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Intercropping of Arabica Coffee with Turmeric (Curcuma longa) and Ginger (Zingiber officinale Rose) at Tepi

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Abstract
Investigation of coffee intercropping with turmeric and ginger was conducted at Tepi, southwest Ethiopia, with the objectives to evaluate the agronomic and economic benefits of the practice. Compact (74112 and 7110) and intermediate (7440) coffee cultivar, planting methods (sole vs. intercrop) and coffee population density (1600, 2500, 3265, 4444 and 6398 trees ha^{-1}) were factorially combined as main, sub- and sub- sub plot treatment, respectively, with three replications. Coffee cultivar 7440 intercrop with turmeric, while 74110 and 7440 intercrop with ginger variety Gin.37/79 and Gin.40/79, respectively. Sole plot of each crop was also planted. The results depict 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 stands. The compact coffee cultivars were more suitable for intercropping than the intermediate coffee type to sustain crop yields over crop years. Mean yield of turmeric and ginger over the study period were significantly ($p < 0.01$) higher for sole stands than intercropped plots. Unlike turmeric and ginger, yield of the three coffee cultivars significantly ($p < 0.01$) increased with increasing population density. The land equivalent ratio also depicted the yield advantage of growing coffee together with turmeric and ginger. As a whole, the research findings reveal that coffee intercropping with turmeric and ginger was found to be agronomically and economically beneficial in the southwest Ethiopia. Therefore, depending on the suitability of the area and the priority of the farmers, coffee intercropping with turmeric and ginger can be practiced as an important remedy to increase crop production and economic returns.
Keywords: Coffee intercropping, garden coffee, land equivalent ratio, relative yield

Introduction

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. Hence, it is not uncommon to see multiple crops grown with coffee on the same land holding to intensify use of available land, particularly in the garden coffee production system (Taye *et al*., 2008), which is characterized by low plant population density (Workafes and Kassu, 2000).

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, it help farmers to get balanced nutrition and an additional income and maintain land race crop diversity. Farm inputs including family labor and natural resources may also be more efficiently utilized. However, the merits and demerits of intercropping depend up on climatic conditions, soil fertility, plant growth nature, disease and insect pests and socio-economic aspect of the people. The benefits of the approach can be evaluated in terms of relative crop yields, monetary returns and calories obtained (Coste, 1992).

Hence, its practical importance in subsistence farming has been considered to enable farmers to obtain maximum crop yields from a given unit area by efficiently utilizing the open spaces when the coffee trees are young and/or at cycle change stage (Yacob *et al*., 1996; Taye *et al*., 2008). Therefore, investigations on coffee intercropping with ginger and turmeric was conducted at Tepi, southwest Ethiopia, with the objectives to evaluate the yield and economic benefits of the practice under field conditions.

Materials and Methods

Experiment intercropping of coffee with turmeric and ginger was conducted at Tepi Agricultural Research Center. The Center is located in southwestern Ethiopia at coordinates of 7^0 46' N latitude and 36^0 0' E longitudes. and at elevation of 1200 meters above sea level. The center received an average annual rainfall of 1529 mm with the mean minimum and maximum temperatures of 15.4 and 29.9 ^{0}C, respectively. The predominant soil of the center is *Eutric Nitosols* and *Cambisols* with an average pH of 5.2 (Paulos, 1994).

Coffee variety, planting methods (sole vs. intercrop) and coffee population density were factorially combined in split-split plot design as main, sub- and sub-sub plot treatment with three replications. In this regard, CBD resistant coffee lines with compact (74112 and 74110) and intermediate (7440) canopy nature were planted at population density of 1600, 2500, 3265, 4444 and 6398 trees ha^{-1} in systematic fan arrangement were used for the study. Coffee cultivar-74110 was intercropped with turmeric, while 74112 and 7440 were intercropped with ginger variety Gin.37/79 and Gin.40/79, respectively. A sole plot of each crop was also planted. Ginger and

turmeric were planted at inter and intra row spacing of 15 cm × 30 cm, respectively.

All cultural practices were applied uniformly to all experimental units as per research recommendation for coffee (IAR, 1996, Yacob *et al*., 1996) and spices (Edossa, 1998). Yield of coffee, turmeric and ginger collected for six consecutive cropping seasons were subjected to analysis of variance for the design using SAS software (SAS version 9.1, 2008). Results were presented as means and was separated using Duncan's Multiple Range Test whenever the 'F' test was significant (Mandefero, 2005). Finally, the collected coffee, turmeric and ginger yield data were used to calculate land equivalent ratio (LER) based on the methods described by Onwue and Sinha (1991) as:

$$LER = \frac{Itercropped\ yield\ of\ crop\ A + Intercropped\ yield\ of\ crop\ B + Itercropped\ yield\ of\ crop\ n}{Sole\ yield\ of\ crop\ A + Sole\ yield\ of\ crop\ B + Sole\ yield\ of\ crop\ n}$$

Results and Discussion

Results show that there were no significant differences between sole and intercropped coffee plots throughout the study period, though the latter exhibited inferior yield performance as compared to the former. Similarly, mean yield difference between the coffee cultivars was not significant. However, the intermediate (7440) coffee cultivar gave higher yield than the compact coffees (74112 and 74110) in both sole and intercropped plots (Table 1). This confirms the high suitability of the low land Tepi area for intermediate coffee cultivar.

The influence of population density was significant ($p < 0.01$) on coffee yield and the average clean coffee yields significantly decrease with decreased tree population across the crop years and this was presented for the last crop year (Figure 1a). The yield reduction was highest for the intermediate coffee cultivar as compared with the compact types, indicating the more suitability of the latter coffee cultivars for intercropping. This is in line with the work done by Taye *et al.* (2001).

On the other hand, mean yield of turmeric and ginger over the study period were significantly ($p < 0.01$) higher for sole stands than intercropped plots. However, turmeric yield was higher for intercropped plots than sole plots on the early year, and mean yield of turmeric ad giger intercropped with coffee significantly decreased with increasing population density (Figure 1b) and age of coffee trees. This is probably because of the gradual increasing shade level by the upper strata of coffee canopies and reduced light interception by turmeric and ginger underneath during the latter year of production. The biennial bearing nature of coffee trees was reflected by inconsistent yield over production season.

The LER depicted the yield advantage of growing coffee and turmeric and ginger together, suggesting their complementary to utilize efficiently the available resources and their beneficial effects on each other. However, LER less than one were obtained for ginger and coffee cultivar 74112 at the early crop year and for ginger and cultivar 7440 during the latter year of production (Figure 2). In other words, high relative yield was achieved when ginger and turmeric were intercropped with compact coffee type than with the intermediate cultivar, indicating the more suitability of of the former coffee cultivar for intercropping (Taye *et al.*, 2001; Taye *et al*., 2008). The average values of LER were higher for coffee than spices throughout the study period. The total LER was greater during the first two cropping years and tends to decline then after (Figure 2), indicating that intercropping coffee and spices is more advantageous at the early stages. Apart from this, higher gross field benefit or income was obtained from sole plot than intercropped plots of all crop types (Table 2).

Conclusion and recommendations

Coffee can be grown with ginger and turmeric without significant yield reductions. The compact ctivar were found to be more suitable for intercropping with turmeric and ginger than intercropped coffee type. As a whole, coffee intercropping with turmeric and ginger was found to stabilize yield advantages and gross economic returns, particularly at the early year of stand establishment. Hence, the small holding farmers can more or less be buffered against crop failure and low market price of one crop. Cognizant of the limited farm size owned by farmers and long time required for the coffee trees come into bearing intercropping is the only remedy to increase crop productivity per unit area of landed/or [er year. Therefore, depending on the preference and priority of the farmers, intercropping coffee with turmeric and ginger is an important practice to increase yield and reduce risks associated with environment and price fluctuations, particularly in the garden coffee production of the country.

Table 1.Mean clean coffee yield (Qt ha^{-1}) and fresh rhizome yields of spices (Qt ha^{-1}) as influenced by the intercropping practices at Tepi over six crop years

Coffee/spices	1st year			2nd year			3rd year			4th year			5th year			6th year		
	SC	IC	Mean	Sc	IC	Mean	SC	IC	Mean	SC	IC	Mean	SC	IC	Mean	SC	IC	Mean
Coffee																		
74112	6.2	5.4	5.8	22.8	20.8	21.9	2.2	1.7	1.9	17.6	17.5	17.6	10.6	10.5	10.6	3.9	2.7	3.3
74110	5.3	4.1	4.7	22.5	18.3	20.4	4.3	3.7	4.0	14.9	13.0	13.9	10.0	7.2	8.6	5.4	3.4	4.4
7440	13.5	14.0	13.8	36.0	34.5	35.3	2.0	1.2	1.6	28.6	23.9	26.2	4.4	2.7	3.6	14.4	13.7	14.1
Mean	8.3	7.8		27.1	24.5		2.8	2.2		20.4	18.1		8.3	6.8		7.9	6.6	
Spices																		
Turmeric	251.4	283.6	267.6a	203.2	222.9	213.1a	271.8	194.2	233.0a	211.4	111.4	161.4a	151.8	68.5	110.1a	230.4	86.8	158.6a
Gin. 37/79	22.8	9.4	66.1c	32.6	11.8	22.2c	63.2	25.3	44.3b	137.1	26.6	81.8b	91.1	25.7	8.6b	83.3	34.2	58.8b
Gin. 40/79	192.8	47.8	120.8b	124.6	37.4	80.99b	85.4	19.6	52.5b	106.8	12.1	59.4b	80.1	13.6	46.8b	92.5	11.6	52.1b
Mean	189.0a	113.7b		120.1a	90.7b		140.1a	79.7b		151.8a	50.0b		107.8a	35.9b		135.4a	44.2b	

Qt = Quintals, where 1 Qt = 100 kg; Figures followed by the same letter(s) within a row/column are not significantly different at 0.05 probability level. SC = Sole cropping and IC = Intercropping.

a) b)

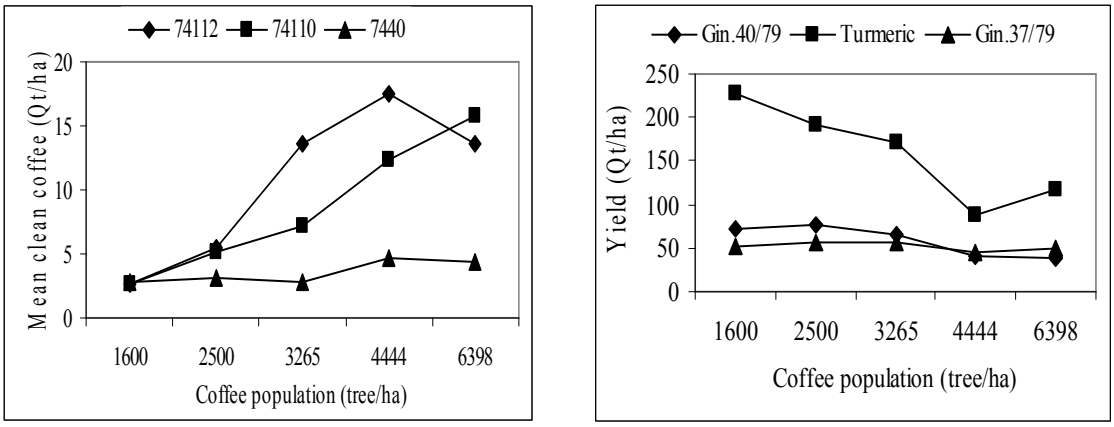

Figure 1. Mean clean coffee yield (a) and fresh rhizome yields of turmeric and ginger (b) as influenced by coffee population density at Tepi during the last crop year

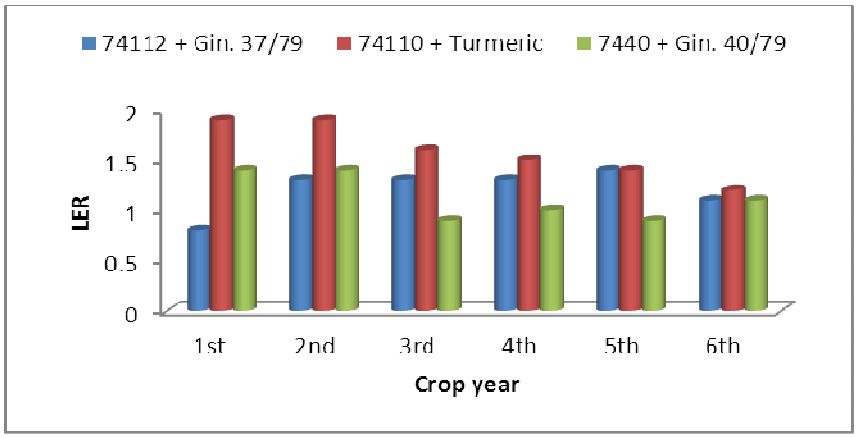

Figure 2. Land equivalent ratio (LER) of coffee cultivars intercropped with turmeric and ginger (Gin. 37/79 and Gin. 40/79) over six crop years at Tepi

Table 2. Estimated gross field benefit [Ethiopian Birr (ETB)* ha^{-1}] from coffee and turmeric and ginger over three consecutive crop years

	4th year			5th year			6th year		
Crop type	**Sole**	**Intercrop**	**Mean**	**Sole**	**Intercrop**	**Mean**	**Sole**	**Intercrop**	**Mean**
Coffee	9747	8665	9206	8398	6892	7645	9982	8298	9140
Turmeric	6659	3509	5084	3185	1438	2312	9675	3647	6661
Ginger	12394	1933	7164	6442	1474	3958	4392	1145	2768
Total	**28800**	**14107**	**21454**	**18025**	**9804**	**13914**	**24049**	**13090**	**18569**

*20 ETB = 1 US Dollar; Field prices of dry coffee for the respective crop years were 225, 475 and 591 ETB Qt^{-1}. The respective field prices of processed turmeric and fresh ginger yields were 150, 100 and 200 and 100, 75 and 50 ETB Qt^{-1} during the 1st, 2nd and 3rd crop years, respectively.

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