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Intercropping of Arabica Coffee (Coffea Arabica L.) with Korerima (Aframomum Korarima) in South Western Ethiopia

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Abstract
Study of coffee intercropping with Korerima (*Aframomum Korarima*) was conducted at Jimma and Gera, southwest Ethiopia, with the objectives to evaluate the agronomic and economic benefits of the practice. Coffee variety compact canopy 74165 and local korarima clone was used as planting material, the experiment holds six treatments arranged in a randomized complete block design with three replications. The results show that intercropping did not significantly affect growth and yield of coffee trees. However, higher coffee yield advantages were found from sole plots as compared with intercropped coffee plots followed by staggered plot at both locations. Mean yield of Korerima over the study period were significantly ($p < 0.01$) higher for sole stands than intercropped plots. The land equivalent ratio also depicted the yield advantage of growing coffee together with Korerima. As a whole, the research findings reveal that coffee intercropping with Korerima was found to be agronomically and sparingly feasible in the southwest Ethiopia. Hence, based on the suitability of the area and the priority of the farmers, coffee intercropping with Korrerima can be practiced as an important remedy to increase crop production and economic returns to user in farm diversification of coffee production system.
Keywords; coffee yield, Intercropping, Land equivalent ratio, sole cropping

Introduction

Self-sustaining, low-input, and energy-efficient agricultural systems in the context of sustainable agriculture have always been in the centre of attention of many farmers, researchers, and policy makers' worldwide (Altieri *et al*., 1983; Altieri, 1999). Restoring on-farm biodiversity through diversified farming systems that mimic nature is considered to be a key strategy for sustainable agriculture (Jackson *et al*., 2007). On-farm biodiversity, if correctly assembled in time and space, can lead to agro ecosystems capable of maintaining their own soil fertility, regulating natural protection against pests, and sustaining productivity (Thrupp, 2002; Scherr and McNeely, 2008). Biodiversity in agro ecosystems can be enhanced in time through intercropping.

Plant interactions are both competitive and cooperative. Farmers use intercropping to the mutual advantage of both main and secondary crops in a multiple-crop-production system. In less developed countries, the majority of farmers still practice intercropping because of a lack of access to credit, inputs, or machinery. Crop productivity can be increased either through horizontal expansion of farmland or intensive cultivation. The former is becoming difficult in developing countries like Ethiopia due to increasing population pressure (Anteneh, 2015).

In coffee growing areas of the country, coffee is mostly grown in multistory cropping system with shade trees, citrus, papaya and enset the upper story followed by coffee while the ground floor by cereals (maize, sorghum and teff), legumes (peas, beans and lentils), vegetables (cabbage, kale, chilly and pepper), spices (ginger, turmeric and korarima) and root crops (sweet potato and Irish potato) (Awoke, 1997). Intercropped coffee with other plants provide some advantages like control of weeds, recycling of nutrients, use of unproductive areas, use of shade and extra income. The patterns of different cropping systems are highly variable as diverse as are the crops themselves and the climates, habitats, levels of mechanization, and human customs under which crop production is undertaken. In Ethiopia coffee is grown as garden plantation being intercropped with different crops such as sweet potato, banana, Chat (Chata edulis) and some other fruit crops (Damenu, 2008). Korarima is like coffee economically important species used as traditional medicine and food preservative, to flavor coffee and bread, as source of income from local and export markets, for soil conservation and as substitute of Indian cardamom (Eyob *et al*., 2007). It is a shade loving plant. That grows in almost the same habitats as wild Arabica coffee in high rain forests areas of the country (Jansen, 2002).In the south western part of Ethiopia under natural forest condition coffee with korarima diversified cropping system is common. Therefore, the objective of investigation was to determine the optimum intercropping ratio of coffee to korarima that would promote yield and productivity of both crops and.to draw recommendation on biologically and economically sound coffee to korarima intercropping ratio for southwest Ethiopia.

Material and method

The field experiment was executed at Jimma Agricultural Research Center (JARC) located at 365 km Southwest of Addis Ababa and 12 km from the Jimma town. It is located within tepid to cool humid highland agro-ecological zone of the country at an altitude of 1750 m.a.s.l., at latitude of 7°, 46" N, and longitude of 30°, 50 "E in the sub humid tropical belt of south western Ethiopia. The area receive an average total annual rain fall of

1530 mm, with 66% of average relative humidity, and mean minimum and maximum temperatures of 11.6°C and 26.3°C, respectively and at Gera sub-research center. The Jimma local korarima clone was intercropped at both locations. The treatments consisted of sole plots of coffee and korarima, and rows of coffee to korarima in 1:1, 1:2 and 2:1 ratios, respectively, and korarima was planted in staggered fashion between rows of coffee bushes at recommended spacing of 2 m x 2 m. The experiment was laid out in a randomized complete block design with three replications.

Coffee variety with compact canopy 74165 was used. In sole plots both crops were planted at a spacing of 2 m x 2 m. Similarly, in intercropped experimental unit, except in staggered plots, rows planted with coffee and korarima were separated by 2 m. In the course of the study coffee trees were trained in single stem and capped at 2 m height. Undesirable suckers, lateral growths of long drooping primaries, secondary branches growing within 15 cm were controlled and removed throughout the course of the experiment. Except experimental variables other management practices were applied for both crops as of the recommendation. The experiment will be completed after two crop seasons. Data of Yield and yield related traits of coffee and Korerima was collected as per the schedules.

Land equivalent ratio (LER), which is one of the best indices that have been suggested for evaluating productivity and efficiency per unit area of land in any intercrop system (Sullivan, 1998), will be calculated using the following formula:

$$LER = \left(\frac{Yij}{Yii}\right) + \left(\frac{Yij}{Yjj}\right) \ldots,$$

Where, Yii, and Yjj are sole crop yield of coffee and korarima Yij and Yji are inter crop yield of coffee and complimentary crop, respectively.

Result and Discussions

Over years mean clean Coffee Yield variation among treatments was significant in all cropping season at both location except, on 2009/2010 at Gera and 2012/2013 at Jimma.

The maximum yield obtained from sole coffee 808.3 kg/ha and 1291.9 kg/ha at Jimma and Gera respectively (Table1& 4). Whereas the lowest mean clean coffee was obtained from 2:1 coffee to korarima at Gera and 1:2 Coffee to Korarima (248.05 kg/ha) treatments at Jimma. Yield of over years mean dried korarima also show same yield pattern with coffee. On sole korarima plots yield of korarima was significant over intercropped treatments (Tables.2 & 4). Our result in agreement with the findings of Taye *et.al*.(2008), mean yields of both coffee and spices significantly higher for sole stands than for the intercropped plots.

Productivity of land was better at staggered planting fashion of korarima between rows of coffee bushes have higher productivity of land as compared from other treatments at Gera (table 3). On the other hand at Jimma with one row coffee and two rows korarima ratio planting system was higher return of yield per hectare (Table.6). Similar result reported by Taye et.al. (2008), land equivalent ratio depicted the yield advantage of growing coffee and spice together. Even though land equivalent ratio was high, the yield shows Instability of yield and productivity across location, Due to long period of drought season and computation of light and nutrient between component crops.

Table 1. Mean clean coffee yield kg/ha as affected by coffee with Korarima intercropping ratio at Gera

Treatments	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	Mean
sole Korarima	-	-	-	-	-	
2:1 coffee to korarima	263.38	149.72^{b}	567.60^{c}	852.81^{b}	550.80^{c}	476.86^{c}
1:1 coffee to korarima	303.76	66.86^{b}	575.96^{c}	665.01^{b}	867.69^{bc}	495.86^{c}
sole coffee	902.11	460.53^{a}	1734.07^{a}	2018.36^{a}	1344.44^{bc}	1291.90^{a}
1:2 coffee to korarima	451.11	138.48^{b}	786.19b^{c}	1147.06^{b}	786.70b^{c}	661.91b^{c}
staggered	492.09	226.66^{b}	1293.42^{ab}	1132.00^{b}	1737.54^{a}	976.34^{ab}
C.V (%)	**40.57**	**53.16**	**33.16**	**33.07**	**30.39**	**31.03**
LSD(±)	**368.57(NS)**	**208.64**	**618.92**	**724.15**	**605.09**	**324.73**

Means with the same letter or are not significantly different, >> at 5% probability level according to lsd test

Table. 2. Mean korarima yield kg/ha as affected by coffee with Korarima intercropping ratio at Gera

Treatments	2009/2010	2010/2011	2011/2012	2013/2014	Mean	LER
sole K	144.16^{ab}	1385.06^{a}	601.83	740.45	717.88^{a}	-
2:1 c to k	128.73^{b}	1352.50^{a}	713.85	375.87	642.74^{a}	1.2
1:1 c to k	111.25^{b}	982.22^{bc}	626.43	172.74	473.16^{ab}	1.1
sole coffee	-	-	-	-	-	-
1:2 c to k	115.44^{b}	1179.35^{ab}	695.65	361.98	588.10^{ab}	1.3
Staggered	224.07^{a}	589.27^{c}	525.74	102.43	360.38^{b}	1.5
C.V (%)	**31.32**	**64.68**	**39.55**	**69.35**	**32.14**	
LSD(±)	**85.36**	**1336.8**	**471(NS)**	**978.78(NS)**	**275.58**	

Means with the same letter are not significantly different, >> at 5% probability level according to LSD test * * Coffee (C) and Korarima (K)

Table: - 3 Coffee with korarima Intercropping effect on productivity of land at Gera.

Treatments	Year1	Year 2	Year 3	Year 4	Year 5	Mean
sole Korarima	-	-	-	-	-	-
2:1 c to k	1.2	1.3	1.5	-	0.9	1.2
1:1 c to k	1.1	0.9	1.4	-	0.9	1.1
sole coffee	-	-	-	-	-	-
1:2 c to k	1.3	1.2	1.6	-	1.1	1.3
staggered	2.1	0.9	1.6	-	1.4	1.5

Means with the same letter are not significantly different, >> at 5% probability level according to LSD test

Table 4. Mean coffee yield (kg/ha) as affected by coffee with Korarima intercropping ratio at Jimma

Treatments	2010 /11	2011/12	2012/13	2013/14	Mean
Sole coffee	73.37^{a}	1002.69^{a}	571.83	1585.3^{a}	808.30^{a}
sole korarima	-	-	-	-	
1:1 C to K	20.75^{b}	277.13^{bc}	562.33	458.0^{cd}	329.55^{b}
2:1 C to K	21.61^{b}	289.76^{bc}	669.41	574.6^{bc}	388.85^{b}
1:2 C to K	12.84^{b}	160.27^{c}	534.27	284.8^{d}	248.05^{b}
staggered	41.99^{ab}	440.69^{b}	463.21	776.8^{b}	430.67^{ab}
C.V (%)	**69.69**	**22.5**	**37.78**	**2.17**	**56.63**
LSD(0.05)	**44.76**	**183.98**	**122.39 (NS)**	**65.95**	**384.82**

*Means with the same letter are not significantly different, >> at 5% probability level according to LSD test

Table .5 Mean dried korarima yield kg/ha as affected by coffee with Korarima intercropping ratio at Jimma

Treatments	2010/11	2011/12	2013/14	Mean
Sole coffee	-	-	-	-
sole korarima	1010.20^{a}	121.60	41.08	390.96
1:1 C to K	355.66^{c}	106.89	18.45	160.33
2:1 C to K	489.42^{bc}	181.84	27.21	232.82
1:2 C to K	784.16^{ab}	344.82	13.03	380.67
staggered	606.30^{bc}	162.56	18.11	262.32
C.V (%)	**27**	**98.87**	**78.57**	**52.74**
LSD(0.05)	**330.11**	**341.68 (NS)**	**34.88 (NS)**	**283.41 (NS)**

*Means with the same letter are not significantly different, >> at 5% probability level according to lsd test

Table.6 Coffee with korarima Intercropping effect on productivity of land at Jimma

Treatments	Year 1	Year 2	Year 3	Year 4	mean
Sole coffee	-	-	-	-	-
Sole korarima	-	-	-	-	-
1:1 C to K	0.63	1.16	-	0.74	0.84
2:1 C to K	0.78	1.78	-	1.02	1.19
1:2 C to K	0.95	3	-	0.5	1.48
Staggered	1.17	1.78	-	0.93	1.29

*Means with the same letter are not significantly different, >> at 5% probability level according to LSD test

Conclusion and Recommendation

Coffee can be grown with Korerima without significant yield reductions. The compact Arabica coffee cultivar were found to be more suitable for intercropping with Korrerima. Intercropping coffee with korarima at early stage is not advisable. Hence, a great competition between korarima and coffee plant had been existed at early growth stage of coffee plant. This is due to Korarima growth was very fast and covers all spaces at early stage. These have an influence on the lower primary branches products. And also for the growth of korarima plant it needs heavy shade as compared to coffee. So to balance the compatibility of the crop, korarima must be planted after two or three crop harvest season. Because at this time shade level for korarima will increase obtained from both coffee and shade tree. Generally to solve this problem it is better to use relay intercropping system. At early stage coffee will be intercropped with annual crops and later it will be intercropped with korarima.

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