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Research Article

Influence of Custard Apple (*Annona squamosa* L.) Based Agri-Horticulture System on Intercrop Yield and Soil Properties

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ABSTRACT

An experiment was conducted at All India Co-ordinated Research Project for Dryland Agriculture, Gandhi Krishi Vignana Kendra, Bangalore to assess the effect of custard apple (CA) based Agri-Horticulture system on yield of different crops and soil properties during kharif 2017. The experiment consisted of 15 treatments viz., T_1:CA+finger millet, T_2:CA+fodder maize, T_3:CA+field bean, T_4:CA+niger, T_5:CA+chilli, T_6:CA+cowpea, T_7:CA+foxtail millet, T_8: Finger millet alone, T_9: Fodder maize alone, T_{10}: Field bean alone, T_{11}: Niger alone, T_{12}:Chilli alone, T_{13}: Cowpea alone, T_{14}: Foxtail millet alone and T_{15}: Custard apple alone, replicated thrice using randomised block design.

The results revealed that all crops recorded higher yield in sole treatments compared to their respective intercropping systems. The yield of CA was higher under sole treatment (4477.34 kg ha^{-1}) and lower yields in CA+fodder maize treatment (3800.83 kg ha^{-1}). The custard apple equivalent yield (CEY) was found higher in CA+finger millet treatment (807.14 kg ha^{-1}) followed by CA+chilli treatment (715.01 kg ha^{-1}) and lowest was observed under CA+foxtail millet (132.51 kg ha^{-1}) treatment. Soil available nutrients like nitrogen, phosphorus and potassium were recorder higher under CA+cowpea (262.50, 80.91 and 176.22 kg ha^{-1}, respectively) treatment followed by CA+field bean (258.95, 78.70, 171.39 kg ha^{-1}, respectively). The lowest available nutrients were recorded under fodder maize alone treatment.

Key words: *Custard apple, Intercropping, Equivalent yield, Organic carbon and Available nutrients.*

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INTRODUCTION

Agri-horticulture system is an important approach which not only provides higher yields but also generates additional income as well as improves soil fertility status. Intercropping is an age old practice in India, especially under rainfed conditions, which aims at increasing total productivity per unit area through equitable and judicious use of land resource and farming inputs including labours. The intercropping system besides meeting the various requirements of a farmer, also harnesses the farmer resources efficiently. To get higher yield and returns, to maintain soil health, preserve environment and meet daily food and fodder requirement of human and animal population diversification of cropping system is necessary[8]. In intercropping system due to complimentary effect of crops we can get higher yields and net income. Maintenance of good soil fertility is essential for any crop production system which can be achieved by adopting proper intercropping systems.

Custard apple (*Annona squamosa* L.), a native of Tropical America is widely distributed throughout the tropical and subtropical regions. It has several synonyms such as sithaphal, sharifa, sugar apple, sweet sop etc, and there are more than 70 species which come under the genus *Annona*. India is one of the major producers of custard apple and is not cultivated as extensive plantation in any country. In India, an estimated area and production of custard apple is 19,660 ha and 1,33,050 tonnes, respectively and the productivity is 6.76 tonnes ha^{-1}. The area under custard apple in Karnataka is 1,800 ha with production of 13,400 tonnes and productivity of 7.4 tonnes ha^{-11}. So, the objective of this paper is to see the performance of the different crops under intercropping and sole cropping systems under custard apple based agri-horticulture system and to know the changes in important soil properties under these systems.

MATERIAL AND METHODS

The experiment was conducted at All India Coordinated Research Project for Dryland Agriculture, UAS, GKVK, Bangalore. The centre is situated in the Eastern Dry Zone of Karnataka (Agro-climatic zone V) at 12°58′ North latitude and 77°35′ East longitude with an altitude of 930 m above mean sea level. The experiment was conducted in an eight years old established custard apple orchard with 15 treatments during *kharif* 2017 in randomized complete block design with three replications. The experiment was initiated in *kharif* 2012 and from then onwards the experiment is being continued with fixed treatments. The experiment consisted of 15 treatments *viz.*, T_1:CA+finger millet, T_2:CA+fodder maize, T_3:CA+field bean, T_4:CA+niger, T_5:CA+chilli, T_6:CA+cowpea, T_7:CA+foxtail millet, T_8:Finger millet alone, T_9:Fodder maize alone, T_{10}:Field bean alone, T_{11}:Niger alone, T_{12}:Chilli alone, T_{13}: Cowpea alone, T_{14}: Foxtail millet alone and T_{15}: Custard apple alone. All the package of practices including fertilizer application was followed as per the university recommendation. The variety, spacing and recommended dose of fertilizer applied are presented in **Table 1**.

The experiment was devised as per the treatments and planting was taken up during *kharif* 2017, sole as well as intercropping. The recommended dose of nitrogen was applied as two equal splits, one as basal dose and another at 45 days after sowing/transplanting in case of finger millet, fodder maize and chilli. Well decomposed farmyard manure @ 7.5 t/ha was applied as per the treatment specifications two weeks before transplanting/sowing of the crops and was mixed thoroughly with soil. The nutrients were applied in the form of urea, diammonium phosphate and muriate of potash. The initial soil properties (as recorded in 2012) of the experimental site[10] indicated that the soil was slightly acidic (pH-5.6) in reaction with low organic matter (0.40%) content with normal electrical conductivity (0.07 dS m^{-1}). Available nitrogen (224.0 kg ha^{-1}) was low with high phosphorus (72.0 kg ha^{-1}) and medium potassium (163.0 kg ha^{-1}). The soil sampling was done before sowing at 0-15 cm depth and was analysed for its pH, electrical conductivity, organic carbon, available

nitrogen, phosphorus and potassium following standard protocols.

Statistical analysis: The data collected were analysed statistically following the procedure as described by Panse and Sukhatme[9]. The level of significance used in 'F' and 't' test was *P=0.05*. Critical differences were calculated using the 't' test wherever 'F' test was significant.

RESULTS AND DISCUSSION

Effect of agri-horticulture system on yield of custard apple, intercrop and sole crop yield and Custard apple equivalent yield (CEY)

The results regarding yield of custard apple, intercrop and sole crop yield of different crops and CEY are presented in **Table 2**.

Custard apple yield under agri-horticulture system

The custard apple yield was varied significantly among different treatments **(Table 2)**. Higher yield of custard apple was recorded in custard apple alone treatment (4477.34 kg ha^{-1}) compared to custard apple under intercropping systems. Under different intercropping systems, the yield of custard apple was higher in CA+cowpea (4329.70 kg ha^{-1}) treatment followed by CA+field bean (4228.28 kg ha^{-1}). Custard apple yield was found on par under CA+chilli, CA+niger, CA+finger millet and CA+foxtail millet. Significantly lower yield was recorder in CA+fodder maize (3800.83 kg ha^{-1}) treatment. The decreased custard apple yield under intercropping system compared to sole crop might be due to competition among main and component crop for different sources. Lal *et al*.[5], Munde *et al*.[7] and Swain *et al.*[13] also observed reduction in yield due to intercropping systems.

Intercrop and sole crop yield under agri-horticulture system

The yields of different crops were varied due to intercropping and sole cropping system **(Table 2)**. Generally, the yield different crops were higher under sole cropping system compared to the intercropping. The differences in the yield between sole cropping and intercropping were mainly as a consequence of differences in the plant population. Decreased yield of different crops under intercropping system compared to sole cropping might be attributed to fact that the crops under intercropping might face competition from main crop (Custard apple) for different sources like light, moisture, nutrients and spacing as well as shade effect of the custard apple. Das *et al*.[4] and Chauhan *et al.*[3] also reported the reduced yield of agronomic crops under intercropping systems compared to their sole crops.

Custard apple equivalent yield (CEY) under agri-horticulture system

CEY was used to convert the yield of component/intercrop into main crop yield (Custard apple). The data pertaining to the CEY is presented in **Table 2**. CEY varied significantly among different intercropping systems. The treatment CA+finger millet (807.14 kg ha^{-1}) recorded significantly higher CEY followed by CA+chilli (715.01 kg ha^{-1}) and CA+fodder maize (490.91 kg ha^{-1}). Lower CEY was recorded in CA+foxtail millet, CA+field bean, CA+niger and CA+cowpea. The higher CEY in CA+finger millet (807.14 kg ha^{-1}) was attributed to the higher yield of finger millet since CEY is directly related to the yield and price of the produce. The higher CEY indicates the additional higher yield of the main crop (Custard apple) compared to the actual yield. Higher custard apple equivalent yield under intercropping systems was attributed to yield advantages achieved in intercropping system. This is in accordance with the findings of Sujatha *et al*.[12], Avinash *et al*.[2] and Ramulu[10].

Soil properties under agri-horticulture system

Soil properties especially organic carbon, available nitrogen, phosphorus and potassium varied significantly among different treatments. The data pertaining to the soil properties is presented in the **Table 3 and 4**.

Soil pH, electrical conductivity and organic carbon content of soil

The soil pH and electrical conductivity was found to be non-significant among different

treatments (**Table 3**). The organic carbon content of soil varied significantly among different treatments. Generally higher organic carbon was found in intercropping systems compared to sole crops. Significantly higher organic carbon content was recorded in CA+cowpea (0.65%) treatment which was on par with CA+field bean (0.64%), cowpea alone (0.62%) and field bean alone (0.61%). Significantly lower organic carbon content was found in treatments fodder maize alone (0.48 %) and CA+fodder maize (0.50 %). The higher organic carbon under intercropping systems was due to the higher addition of crop residues both from main crop and intercrop, better soil and moisture conservation and less oxidation due to high intensity sunlight which is higher under sole cropping system. Similar results were reported by Das *et al*.[4] and Ramulu[10].

Available nitrogen, phosphorus and potassium in soil

Available nitrogen, phosphorus and potassium in soil among different treatments under custard apple based agri-horticulture system varied significantly and the values are presented in **Table 4.** Among the different treatments, significantly higher available nitrogen, phosphorus and potassium was recorder in treatment CA+cowpea (262.50, 80.91, 176.22 kg ha^{-1}, respectively) followed by CA+field bean (258.95, 78.70, 171.39 kg ha^{-1}, respectively), cowpea alone (244.05, 74.24, 168.22 kg ha^{-1}, respectively) and field bean alone (246.34, 73.41, 165.23 kg ha^{-1}, respectively). Generally higher available nitrogen, phosphorus and potassium were observed under intercropping systems compared to the sole cropping. Significantly lower available nitrogen, phosphorus and potassium in soil was found in treatment fodder maize alone (167.31, 50.83, 116.60 kg ha^{-1}, respectively) and CA+fodder maize (172.16, 48.64, 120.69 kg ha^{-1}, respectively).

This could be attributed to addition of nitrogen to soil through symbiotic nitrogen fixation and addition of organic matter in the form of leaf litter by the legume components. Due to higher biomass production, higher nutrient uptake and as an exhaustive crop fodder maize both under sole and intercropping recorded lower available nutrients. Similar results were obtained by Lal *et al*.[5], Avinash *et al*.[2] and Lehmann *et al*.[6]. Srinivasan *et al.*[11] reported that presence of legumes in the mixture benefits the associated non-legumes as the legumes provide a portion of biologically fixed nitrogen to non-legume components. Further, legumes increase the soil nitrogen content and help to maintain soil fertility. Tree based land use system has the potential to improve soil fertility.

Table 1: Varieties, spacing and fertilizer dosage used for different crops

Crops	Variety	Spacing	RDF (NPK ha^{-1})
Custard apple	Arka Sahan	5.0 m x 5.0 m	60:40:40
Finger millet	GPU-28	30 cm x 10 cm	50:40:25
Fodder maize	S. A.Tall	30 cm x 15 cm	100:50:50
Field bean	Hebbal avare-4	45 cm x 30 cm	25:50:25
Niger	No. 71	30 cm x 10 cm	20:40:20
Chilli	Samruddhi	45 cm x 45 cm	100:50:50
Cowpea	IT 38956-1	45 cm x 15 cm	25:50:25
Foxtail millet	R. S-118	30 cm x 10 cm	40:40:00

Table 2: Custard apple yield, Intercrop and sole crop yield and Custard apple equivalent yield as influenced by different intercrops in agri-horticulture system (2017)

Treatments	Custard apple yield (kg ha^{-1})	Intercrop and sole crop yield (kg ha^{-1})	Custard apple equivalent yield (kg ha^{-1})
T_1: CA + finger millet	4024.37	1614.28	807.14
T_2: CA + fodder maize	3800.83	29454.73	490.91
T_3: CA + field bean	4228.28	348.03	139.21
T_4: CA + niger	4144.73	186.1967	186.20
T_5: CA + chilli	4113.40	2860.02	715.01
T_6: CA + cowpea	4329.70	375.75	187.88
T_7: CA + foxtail millet	4069.02	397.52	132.51
T_8: Finger millet alone	----	2931.16	----
T_9: Fodder maize alone	----	47744.55	----
T_{10}: Field bean alone	----	726.97	----
T_{11}: Niger alone	----	289.39	----
T_{12}: Chilli alone	----	4157.97	----
T_{13}: Cowpea alone	----	837.54	----
T_{14}: Foxtail millet alone	----	813.13	----
T_{15}: Custard apple alone	4477.34	4477.34	----
S.Em±	**96.88**	----	**25.59**
CD at 5 % (*p=0.05*)	**293.86**	----	**79.74**

Table 3: Soil pH, electrical conductivity and organic carbon as influenced by different intercrops in agri-horticulture system (2017)

Treatments	Soil pH	EC (dS/m)	Organic carbon (%)
T_1: CA + finger millet	5.51	0.05	0.57
T_2: CA + fodder maize	5.48	0.04	0.50
T_3: CA + field bean	5.45	0.06	0.64
T_4: CA + niger	5.49	0.05	0.54
T_5: CA + chilli	5.50	0.06	0.55
T_6: CA + cowpea	5.43	0.05	0.65
T_7: CA + foxtail millet	5.53	0.06	0.53
T_8: Finger millet alone	5.49	0.06	0.55
T_9: Fodder maize alone	5.47	0.05	0.48
T_{10}: Field bean alone	5.45	0.05	0.61
T_{11}: Niger alone	5.48	0.06	0.51
T_{12}: Chilli alone	5.49	0.07	0.53
T_{13}: Cowpea alone	5.46	0.06	0.62
T_{14}: Foxtail millet alone	5.49	0.05	0.51
T_{15}: Custard apple alone	5.53	0.07	0.51
S.Em±	**0.05**	**0.01**	**0.03**
CD at 5 % (*p=0.05*)	**NS***	**NS**	**0.08**

***NS**: Non-significant

Table 4: Available nutrients (N, P_2O_5 and K_2O) in soil as affected by different intercrops in agri-horticulture system (2017)

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
T_1: CA + finger millet	214.69	71.31	159.78
T_2: CA + fodder maize	172.16	48.64	120.69
T_3: CA + field bean	258.95	78.70	171.39
T_4: CA + niger	213.96	66.24	142.11
T_5: CA + chilli	223.01	72.05	136.59
T_6: CA + cowpea	262.50	80.91	176.22
T_7: CA + foxtail millet	209.79	69.67	146.23
T_8: Finger millet alone	205.50	65.01	147.09
T_9: Fodder maize alone	167.31	50.83	116.60
T_{10}: Field bean alone	246.34	73.41	165.23
T_{11}: Niger alone	205.77	60.34	135.74
T_{12}: Chilli alone	215.11	70.76	136.78
T_{13}: Cowpea alone	244.05	74.24	168.22
T_{14}: Foxtail millet alone	199.53	65.02	140.19
T_{15}: Custard apple alone	201.66	54.25	135.72
S.Em±	**10.47**	**4.97**	**8.30**
CD at 5 % (*p=0.05*)	**30.32**	**14.39**	**24.05**

CONCLUSION

Agri-horticulture system is an essential approach to have higher farm income and for maintaining better soil fertility. Even though the yield of individual crops including custard apple was higher under sole crops but the additional yield from component crops is an added advantage under intercropping system. The better soil and water conservation and reduced oxidation loss of native organic matter in soil and legume components under agri-horticulture system results in better soil properties like available nutrients, organic carbon and other soil physical and biological properties. So it is concluded that the custard apple based agri-horticulture system is very important especially under dryland situations to get the higher farm returns as well as improving the soil fertility.

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