

Intercropping of Sweet Basil (*Ocimum Basilicum* L.) with Maize (*Zea Mays* L.) as Supplementary Income Generation at Wondo Genet Agricultural Research Center, South Ethiopia

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Abstract: Field experiments were conducted at wondo genet research center in 2017 and 2018 cropping seasons. The aim of the study was to determine the optimum population density of sweet basil intercropping ratio into a maize-based cropping system. The experiment was laid out in randomized complete design using five intercropping ratios = T1= sole basil, T2= maize sole, T3=100% maize + 100% Sweet Basil, T4=100% Maize+75% Sweet Basil, T5=100% Maize+50% Sweet Basil, T6= 100% Maize +25% Sweet Basil. Combined mean grain yield of maize was not significantly affected by treatment of intercropping ratio of basil, whereas mean herbage yield of basil was significantly affected by the intercropping ratio of basil proportion in maize. The combined mean yield advantage in terms of total LER indices was greatest in the cases of 100% sweet basil into 100% maize intercropping (1.66) which might be attributed to more efficient total resource exploitation and greater overall production. Intercropping basil population in 100% and 75% in to 100% maize gave higher mean grain yield of maize, basil herbage and economically profitable as compared to sole maize and sole basil cropping therefore we recommend intercropping 75%, up to 100% sweet basil population in maize is would be profitable for small scale farmers who practice monocropping around wondo genet and similar agro-ecology.

Keywords: Intercropping ratio, Sweet Basil, Maize, Land Equivalent Ratio and Economic Advantage

1. INTRODUCTION

Intercropping as a method of sustainable agriculture is the growing of two or more crops during the same season on the same area so as to utilize common limiting resources better than the species grown separately, and hence it is as an efficient resource use method (Ghosh *et al.*, 2006). Now a day this method has become one of the popular methods in the agricultural system due to the more efficient use of resources and its role in the reduction in weeds interference and other pests (Chen *et al.*, 2012; Lithourgidis *et al.*, 2011). It should be kept in mind that intercropping has a long history of food production in the world.

According to Seran and Brintha, (2010) the intercropping system gave higher cash return to smallholder farmers than growing as the mono-crops. Intercropping maize with cowpea has been reported to increase light interception in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize grown alone (Ghanbari *et al.*, 2010).

Medicinal plants are considered as a source of health products, essential oils and other natural aroma chemicals in the national and international markets (Sujatha *et al.*, 2011). In addition, many studies have emphasized the use of medicinal plants in intercropping systems, such as cassava/okra, Okra with chili pepper, saffron, and chamomile, were also reported by Muoneke and Mbah, (2007), Uddin and Odebiyi, (2011).

In addition, to conserve the biodiversity, presence of medicinal plants in intercropping will also enhance yield quantity. For example, intercropping peppermint (*Mentha piperita*) plants with soybean produced a significantly higher amount of essential oil when compared to monoculture plants and the oil yield increased by 50% (Maffei and Mucciarelli, 2003).

In many studies, one of the most common reasons for the adoption of intercropping is yield beneficial which is justified by the greater resource exploitation by intercrops than monoculture (Poggio, 2005). The more efficient exploitation of resources in intercropping happens because the component crops use the resources either at different times or obtain resources from different parts of soil or aerial environment (Echarte *et al.*, 2011). Regarding yield advantage, in a field study, Esmaeili *et al.* (2011) reported that the total seed yield of barley (*Hordeum vulgare*) and annual medic (*Medicago scutellata*) was improved in some of the intercropping ratios when compared to the monoculture of either crop.

Another advantage of intercropping systems is weed suppression (Banik *et al.*, 2006). The reduction of weed growth by crop interference is a viable alternative to reduce the reliance on herbicide application in weed management (Poggio, 2005). Even though maize is a major food crop produced in south Ethiopia, there is a little bit information on intercropping with aromatic plants such as sweet basil. Basil (*Ocimum basilicum L.*) is an erect herbaceous annual aromatic, spice and medicinal plant that belongs to the Lamiaceae family (Helen, 1980). In Ethiopia, sweet basil is locally known as “Besso bila” in Amharic and different Ethiopian ethnic group has a different name for sweet basil, (Gebrehiwot, *et al.*, 2015). Common basil or sweet basil (*O. basilicum L.*) is most widely used due to its high economic value, popularity, and demands among these economically important species of basil (Simon *et al.*, 1999). Ethiopian farmers conventionally cultivate and use this crop for house consumption and provide for the local market and some investors started exportation of sweet basil to different countries (Yimer, 2010). Some finding indicated that identifying compatibility and profitability of intercropping aromatic and medicinal plant with major growing crops in Ethiopia. As explained by Lulie (2014), intercropping spearmint with maize at a 42cm inter-row spacing of spearmint followed by 36cm inter-row spacing is biologically efficient, economically feasible, more profitable and provide opportunities for the producers than planting alone. Therefore, the main objectives of this study were to assess the influence of intercropping sweet basil with maize on yield and yield component of maize and basil yield. To diversify maize-sweet basil based farming practices by the inclusion of sweet basil for additional cash generation.

2. MATERIAL AND METHODS

The research was conducted at Wondo Genet Agricultural Research Center’s fields, in Southern Ethiopia during 2017 and 2018 growing seasons. Wondo Genet is located 270 km South of Addis Abeba and 14km southeast of Shashemene. The geographical coordination of the area is 7°19’ N latitude and 38° 38’ E longitudes with an altitude of 1780 meters above sea level (masl). The site receives a mean annual rainfall of 1128mm with minimum and maximum temperature of 11°C and 26°C, respectively

The experiment was laid out in a randomized complete block design with three repeats. The treatments consisted with six additive series intercropping combinations viz: T1= sole Basil (60cm inter-row with 40cm intra-row spacing), T2=Sole maize (80cm x 30cm), T3= 100% maize + 100% Sweet Basil (60cm inter-row x 40cm intra-row), T4=100% Maize+75% Sweet Basil (Jumping two rows of maize + one row of sweet Basil with 50cm intra-row), T5=100% Maize+50% Sweet Basil (jumping two row of maize + one row of Sweet Basil with 40cm intra-row), T6= 100% Maize +25% Sweet Basil (jumping two row of maize + one row of sweet Basil with 60cm intra row spacing. Maize variety BH546 was used and spaced at a distance 30cm x 80cm with 41663ha⁻¹plant population and the companion crop was Sweet Basil. Maize seeds were sown at the rate of two seeds per hill and simultaneously uniform sweet basil seedlings were transplanted at the height of around 15 cm or two months after sowing according to the treatments. Maize was thinned to one plant per hill after three weeks. Gross plot size of the experiment was 16 m² (4m x 4m) and the distance between the plots and blocks were 1 and 1.5 m apart respectively. Each plot consisted of five rows of maize. The net central unit areas (2.4m x 3.4m =8.16 m²) of each plot excluding the borders were used for data collection. Recommended hand weeding and harvesting practices were followed, and fertilizers were applied at rates of 50 kg urea and 46 kg P ha⁻¹.

2.1. Data Collection and Measurements

Data for maize on plant height, cobs per plant, cob length, and data for sweet basil on plant height were determined from 10 randomly sampled plants per plot during physiological maturity. The maize grain yield, leaf and inflorescence weight per plant (gm), dry herbal yield kg ha⁻¹, and Oil yield kg ha⁻¹

of each crop of the component crop in the intercrop was determined from the harvestable plots and converted to kg ha⁻¹. Sweet basil leaf and inflorescence oil extraction were done using the hydro-distillation method in a Clevenger type apparatus. Analysis of variance was used to test the significance of treatment effects using the computer program SAS 9.1.3. Least Significant Difference (LSD) test was used to compare treatment means.

Land equivalent ratio (LER) was determined using the formula defined by Willey (1991)

$$LER = La + Lb = Yab/ Yaa + Y ba/Ybb$$

Where Lm and Lb are the LERs for the individual crops of the system

Ymb = Intercrop yield of crop ‘Maize’

Ybm = Intercrop yield of crop ‘sweet Basil’

Ymm = Pure stand crop yield of ‘Maize’

Ybb = Pure stand crop yield of ‘sweet basil’

Economic benefits of maize-basil intercropping were determined by calculating monetary advantage index (MAI) using formula established by Willey (1979). Prevailing local market prices of maize and basil were taken for economic analysis and the prices of maize and basil were 5.5 and 30 ETB/Ethiopian Birr), respectively, during the experiment.

$$MAI = (\text{Value of combined intercrops}) \times (LER-1)/LER$$

Where MAI = Monetary advantage index

LER = Land equivalent ratio

3. RESULTS AND DISCUSSION

3.1. Maize Components

Among all measured parameters of maize for two years only in the first year; above ground biomass had a significant difference. The highest above ground biomass (18706 kg ha⁻¹) was recorded from sole maize followed by 25% of sweet basil intercropping in maize (13483 kg ha⁻¹) and the lowest (10502kg ha⁻¹) was obtained from 100% of sweet basil with 100% maize it indicated that intercropping highest present of sweet basil in maize affect the biomass of maize. However, the second year and the combined mean were not significantly affected above ground biomass of maize.

Similarly, Ghanizadeh *et al.* (2014) reported that the total yield of sole maize was more than their intercrops in maize: sweet basil: borage intercropping.

Table1. Influence of Maize- Sweet Basil intercropping on yield and yield components of maize for two consecutive years

Treatments	Plant height(m)			Number of Ear per plant		
	2017	2018	Combined mean	2017	2018	Combined mean
Sole Maize	2.56	2.37	2.57	1.3	1.3	1.4
100% Maize+100% Sweet Basil	2.71	2.33	2.36	1.7	1.5	1.3
100% Maize+ 75% Sweet Basil	2.76	2.23	2.58	1.3	1.2	1.4
100% Maize+50% Sweet Basil	2.54	2.55	2.39	1.2	1.3	1.0
100% Maize+25% Sweet Basil	2.56	2.16	2.62	1.4	1.3	1.6
LSD _{0.05}	ns	ns	ns	ns	ns	ns
CV%	7.6	4.7	5.1	18.3	24.2	23

Also, Girma (2015) stated that the highest biological yield obtained from monoculture than intercropped. The higher yield of monoculture compared to intercrop may be due to minimal disruption of the plant's habitat (Banik *et al.*, 2006).

Table2. Influence of Maize- Sweet Basil intercropping on yield and yield components of maize for two consecutive years

Treatments	Ear length (cm)			Grain yield (kg ha ⁻¹)		
	2017	2018	Combined mean	2017	2018	Combined mean
Sole Maize	17.7	20.1	19.52	6262	5276.9	5769.4
100% Maize+100% Basil	17.5	19.9	18.4	6079.6	4262.2	5751.8
100% Maize+ 75% Basil	18.7	19.3	18.9	6441.2	5163.4	5609.3

Intercropping of Sweet Basil (*Ocimum Basilicum L.*) with Maize (*Zea Mays L.*) as Supplementary Income Generation at Wondo Genet Agricultural Research Center, South Ethiopia

100% Maize+50% Basil	18.6	19.6	19.2	5811.2	4777.4	5487.3
100% Maize+25% Basil	18.6	19.6	19.2	6424.3	5424.1	5343.3
LSD _{0.05}	ns	ns	Ns	ns	ns	ns
CV%	2.9	3.18	2.25	12.6	19.24	14.0

The other parameters; - plant height (cm), number of ear per plant, ear length, grain yield, and Harvest index were not showed significant differences among the intercropped ratio of basil in 100% of maize or in another word those parameters don't influence by the intercropping population density of sweet basil; this could be due to the reason that intercropping sweet basil in maize at an early stage or immediately after maize emerged doesn't affect maize growth parameters and grain yield; on the other hand before the canopy of maize formed and competition occurred sweet basil harvesting time reached within two and half month (Table 1, 2, & 3).

Table3. Influence of Maize- Basil intercropping on yield and yield components of maize for two consecutive years

Treatments	Aboveground biomass (kg ha ⁻¹)			Harvest index		
	2017	2018	Combined mean	2017	2018	Combined mean
Sole Maize	18706a	10045	12969.9	0.34	0.54	0.45
100% Maize+100% Basil	10502b	9868	11750.0	0.63	0.54	0.47
100% Maize+ 75% Basil	10577b	9742	12311.4	0.65	0.52	0.46
100% Maize+50% Basil	12967b	9693	11940.4	0.45	0.47	0.46
100% Maize+25% Basil	13483ab	8044	11520.2	0.45	0.53	0.50
LSD _{0.05}	5245.8*	ns	ns	ns	ns	ns
CV%	21.0	13.1	7.9	27.1	14.9	8.9

3.2. Basil Component

In each year and the combined mean plant height was significantly ($P < 0.05$) affected by the intercropping ratio of sweet basil. Sweet basil planted at the ratio of 100% basil with 100% maize gave higher mean plant height (50.5cm), followed by decreasing consecutively with a decreased ratio of basil (Table 4). Such an increase in plant height with increased plant density may be explained by increased activity of stem growth hormone for plant sunlight competition. This finding was consistent with the data reported by Girma (2015) who observed that taller basil plants were achieved from the high intercropping population density of basil-maize intercropping. Significantly higher combined mean fresh leaf yield per plant (40.1kgp⁻¹) was obtained from sole basil. Even though statistically were not significant difference observed between the intercropping ratio of basil in maize from 25% up to 100%; here are increments of value when the percent of basil decreased in maize (Table 4). This might be due to the shade effect of maize and competition. Dry herbage yield and oil yield were significantly influenced by the intercropping ratio of basil in maize. The Combined mean higher dry herbage yield (1560kg ha⁻¹) and oil yield (7.95 kg ha⁻¹) were obtained from the sole basil followed by the intercropping ratio of 100% basil in 100% maize for both and the lowest combined mean dry herbage (485 kg ha⁻¹) and oil yield (3.3 kg ha⁻¹) were obtained from the intercropping ratio of 25% basil in maize treatment.

Table4. Influence of Maize- Basil intercropping on yield and yield components of Basil for two consecutive years

Treatments	Plant height (cm)			Leaf weight per plant (gm)		
	2017	2018	Combined Mean	2017	2018	Combined Mean
Sole basil	43.2c	41.3ab	42.2cd	44.2a	36.1	40.1a
100%Maize+100%Basil	53.9a	47.06a	50.5a	14.1b	27.3	20.7b
100%Maize+75%Basil	51.9a	40.5b	46.2b	14.8b	25.4	20.7b
100%Maize+50%Basil	55a	35.6b	45.3bc	18.7b	27.8	23.24b
100%Maize+25%Basil	47.5b	36.2b	41.8d	17.2b	40.1	28.6b
LSD _{0.05}	4.2*	6.1*	3.4*	9.2*	ns	11.4*
CV%	3.5	5.9	3.03	22.3	29	22.6

This higher dry herbage yield and oil yield insole and in 100% basil in 100% maize treatment attributed to competition free and the accommodation of the high number of basil per unit area contribute to producing high biomass of herbage yield (Table 5). This finding was consistent with the result of Girma (2015) who reported higher dry herbage yield at maize: sweet basil (1:1) intercropping.

Table5. Influence of Maize- Basil intercropping on yield and yield components of Basil for two consecutive years

Treatments	Dry herbage weight (kg ha ⁻¹)			Oil yield(kgha ⁻¹)		
	2017	2018	Combined Mean	2017	2018	Combined Mean
Sole basil	1926.6a	1501a	1560a	7.8aa	8.05	7.95a
100%Maize+100%Basil	544.9b	1331ab	938.1b	6.1a	4.8	4.62ab
100%Maize+75%Basil	532.3b	793.5cd	662.9bc	3.5b	6..0	4.5ab
100%Maize+50%Basil	423.4b	956.8bc	644.6bc	2.5bb	66.6	4.2ab
100%Maize+25%Basil	332.4b	386d	485c	6.1a	2.3	3.3b
LSD _{0.05}	407.04*	494.1*	348.2***	2.6*	Ns	4.2*
CV%	28.7	26.4	21.5	26.3	30.1	28.2

3.3. Total Land Equivalent Ratio

Intercropping ratio of sweet basil to maize crop had a significant ($P < 0.05$) effect on the total land equivalent ratio in both years and the combined mean. In 2017 cropping year maximum LERt (1.64) was obtained from 75% of basil intercropping in maize, which was statistically similar with total land equivalent ratio (1.45) obtained from 100% basil in 100% maize and 50% basil intercropping in 100% maize treatments. The lowest LERt (1.07) was recorded from 25% basil intercropping in 100% maize treatment. In 2018 cropping year higher LERt (1.86) was obtained from 100% basil intercropping in 100% maize treatments followed by LERt (1.54) which was obtained from 75% of basil intercropping in 100% maize which were statistically similar with the LERt obtained from 50% basil intercropping in 100% maize treatment. This total land equivalent ratio difference between the years could be due to the favorable environment condition found in cropping year.

All combined mean LERt intercropping ratio of proportion was above the unity (1.00) indicating the advantages of intercropping over sole cropping. The combined mean yield advantage in terms of total LER indices was greatest in the cases of 100% basil into 100% maize intercropping (1.66) which might be attributed to more efficient total resource exploitation and greater overall production. This indicated that additional 0.66 ha (66%) more area would have been needed to get equal yield to planting maize and basil in pure stands. The intercropping ratio of basil in maize in additive series from 25%, 50%, 75% & 100% in maize cropping were showed yield increment advantage in 6%, 44%, 59% and 66% consecutively over the sole cropping. A similar finding was reported by Girma (2015) on Maize- basil intercropping. Also, Higher LERt were reported by Abate and Alemayehu, 2018; Takele and Mohammed, 2014; Hirpa, 2014 on intercropping fenugreek, field pea, haricot bean and sorghum in maize compared to monocropping of maize in Ethiopia.

3.4. Monetary Advantage Index (MAI)

MAI also used to evaluate the economic advantages of the intercropping system. Monetary advantage index was significantly ($p < 0.05$) influenced by the intercropping ratio of basil in maize in both years and the combined mean. In 2017 cropping year intercropping ratio of 100% basil into 100%, maize gave significantly higher economic return (22659 birr ha⁻¹); which were statistically similar with MAI obtained from 75% basil intercropping in 100% maize and 50% basil intercropping. The lowest economic return (2332 birr ha⁻¹) was obtained from the intercropping ratio of 25% basil in 100% maize this could be due to the low number of basil population that might result in less biomass production in terms of basil yield that affect the economic return.

Table6. Land equivalent ratio and monetary advantage of Intercropping Maize and Basil Crops as Affected by additive % Proportion for two consecutive years

Treatments	The total land equivalent ratio			Monetary advantage index(birr ha ⁻¹)		
	2016/17	2017/18	Combined mean	2016/17	2017/18	Combined mean
100%Maize+100%Basil	1.45a	1.86a	1.66a	22659a	31631a	27145a
100%Maize+75%Basil	1.64a	1.54ab	1.59a	16194a	22961ab	19577.5b
100%Maize+50%Basil	1.44a	1.43b	1.44b	15623a	15191b	15407b
100%Maize+25%Basil	1.07b	1.06c	1.06c	2332b	1484c	1908c
LSD _{0.05}	0.28*	0.22*	0.17*	10535*	9174.6*	6439.3*
CV%	10.24	7.4	5.7	28.9	32.3	31.2

In second year maximum economic return (31631birr ha⁻¹) was obtained from the 100% basil intercropping ratio in 100% maize and the lowest economic return (1484birr ha⁻¹) from 25% basil intercropping in maize. Similarly the combined mean economic return was recorded from 100% basil intercropping in 100% maize and the lowest economic return obtained from 25% basil intercropping in 100% maize. These results suggest that intercropping ratio could improve the smallholder farmers' incomes and total efficiency of the system with low input investment by varying planting population and time. Similar finding was reported by Girma (2015) on Maize- basil intercropping.

4. CONCLUSION

The trial conducted for two years when we concluded; mean grain yield of maize was not significantly affected by treatment of intercropping ratio of basil, whereas mean herbage yield of basil was significantly affected by the intercropping ratio of basil proportion in maize. Intercropping basil population in 100% and 75% in to 100% maize gave higher mean grain yield of maize, basil herbage and economically profitable as compared to sole maize and sole basil cropping therefore we recommend intercropping 75%, up to 100% sweet basil population in maize is would be profitable for small scale farmers who practice monocropping around wondo genet and similar agro-ecology.

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