. 2006. Initiation and growth of shoots of *Gongronema latifolia* Benth stem cuttings in different rooting media. *African J.*

Biotech., **5**:425–428

AOSA. 1983. Seed vigour testing handbook, (contribution No. 32). Association of Official Seed Analysis, Ithaca, USA, 45 pp

Bachman, G.R. and Metzger, J.D. 2008. Growth of bedding plants in commercial potting substrate amended with vermicompost. *Biores Tech.*, **99:**3155-3161

Baiyeri, K.P. 2006. Seedling emergence and growth of pawpaw (*Carica papaya*) grown under different coloured shade polyethylene. *Int'l Agrophysics,* **20:**35-39

Campos Mota, L., Van Meeteren, U. and Blok, C. 2009. Comparison of physical properties of vermicompost from paper mill sludge and green compost as substitutes for peat based potting media. *Acta Hort.*, **819**:227-234

Chako, E.K. and Singh, R.N. 1966. Studies on the longevity of papaya, phalsa, guava and mango seeds. *Proc. Int'l Seed Test Assoc.,* **36:**147-158

De Kreij, C. and Leeuven, G.J.L. 2001. Growth of pot plants in treated coir dust as compared to peat. *Comm. Soil Sci. Pl. Anal.,* **32**:2255-2265

Hossain, M.A., Arefin, M.K., Khan, B.M. and Rahman, M.A. 2005. Effect of seed treatments on germination and seedling growth attributes of horitaki (*Terminalia chebula* Retz.) in the nursery. *Res. J. Agri. Biol. Sci.,* **1**:135-141

Islam, A.K., Anuar, M.A. and Yaakob. 2009. Effect of genotypes and pre-sowing treatment on seed germination behavior of jatropha. *Asian J. Pl. Sci.,* **8:**433-439

Karama, A.S. and Manwan, I. 1990. Penggunaan pupuk organic pada tanaman pangan. Makalah pada Lokakarya Nasional Efisiensi Penggunaan Pupuk. Cisarua Bogor, 12-13 November 1990, pp. 44

Novak, J. 2004. The effect of rooting media and CO_2 enrichment, P–nutrition and micorrhizal inoculation on rooting and growth of *Osteospermum*. *Acta Hort.*, **644**:589-593

Pickering, J.S. 1997. An alternative to peat. *The Garden***,** **122:**428-429

Sahni, S., Sharma, B.K., Singh, D.P., Singh, H.B. and Singh, K.P. 2008. Vermicompost enhances performance of plant growth promoting rhizobacteria in *Cicer arietinum* rhizosphere against *Sclerotium rolfsii*. *Crop Prot.,* **27:**369-376

Smith, C. 1995. Coir: a viable alternative to peat for potting. *Horticulturist,* **4:**25-28

Wilson, S.B., Stoffella, P.J. and Graetz, D.A. 2001. Use of compost as a media amendment for containerized production of two subtropical perennials. *J. Env. Hort.,* **19:**37-42

Zaller, J.G. 2007. Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. *Sci. Hort.,* **112**:191-199

(MS Received 20 December 2011, Accepted 15 April 2013, Revised 15 April 2013)