International Journal of Research in Agriculture and Forestry
Volume 7, Issue 6, 2020, PP 42-47
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Intercropping of Coffee with Korarima (Aframomumcorrorima (Braun) P.C.M. Jansen) at Tepi, Southwest Ethiopia

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ABSTRACT

Diversifying cropping systems by increasing the spatial and temporal heterogeneity of agricultural mosaics has been proposed as a feasible alternative to overcome the negative effects of modern agriculture. Coffee-spice based cropping system is a typical cropping system in the southwestern part of Ethiopia. A study on coffee intercropping with korarima was conducted at Tepi, southwest Ethiopia to determine the biological optimum intercropping ratio in row mixture for high yield of the component crops and to evaluate the land productivity in an intercropping system. The Catimore-J21 coffee variety and local korarima variety were used as planting materials. The experiment consists of five treatments arranged in a Randomized Complete Block Design with three replications. As a result, the coffee yield was significantly ($p<0.05$) influenced by intercropping, while the growth of the coffee tree did not significantly affect by intercropping. Whereas, the growth and yield of korarima plants were significantly ($p<0.05$) influenced by intercropping except for plant height, length, and girth of fruit capsule. Accordingly, the higher coffee yield advantages were found from sole plots when compared with intercropped coffee plots and followed by 2 to 1 coffee and korarima intercropping ratio. Similarly, the advanced yield of korarima was recorded from sole stands followed by 1 to 2 coffee and korarima intercropping ratio. The maximum land equivalent ratio was recorded at a planting pattern of 2 to 1 coffee and korarima intercropping ratio as compared to other treatments. Therefore, it could be concluded that intercropping of coffee with korarima is biologically and agronomically feasible, and the aforementioned treatment could be recommended for the study area. However, it is important to advise farmers in the area and similar agro-ecology to supplement irrigation water to the field especially during the dry spell period.

Keywords: *Coffee yield, Intercropping, Land equivalent ratio, Korarima yield,*

INTRODUCTION

In most developing countries of the tropics, the bulk of food consumed is derived from small scale agriculture. The cropping systems of these countries are characterized by the landholding of few hectares, limited mechanization, low levels of purchased inputs, intensive labor, and multiple cropping that include intercropping as its mainstay (FAO, 1983; Francis, 1986). Although risk minimization is the major objective of intercropping in developing countries, small farmers also view intercropping as a potential system for diversification and intensification of production on their smallholdings. Though intercropping is defined by different authors differently, the basic idea is more or less alike. It is defined as the growth of two or more crops simultaneously on the same field with crop intensification in both time and space dimensions (Willey, 1979; Francis, 1986).

Growing two or more crops on the same land at the same time can increase crop yield per unit area, reduce risks associated with crop failure and price fall. Also, it helps farmers to get balanced nutrition and an additional income. Several authors indicated that intercropping helps for efficient use of farm inputs including family labor, growth resources (Aggarwal *et al.*, 1992); it is an option to weed control (Baumann *et al.*, 2002). Farm inputs including family labor and natural resources may also be more efficiently utilized. However, the merits and demerits of intercropping depend upon climatic conditions, soil fertility, plant morphology and growth duration, disease and insect pests, and socio-economic aspects of the people. The

benefits of the approach can be evaluated in terms of land equivalent ratio (LER) (Willey, 1979) and relative crop yields obtained (Coste, 1992).

In the southwestern part of Ethiopia, the farming system is commonly characterized by the growth of one or more of these complementary crop species. In previous studies, it has been reported that successful intercropping of cardamom and other lowland spices with Arabica coffee under small-scale production (Girma*et al.*, 2008) andaccording to their finding the above result could be attributed to the optimal shade level that the coffee plant gave to the cardamom during the growing periods of the component crops. Korarima is like coffee economically important species used as traditional medicine and food preservative, to flavor coffee and bread, as a source of income from local and export markets, for soil conservation and as a substitute of Indian cardamom (Eyob *et al.*, 2007). It is a shade loving plant, which grows in almost the same habitats as wild Arabica coffee in high rain forests areas of the country (Jansen, 2002). Despite, its importance and compatibility with the coffee-growing system so far there is no research finding on the growing relationship between korarima with coffee irrespective of farmer staggered planting system and natural forest growing system in the study area. Therefore, the objective of this research work is to determine the biological optimum intercropping ratio in row mixture for high yield of the component crops and to evaluate the land productivity of coffee with korarima intercropping system.

Material and Methods

The experiment was conducted at Tepi National Spices Research Center (TNSRC) from the year 2013 - 2017. The center is located at 7° 10' N latitude and 35° 25' E longitude (Fig. 1) and situated at an altitude of 1200 m.a.s.l representing a lowland altitude and characterized by hot humid with an average annual rainfall of 1559 mm (EIAR, 2012) and mean maximum and minimum temperature of 30.23 ºC and 16.09 ºC, respectively (Girma*et al.*, 2008a). The soil type of the experimental site is classified as Nitisols and Fluvisols with the minor occurrence of Leptosols, which is dominated by a loam texture with a pH range of 5.60 to 6.0 (Abayneh and Ashenafi, 2005). The soil depth is very deep (>150 cm) and has a color of dark brown (7.5 YR3/2) when moist. The organic matter content is medium to very high (2.47 to 7.02%) according to Murphy (1968) classification. The total nitrogen content is low to very high (0.09 to 0.73%) according to Tekalign*et al.* (1991) classification, while the available phosphorus is low to medium (0.97 to 7.36 ppm) based on the rating of Olsen *et al.* (1954).

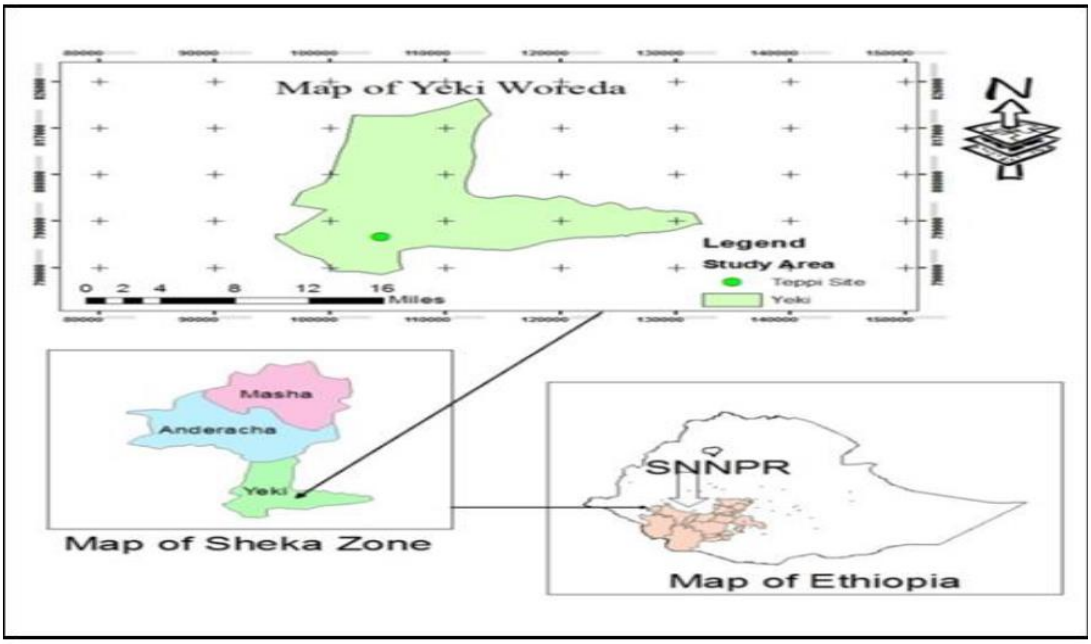

Figure1. *Administrative map of the study area (Source: Regional statistic and population office of SNNPR)*

The treatments consisted of sole plots of coffee and korarima, and rows of coffee to korarima in 1:1, 2:1 and 1:2 ratios, respectively. Insole plots of both crops were planted at a spacing of 2 m x 2 m. Similarly, in an intercropped experimental unit, rows planted with coffee and korarima

were separated by 2 m. The experiment was laid out in a randomized complete block design with three replications.The Catimore-J21 coffee variety and local korarima clone were used for the study.In the course of the study, coffee trees were trained in a 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 experiment. Except for experimental variables other management practices were applied for both crops as of the recommendation.

Two years of data on coffee yield and yield components, viz. stem height, number of primary branches, number of nodes of a primary branch, internode length of the primary branch and clean coffee yield were taken randomly from 10 trees from each experimental unit. On the other hand, one-year data on korarima yield and yield-related traits, such as plant height, number of tillers, and number of leaves per tiller, fresh capsule length and girth, fresh and dry capsule yield were recorded randomly from 5 korarima plants for each experimental unit.

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 an intercrop system (Sullivan, 1998), will be calculated using the following formula:

$$LER = \frac{Y_{ij}}{Y_{ii}} + \frac{Y_{ji}}{Y_{jj}}$$

Where, $\mathbf{Y_{ii}}$, and $\mathbf{Y_{jj}}$ are sole crop yield of coffee and korarima$\mathbf{Y_{ij}}$ and $\mathbf{Y_{ji}}$ are intercrop yield of coffee and complimentary crop, respectively.

The collected data were statistically analyzed using SAS computer software version 9.2 (SAS, 2008). The significant difference between any two treatments means was tested by least significant difference (LSD) at 5% probability level. It must be noted that two-year data of coffee yield and yield components and one-year data of korarima yield and yield components were analyzed to determine the year effect.

Result And Discussions

Coffee growth parameters, viz. number of primary branches, number of nodes of the primary branch and internode length of primary branch did not significantly ($p<0.05$) influenced by intercropping ratios with korarima (Table 1 and 2). However, mean clean coffee yield variation among treatments was significant for consecutive two cropping seasons (Table 2). The maximum yield was obtained from sole coffee 1826 and 1747 kg ha^{-1} in 2015/2016 and 2016/2017, respectively. Whereas, the minimum coffee yield (464.8 and 866 kg ha^{-1}) was found in 2015/2016 and 2016/2017, respectively, from the same plot in which coffee and korarima were intercropped in 1:2 ratio (Table 2).On the other hand, the growth of korarima plant height, length, and girth of fruit capsule did not significantly ($p<0.05$) influenced by intercropping with coffee. However, korarima yield, tiller number per plant, and leaf number per tiller were significantly ($p<0.05$) influenced by intercropping with coffee (Table 3). The highest number of tillers and leaves were recorded from sole korarima stands followed by 1:1 coffee with korarima intercropping ratio. Likewise, the yield of sole korarima was significant over other intercropped treatments except for a 1:2 intercropped ratio of coffee with korarima (Table 3). This mainly associated competition for resources,in most cases when crops growing in a sole it receives all the resources without any competition with the component crops and increases yield, to the opposite, if it is intercropped with any crops resulted in yield reduction due to competition for resources. The present result in agreement with the findings of Taye et al. (2008) and Addis et al. (2015) mean yields of both coffee and korarima and other spices significantly higher for sole stands than for the intercropped plots. Furthermore, the report by (Mithamo, 2014)on coffee intercropping with fruit trees showed that in most cases both yield and quality of coffee, as well as the component fruit trees, increases when both crops growing in the sole stand than intercropping regardless of the fruit type. In contrast to the above findings, (Reyes et al., 2009)reported that intercropping of cardamom with grevillea and pepper gave the highest growth, yield, and quality than a sole crop. Further, a report by (Eyob, 2007) found growth and yield of coffee do not affect by the intercropping system.

Table 1.*Growth of coffee tree as influenced by intercropping with korarima.*

Treatments	No. of Primary Branches			No. of Nodes of Primary Branch		
	2015/16	2016/17	Mean	2015/16	2016/17	Mean
Sole Coffee	66.60	56.20	61.40	18.80	38.60	28.70

Sole Korarima	-	-	-	-	-	-
1:1 C to K	66.80	61.00	63.90	18.73	39.27	29.00
2:1 C to K	60.60	55.27	57.93	20.07	41.07	30.57
1:2 C to K	65.93	57.33	61.63	21.20	41.13	31.17
C.V (%)	14.13	9.26	11.15	9.26	14.46	8.14
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS

Ns=Not significant (P > 0.05), Coffee (C) and Korarima (K)

Table2. *Internode length of the primary branch and clean coffee yield as affected by intercropping with korarima*

Treatments	Internode Length of Primary Branch			Clean Coffee Yield (kg ha^{-1})		
	2015/16	2016/17	Mean	2015/16	2016/17	Mean
Sole Coffee	3.67	3.89	3.78	1826.00^{a}	1747.00^{a}	1786.50^{a}
Sole Korarima	-	-	-	-	-	-
1:1 C to K	3.64	3.86	3.75	677.80^{bc}	1180.00^{ab}	928.90^{b}
2:1 C to K	3.42	3.75	3.58	1228.40^{ab}	1553.00^{a}	1390.70^{a}
1:2 C to K	3.46	3.74	3.60	464.80^{c}	866.00^{b}	665.40^{b}
C.V (%)	6.42	5.98	5.14	30.14	24.67	18.70
$LSD_{(0.05)}$	NS	NS	NS	*	*	*

*Ns = Not significant (P > 0.05), * = P < 0.05, Means with the same letter are not significantly different according to LSD test at P = 0.05, Coffee (C) and Korarima (K)*

Table3. *Growth and yield of korarima as influenced by intercropping with coffee*

Treatments	Plant Height (cm)	No. of Tillers/Plant	No. of Leaf/Tiller	Capsule Length (cm)	Capsule Girth (cm)	Dry Yield (kg/ha)
Sole Coffee	-	-	-	-	-	-
Sole Korarima	161.67	2.4^{a}	22.00^{a}	42.87	29.40	615.33^{a}
1:1 C to K	164.00	2.27^{ab}	18.73^{ab}	42.33	30.00	521.73^{b}
2:1 C to K	171.67	2.07^{ab}	17.73^{ab}	43.33	30.80	506.13^{b}
1:2 C to K	158.33	1.60^{b}	17.60^{b}	44.20	29.13	561.60^{ab}
C.V (%)	9.37	17.60	11.43	4.35	3.02	5.08
$LSD_{(0.05)}$	NS	*	*	NS	NS	*

*Ns = Not significant (P > 0.05), * = P < 0.05, Means with the same letter are not significantly different according to LSD test at P = 0.05, Coffee (C) and Korarima (K)*

Even though it was four-year research but, due to severe drought for two consecutive years in the study area we were not recording data for both component crops. Based on a single year data, the productivity of land was better with two rows of coffee and one row of korarima ratio has higher productivity of land or land use efficiency as compared to other treatments (Table 4). A similar result also reported by Taye et al. (2008), land equivalent ratio depicted the yield advantage of growing coffee and spice together. By the same token, a report by (Reyes et al., 2009)showed that cardamom intercropped with grevillea produced 2.3 times more than in monoculture. Moreover, (Mithamo, 2014) found irrespective of the fruit trees used intercropping of coffee with fruit trees imporovedyiled and quality of the coffee.

Table 4. *Coffee with korarima intercropping effect on the productivity of land (LER)*

Treatments	Land Equivalent Ratio (LER)
Sole Coffee	-
Sole Korarima	-
1:1 Coffee to Korarima	1.22
2:1 Coffee to Korarima	1.50
1:2 Coffee to Korarima	1.17

CONCLUSION

The study indicated that intercropping of coffee with korarima can be advisable for farmers to produce both crops without significant yield reduction and enhance the productivity of their land. Korarima must be planted after two or three coffee harvests, to avoid inter-competition

at the early growth stage and to balance the compatibility of the component crops. Usually, the growth of the korarima plant is very fast and it covers all spaces within a short period. Hence, the shade level for korarima will increase obtained from both coffee and shade tree. Accordingly, two rows of coffee and one row of korarima intercropping ratio showed better productivity of land, so it could be recommended for the study area. However, it is important to advise farmers in this area to supplement irrigation water to the field especially during the dry spell period (October – April).

ACKNOWLEDGMENTS

We would like to thanks Ethiopian Institute of Agricultural Research (EIAR) for the financial support and TepiNational Spice Research Center for providing the experimental field for this study and also Mr. WondifrawDerib, Mr. Wondimu Gebresillasie, Mr. Aschalew Bekele and Mr. GetenetKassaye technical and field assistants of the agronomy research program at the center during the study period for their unreserved support on fieldworks from land preparation up to data collection.

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Citation: *Behailu Mekonnen, Essubalew Getachew, et. al., "Intercropping of Coffee with Korarima (Aframomumcorrorima (Braun) P.C.M. Jansen) at Tepi, Southwest Ethiopia", International Journal of Research in Agriculture and Forestry, 7(6), 2020, pp. 42-47.*