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Effect of organic manures on growth and yield of Safedmusli (*Chlorophytum borivilianum* Sant. & Fern.) Under Karanj (*Pongamia pinnata* L.) based agroforestry system

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Abstract
The experiment was carried out on an important herbal and medicinal crop, safedmusli (*Chlorophytum borivilianum* Sant. & Fern.) under karanj based agroforestry system at Indira Gandhi Krishi Vishwavidyalaya, Raipur. The experimental materials were planted in Randomized Block Design with eight treatments and three replications under 6m × 6m spacingkaranj plantation. Statistically high significant results were obtained in number of leaves/plant, length of tuber, number of tubers/plant, tuber yield (kg/plot) and tuber yield (Q/ha). Significant readings were also recorded on soil chemical properties against different organic manure treatments. Vermicompost (100%) performed outstanding for improvement of tuber length (11.85 cm), number of tubers (8.57 no.), number of leaves/plant (27.89, 90DAP), tuber yield (4.37 kg/plot) and tuber yield (33.62 Q/ha).High performance of vermicompost could be due to very rich and diverse microbial populations present in vermicompost. The soil chemical properties on post harvest soils was also observed with higher concentrations of N (213.66 kg/ha) and K_20 (465.12 kg/ha) in vermicompost (100%) treated plot. This experiment also revealed that safedmusli can be successfully grown in karanj based agroforestry system with mutual benefit.

Keywords: Safed musli (*Chlorophytum borivilianum* Sant. & Fern.), yield parameters, post harvest soil properties, karanj performance

Introduction
Chlorophytum borivilianum Sant. & Fern. popularly known as safedmusli, belonging to family Liliaceae is a traditionally rare Indian herb considered as a 'white gold' or 'divyaaushad'. The centre of origin of the genus *Chlorophytum* is believed to be tropical and subtropical Africa and was introduced in India from South Africa (Khanam *et al*., 2013) [1]. It is widely distributed in India mainly in Southern Rajasthan, Western Madhya Pradesh, North Gujarat and few parts of Karnataka. Its dried roots are considered as wonder drug in Indian systems of medicine (Ayurveda, Unani and Siddha) due to its aphrodisiac and sex tonic properties. Because of great therapeutic importance, safedmusli roots are the major constituents of more than 100 Ayurvedic formulations (Oudhia, 2000) [2]. The National Medicinal Plants Board (NMPB), set up by the Government of India has ranked safedmusli as the 6th among the 28 selected priority medicinal plants for cultivation and export (Purohit and Prajapati, 2003; Gayathri and Uma, 2009). Despite its importance, the current annual demand of safedmusli roots in India is estimated to be 3500 tonnes as against the supply of 500-600 tonnes (Kothari and Singh, 2001) [3]. In indigenous Indian market, rate of dry musli is around Rs. 800 to 1,800 per kg in whereas in the international market, it is about Rs. 3,000 per kg (Khanam *et al*., 2013) [1]. Cultivation of safedmusli can be done in warm and humid areas that receive 50-150 cm annual precipitation for optimum plant growth and fleshy root development. Too high day temperature (35°C and above) does not favour plant growth. Multipurpose trees can be of many benefits to high value crops when used as intercrops.
Karanj (*Pongamia pinnata* L.) is a potential tree borne oil seed species (TBOS) belonging to Leguminosae family (Suvera *et al*., 2015) [4] and has been used in many agroforestry systems.

Apart from TBOS, it is also a nitrogen fixer, suitable for problematic soils and drought conditions (Duke, 1983) [5], suitable tree in agroforestry (Beniwal and Chauhan, 2011) [6] and a good botanical against phytopathogenic fungi (Kumari *et al.*, 2013 and Dhingani *et al.*, 2013) [7, 8]. The tree is known for its multipurpose benefits and as a potential source of biodiesel (Naik *et al*., 2008).It grows abundantly along the coasts and riverbanks in Myanmar. The seeds are reported to contain on average about 28-34% oil with high percentage of polyunsaturated fatty acids (Sarma *et al*., 2005) [9]. Historically, *Pongamia* has been used as folk medicinal plant, particularly in Ayurveda and Siddha systems of Indian medicine (Meera *et al.*, 2003) [10]. The study on the performance of different organic treatments on safedmusli is crucial for standardizing optimum treatment for the improvement of growth and yield of safedmusli and understanding the suitability of safedmusli under karanj based agroforestry system in Chhattisgarh.

Materials and Methods

The field experiments of the present investigation were carried out at Herbal Garden, Indira Gandhi Krishi Vishwavidyalaya, Raipur which lies at 21º.76'N latitude and 81º.36'E longitude having an altitude of 295m above mean sea level. The soil of experimental area was black clayey soil, which is locally known as Kanhar, fine texture, sticky nature, angular blocky structure, low to medium nitrogen, high potassium and low to medium phosphorus with low organic matter. The experimental materials were planted in Randomized Block Design with eight treatments and three replications under 6m × 6m spacingkaranj (*Pongamia pinnata* L.) plantation. Raised beds of 20 cm high and 4 m × 3.25 m size were made in such a way that in each plot, number of trees representation was equal. Each plot was treated by mixing the soil thoroughly with the organic manure before planting safedmusli as per treatments (T1: 100% FYM @ 10 ton ha^{-1}, T2: 100% Vermicompost @ 5 ton ha^{-1}, T3: 100% Neem cake @ 4 ton ha^{-1}, T4: 50% FYM @ 5 ton ha-1 + 50% Vermicompost @ 2.5 ton ha^{-1}, T5: 50% FYM @ 5 ton ha^{-1} + 50% Neem Cake @ 2 ton ha^{-1}, T6: 50% Vermicompost @ 2.5 ton ha^{-1} + 50% Neem cake @ 2 ton ha^{-1}, T7: 50% FYM @ 5 ton ha^{-1} + 25% Vermicompost @ 1.25 ton ha^{-1} + 25% Neem Cake @ 1 ton ha^{-1} while T8 was kept as control (no treatment). Tubers of approximately 5gms were used for planting in the last week of June, 2018 with a spacing of 40 cm × 20cm.

Several growth parameters of safedmusli such as number of leaves (no.), number of root tubers per plant, length of root tubers (cm), fresh root tuber yield (kg ha^{-1}) and tuber yield (Q/ha). Moreover, karanj tree parameters such as height of tree (m), number of branches/tree (no.) and DBH (diameter at breast height in cm) were also recorded. Post harvest soil properties were determined as per standard methods. The analysis of variance for the studied traits was analyzed as per Panse and Sukhatme (1967) [11] and statistical comparison was worked out based on student's paired 't' test.

Results and Discussion

The treatments varied significantly for all the crop parameters and soil parameters under studied which is presented in Table 1. The mean squares due to treatments were highly significant for all the parameters indicating treatment differences for all the parameters studied. The coefficient of variation was below 10%, for all characters confirming the reliability of the experiment and indicating less treatment by environment interactions except for number of leaves (no.) @ 60DAP, indicating moderate treatment by environment interaction. Similar significant treatments of organic manures in Safed musli crop were also recorded by Kothari and Singh (2003) [12], Patel *et al*. (2008) [13], Gaikwad *et al.* (2011a, 2011b) [14, 15], Chauhan *et al*. (2005) [23] and Kulmi and Tyagi (2010) [24].

Table 1: Analysis of variance for different parameters of Safed musli intercropped under *Pongamia pinnata* based agroforestry system.

Source of variation (d.f)	Mean sum of squares						
	Yield parameters of Safed musli						
	No. of leaves/ plant @ 30DAP	No. of leaves/ plant @ 60DAP	No. of leaves/ plant @ 90DAP	Length of tuber (cm)	No. of tubers/plant	Tuber yield (kg/plot)	Tuber yield (Q/ha)
Replication (2)	0.086	12.469	2.678	0.085	0.049	0.011	0.658
Treatment (7)	7.444**	20.694**	45.655**	14.102**	7.144**	0.651**	38.61**
Error (14)	0.067	4.752	4.820	0.070	0.072	0.012	0.677
CV (%)	2.789	12.833	8.941	2.954	3.406	2.902	2.875
	Mean sum of squares						
	Soil nutrient parameters						
	Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)		
Replication (2)	23.593		0.193		16.408		
Treatment (7)	3,668.620**		76.293**		10,881.50**		
Error (14)	19.551		0.177		15.294		
CV (%)	2.788		2.929		1.072		

The mean data pertaining to variation in number of leaves @30DAP, 60DAP and 90DAP against different treatments under karanj based agroforestry system is given in Table 2. The different organic manure treatments gave significant results at (P< 0.01). The maximum number of leaves per plant was recorded 11.21, 20.14 and 27.89 at 30, 60 and 90 DAP respectively under T_2 followed by T_4 *i.e.* 10.82, 19.35 and 27.44 at 30, 60 and 90 DAP respectively, whereas the minimum number of leaves per plant *i.e.*6.74, 13.21 and 17.62 was recorded 30, 60 and 90 DAP respectively, under T_8. The maximum increase in the number of leaves per plant was observed on application of T_2 (Vermi-compost 100%) with 58.29% increment followed by 55.73% in T_4(FYM 50%+Vermi-compost 50%)and 53.97% in T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%) showed more or less similar role of both vermicompost and FYM(Table- & Fig.). While T_3 (Neem cake 100%) on number of leaves per plant increase only by 10.56% possibly due to the toxic effect of neem cake which inhibits the formation of leaves. In rest of the cases, the formation of number of leaves per plant was increased by 37.46% to 51.19%.

Table 2: Effect of organic manures on number of leaves/plant of safedmusli intercropped under *Pongamia pinnata* based agroforestry system.

Treatments	Number of leaves/plant		
	30 DAP	60 DAP	90 DAP
T_1 (FYM 100%)	8.23	15.23	24.22
T_2 (Vermi-compost 100%)	11.21	20.14	27.89
T_3 (Neem cake 100%)	7.85	13.76	19.48
T_4 (FYM 50%+Vermi-compost 50%)	10.82	19.35	27.44
T_5 (FYM 50%+Neem cake 50%)	10.55	19.01	26.64
T_6 (Vermi-compost 50% +Neem cake 50%)	9.16	17.31	26.02
T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%)	9.46	17.88	27.13
T_8 (Control)	6.74	13.21	17.62
C.D (*P=0.05*)	0.456	3.854	3.882
S.Em±	0.149	1.259	1.268

The effects of organic manure on length of tuber (cm) are given Table 3. Length of tuber (cm) showed statistically significant (*P*< 0.05) differences for organic manure treatments under *Pongamia pinnata* based agroforestry system. Maximum length of tubers was recorded 11.85 cm in T_2 (Vermi-compost 100%) followed by 11.32 cm in T_4 (FYM 50%+Vermi-compost 50%) and 11.08 cm in T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%). While minimum was observed 6.32 cm in T_8 (Control) *i.e.* no manuring. Role of vermicompost was found prominent for length of tuber (cm) and it enhanced 87.5% higher in T_2(Vermi-compost 100%) followed by T_4 (FYM 50%+Vermi-compost 50%) with 79.11% increased in length of tuber (cm) and 75.31% increment in T_7(FYM 50%+Vermi-compost 25%+Neem cake 25%). Significantly higher fasiculated root length was observed with application of vermicompost @ 2 t/ha along with root treatment of *Azotobactor* as reported by Gaikwad *et al.* (2011a) [14] in safedmusli and Emura and Hosoya (1979) [25] in carrot. Shravankumar and Soumana (2016) [26] also reported maximum root length (20.1 cm) from a plot treated with vermicompost (15t/ha) in *Withania somnifera* L.

Table 3: Effect of organic manures on length of tuber (cm) of safedmusli intercropped under *Pongamia pinnata* based agroforestry system

Treatments	Length of tuber (cm)
T_1 (FYM 100%)	7.94
T_2 (Vermi-compost 100%)	11.85
T_3 (Neem cake 100%)	6.63
T_4 (FYM 50%+Vermi-compost 50%)	11.32
T_5 (FYM 50%+Neem cake 50%)	7.99
T_6 (Vermi-compost 50% +Neem cake 50%)	8.63
T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%)	11.08
T_8 (Control)	6.32
C.D (*P=0.05*)	1.219
S.Em±	0.153

Number of tubers/plant showed statistically significant (P<0.05) differences for organic manure treatments under *Pongamia pinnata* based agroforestry system (Table 4). Maximum number of tubers/plant was recorded 8.57 in T_2 (Vermi-compost 100%) followed by 8.13 in T_1 (FYM 100%) and 7.89 in T_4 (FYM 50%+Vermi-compost 50%). While minimum was observed 5.25 in T_8 (Control) *i.e.* no manuring. Role of vermicompost was found prominent again for number of tubers/plant and it enhanced 59.88% higher in T_2 (Vermi-compost 100%) followed by T_1 (FYM 100%) with 51.68% increased in number of tubers/plant and 47.20% increment in T_4 (FYM 50%+Vermi-compost 50%). The application of neem cake in T_3 (Neem cake 100%) showed minimum increase in number of tubers/plant i.e. only 12.13% increment possibly due to its toxic effects on crop as compared to other organic manure. Similarly, due to negative effect of neem cake in T_5 (FYM 50%+Neem cake 50%) and T_6 (Vermi-compost 50% +Neem cake 50%), only 28.54% and 30.78% were recorded respectively. In case of T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%), the number of tubers/plant was increased by 44.22% against control (T_8) i.e. zero manure application. Similar observations were also recorded by Gaikwad *et al.* (2011a) [14] where maximum numbers of fasiculated roots per plant of safedmusli were found in the application of vermicompost @ 2 t/ha along with treatment of *Azotobactor* which was at par with application of vermicompost @ 2 t/ha alone and lower number of fasiculated roots per plant were recorded under the absolute control. These findings are in conformity with the observation of Alam *et al.* (2007) [27] and Bong and Naher (2004) [28].

Table 4: Effect of organic manures on number of tubers/plant of Safed musli intercropped under *Pongamia pinnata* based agroforestry system.

Treatments	Number of tubers/plant
T_1 (FYM 100%)	8.13
T_2 (Vermi-compost 100%)	8.57
T_3 (Neem cake 100%)	6.01
T_4 (FYM 50%+Vermi-compost 50%)	7.89
T_5 (FYM 50%+Neem cake 50%)	6.89
T_6 (Vermi-compost 50% +Neem cake 50%)	7.01
T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%)	7.73
T_8 (Control)	5.36
C.D (*P=0.05*)	0.476
S.Em±	0.155

Organic manure treatments showed significant differences on tuber yield (kg/plot) of safedmusli. The results on tuber yield (kg/plot) are depicted (Table 5). Tuber yield (kg/plot) was recorded maximum in T_2(Vermi-compost 100%) i.e4.37 kg followed by T_1 (FYM 100%) and T_4 (FYM 50%+Vermi-compost 50%) which recorded 4.23 kg and 4.03 kg respectively while the minimum tuber yield (kg/plot) was 3.11 kg in T_8 i.e. Control. The increment in tuber yield (kg/plot) of safedmusli was found 40.51% higher on application of vermicompost (100%) - T_2, followed by 36.01% in FYM (100%) - T_1.

Table 5: Effect of organic manures on tuber yield (kg/plot) of Safed musli intercropped under *Pongamia pinnata* based agroforestry system.

Treatments	Tuber yield (kg/plot)	Tuber yield (Q/ha)
T_1 (FYM 100%)	4.23	32.51
T_2 (Vermi-compost 100%)	4.37	33.62
T_3 (Neem cake 100%)	3.26	25.08
T_4 (FYM 50%+Vermi-compost 50%)	4.03	31.00
T_5 (FYM 50%+Neem cake 50%)	3.43	26.36
T_6 (Vermi-compost 50% +Neem cake 50%)	3.48	26.74
T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%)	3.87	29.79
T_8 (Control)	3.11	23.95
C.D (*P=0.05*)	0.191	1.45
S.Em±	0.062	0.475

Corresponding to tuber yield (kg/plot), the highest tuber yield (Q/ha) was obtained from T_2 (Vermi-compost 100%) which has recorded 33.62 Q/ha and increment of 40.37% against 23.95 Q/ha tuber yield in T_8 (Control) followed by T_1 (FYM 100%) and T_4 (FYM 50%+Vermi-compost 50%) which has

recorded 32.51Q/ha (35.74% increment) and 31.00Q/ha (29.43% increment) respectively. Gaikwad *et al.* (2011a) [14] has reported that the application of vermicompost @ 2 t/ha along with *Azotobactor* showed significantly higher fasiculated root yield (4444 kg/ha) of safedmusli. These results are in line with of Chandrashekharan *et al.* (2000) [17], Jayaprakash *et al.* (2003) [16] and Paturde and Wankhede (2004) [18].

Results on chemical properties of post harvest soil as influenced by different treatments are shown in Table 6. All the eight treatments under study showed wide range of variation for soil nutrient parameters recorded, namely, Available N (kg/ha), available P_20_5 (kg/ha) and available K_20(kg/ha).The highest level of available N (kg/ha) was recorded in T_2 (Vermi-compost 100%)i.e213.66 kg/ha (112.91% increment) followed by 188.16 kg/ha in T_4 (FYM 50%+Vermi-compost 50%) with 87.50% increment and 167.07 kg/ha in the T_6 (Vermi-compost 50% +Neem cake 50%) with 66.49% increment. While minimum available N (kg/ha) was observed in T_3 (Neem cake 100%)i.e125.44 kg/ha (25% increment) against 100.35 kg/ha in T_8 (Control) *i.e.* no manuring. Kumar *et al.* (2011) [20] has also recorded 266 kg/ha available N through vermicompost treatment in stevia. There have been other reports of increase of N in soil after application of vermicompost (Nethra *et al*., 1999) [19]. The highest level of available P_20_5 (kg/ha) was recorded in T_4 (FYM 50%+Vermi-compost 50%)i.e21.86 kg/ha (201.5% increment) followed by 18.27 kg/ha in T_2 (Vermi-compost 100%) with 152% increment and 17.11 kg/ha in the T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%) with 136% increment. While minimum available P_20_5 (kg/ha) was observed in T_3 (Neem cake 100%) i.e7.52 kg/ha (3.72% increment) against 7.25 kg/ha in T_8 (Control) *i.e.* no manuring. The rest of the treatments had increased the available P_20_5 (kg/ha) of post harvest soil ranging from 82.89% to 105%. This result was in conformity with Kumar *et al.* (2011) [20] where highest phosphorus content was achieved in T6 (76.6 kg ha-1) i.eFYM 50%+Vermi-compost 50%) in stevia. The highest level of available K_20 (kg/ha)was recorded in T_2 (Vermi-compost 100%) i.e465.12 kg/ha (56.60% increment) followed by 429.76 kg/ha in T_4 (FYM 50%+Vermi-compost 50%) with 44.70% increment and 400.05 kg/ha in the T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%) with 34.69% increment. While minimum available K_20 (kg/ha)was observed in T_3 (Neem cake 100%) i.e 312.13 kg/ha (5.09% increment) against 297.02 kg/ha in T_8 (Control) *i.e.* no manuring. The rest of the treatments had increased the available K_20 (kg/ha)of post harvest soil ranging from 8.82% to 18.58%. These results are in conformity with Azarmi*et al.* (2008) [22] where the soil available K increased significantly with vermicompost application at the rate of 15, 10 and 5 t ha-1 increased available K in these treatments 58, 46 and 34% respectively in comparison to control plots in tomato. Manivannan *et al*. (2009) [21] has reported that an earthworm-processed waste material contains a higher concentration of exchangeable K due to enhanced microbial activity during the vermicomposting process, which consequently enhances the rate of mineralization. Gaikwad *et al*. (2011b) [15] has reported that the application of vermicompost @ 2 t /ha + *Azotobactor* recorded significantly the highest available nitrogen content (790.84 kg/ha) in soil after harvest and a significantly the lowest available nitrogen content observed (536.73 kg/ha) under control in safedmusli.

Table 6: Effects of different treatments on nutrient status of post- harvest soil.

Treatments	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
T_1 (FYM 100%)	150.52	14.87	340.12
T_2 (Vermi-compost 100%)	213.66	18.27	465.12
T_3 (Neem cake 100%)	125.44	7.52	312.13
T_4 (FYM 50%+Vermi-compost 50%)	188.16	21.86	429.76
T_5 (FYM 50%+Neem cake 50%)	160.56	13.26	323.23
T_6 (Vermi-compost 50% +Neem cake 50%)	167.07	14.69	352.21
T_7 (FYM 50%+Vermi-compost 25%+Neem cake 25%)	163.21	17.11	400.05
T_8 (Control)	100.35	7.25	297.02
C.D (*P=0.05*)	7.818	0.743	6.915
S.Em±	2.553	0.243	2.258

The three growth parameters of karanj (*Pongamia pinnata*) such as height (m), diameter of breast height (cm) and number of branch/tree were recorded before planting of safedmusli and after harvesting of safedmusli. A paired-samples t-test was conducted to check if there was significant increase by comparing the growth parameters of karanj before planting of safedmusli and after harvesting of safedmusli. The effect of intercropping on the growth of tree (*Pongamia pinnata*) data with respect to tree height (m), diameter at breast height (cm) and number of branch/tree is presented in Table 7. There was a significant difference in the scores for height (m) before planting of safedmusli (M=6.48, SD=1.41) and height (m) after harvesting of safedmusli (M=6.77, SD=1.48) conditions; t(7)= 8.32*, p = 0.005. These results suggested that there was a significant increase in height (m) when karanj is intercropped with safedmusli. The average tree height (m) has increased from 6.48 m to 6.77 m during the intercropping period. There was a significant difference in the scores for diameter at breast height (cm) before planting of safedmusli (M=18.72, SD=2.63) and diameter at breast height (cm) after harvesting of safedmusli (M=19.06, SD=2.64) conditions; t(7)= 4.56*, p = 0.005. These results suggested that there was a significant increase in diameter at breast height (cm) when karanj is intercropped with safedmusli. The average tree diameter at breast height (cm) has increased from 18.72 cm to 19.06 m during the intercropping period. There was a significant difference in the scores for number of branch/tree before planting of safedmusli (M=9.37, SD=1.68) and number of branch/tree after harvesting of safedmusli (M=10.00, SD=1.41) conditions; t(7)= 4.16*, p = 0.005. These results suggested that there was a significant increase in number of branch/tree when karanj is intercropped with safedmusli. The average number of branch/tree has increased from 9.37 to 10.00 during the intercropping period. Results has shown that there were only minor increase in height (m), diameter at breast height (cm) and number of branch/tree in karanj *i.e*

4.47%, 1.81% and 6.72% respectively after harvesting of safedmusli, possibly due to shorter duration of experimental period. Kaushik *et al.* (2016) [29] reported increased Karanj growth (height and diameter) in Agri-silviculture as compared to sole plantation.

Table 7: Effect of intercropping on general morphological characters of *Pongamia pinnata* trees.

Parameters	mean BT	mean AT	Difference	SD	Paired t	p Value
Height (m)	6.48	6.77	0.29	0.10	8.32	<0.01
DBH (cm)	18.72	19.06	0.34	0.21	4.56	<0.01
No. of branch/tree	9.37	10.00	0.63	0.43	4.16	<0.01

Conclusion

It is revealed that there was great variation among the different organic manure treatments for yield parameters of safedmusli and soil chemical properties. Beneficial effect of intercropping on karanj trees was also observed. Vermicompost (100%) performed outstanding for improvement of tuber length (11.85 cm), number of tubers (8.57 no.), number of leaves/plant (27.89, 90DAP) and tuber yield (4.37 kg/plot).High performance of vermicompost could be due to very rich and diverse microbial populations present in vermicompost. The soil chemical properties on post harvest soils was also observed with higher concentrations of N (213.66 kg/ha) and K_20 (465.12 kg/ha) in vermicompost (100%) treated plot. It may be due to the process of mineralization and availability of nutrients as enhance by vermicompost that resulted in better performance in crop and post harvest nutrient status. This experiment also revealed that safedmusli can be successfully grown in karanj based agroforestry system with mutual benefit.

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