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Determination of Appropriate Sweet Basil Ratio for Intercropping with Dry Hot Pepper under Rainfed Condition at Hawassa and Halaba, Southern Ethiopia

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Abstract

Intercropping hot pepper (*Capsicum annuum*) with sweet basil (*Ocimum basilicum*) was conducted on farmer's fields at Halaba and at Hawassa experimental sites, Southern Ethiopia to determine appropriate sweet basil ratio for intercropping. The design was RCBD with four replications. The treatments of the experiment were 1=Sole Sweet basil (100% recommended Sweet basil population), 2=Sole Pepper (100% recommended pepper population), 3=100% pepper with 75% Sweet basil, 4=100% pepper with 50% Sweet basil, and 5=100% pepper with 25% Sweet basil. Growth and yield data were collected from experimental sites carefully and subjected to analysis of variance (ANOVA). The ANOVA showed that pepper plant height, fruit length, and fruit diameter did not significantly affect sweet basil ratios. However, sweet basil ratio of 25% resulted in higher significant dry hot pepper yield next to dry hot pepper yield in the sole cropping system at Halaba experimental site. Sweet basil dry leaf yield per hectare and essential oil yield per hectare was significantly influenced by the cropping system and sweet basil ratios. From the higher sweet basil ratio (75%) higher significant dry leaf yield per hectare and essential oil yield per hectare were obtained at both Hawassa and Halaba sites. Better intercropping efficiency was obtained as land equivalent ratio value for 25% and 50% ratios of sweet basil treatments. From the results of the current experiment, intercropping sweet basil with pepper is advantageous for resource-poor smallholder farmers. Hence, 25% sweet basil ratio is suitable for pepper intercropping with sweet basil at both the experimental sites.

Key words: cropping system, intercropping, pepper, basil

1. Introduction

Growing two or more crops on the same land at the same time is commonly practiced in agriculture. It is commonly known as intercropping and it has various forms and objectives (Willey 1985). The common forms of intercropping include row intercropping, mixed intercropping, strip intercropping and relay intercropping (Mousavi and Skandari, 2011). Intercropping is mostly practiced to increase productivity through elaborating cooperation and reducing competition among the target crops (Degri and Ayuba, 2016). Intercropping provides yield and economic advantages so that growers get more amounts and types of yields for different purposes (Waktola et al., 2014; Tadesse et al., 2019). Intercropping contributes commodities for medicine, food, feed, raw material for industry, and product for income generation because of efficient resources utilization as compared to mono-cropping. Such advantages of intercropping can be achieved by considering different principles and strategies. Consideration of the nature of crops for intercropping, their planting densities, as well as resource use patterns, temporal and spatial arrangements played a great role (Willey, 1990). Different intercropping experiments resulted in efficient production possibilities of various crops in various countries. Such information is good for developing countries like Ethiopia, where a lesser amount of mechanized farming systems are practiced.Agriculture is still the backbone of Ethiopia`s economy today. However, it is under pressure because of increasing population, climate variability, and urban expansion. Besides, an increase in prices of improved seed, agrochemicals, and fertilizers is the main problem for many crop producers in Ethiopia. Food and feed uncertainty is the major challenge in the country. Political instability, weaknesses of successive strategic development policies, and shortage of financial assistance in the country is the root cause of the problems (YigezuWendimu, 2021). Moreover, farmers in different agro-ecologies use multiple cropping systems, such as intercropping as an alternative practice for efficient land use, for better pest management options, and also for crop insurance. For instance, an intercropping combination of maize with basil (Tadesse et al., 2019), maize with common bean (Lulie et al., 2016), maize with cassava, coffee with Enset (Mekonnen et al., 2020), and intercropping pepper with sweet potato and maize (Mitiku et al., 2013) were reported as best practices for pest management, yield and economic advantages in Ethiopia. In their study, Mitiku et al. (2013) had shown 35.3% disease incidence and 9.2 % in the control treatment.

The common practices of intercropping maize with sorghum, coffee, khat, sweet potato, and chickpea and also maize with tomato in the West Hararghe zone of Ethiopia was assessed and reported (Degaga and Angasu, 2017). The report showed that about 71.6% of the respondent had willing to continue intercropping of cereal crops with legumes because of land shortage, profit maximization, early maturity of legumes, animal forage, weed control and reducing risk from crop failure. Dikir and Tadesse's (2019) studies at site zone Sankura district of southern Ethiopia reported the advantages of intercropping maize varieties (Limu and Shone) with a common bean variety (Deme). Most of the intercropping practices include a combination of legumes with cereals. However, perennial crop-based intercropping, such as coffee-based, enset based, Khat based, are largely practices. The practices of intercropping annual spice, vegetables, and medicinal plants for income generation are also common in the country. Hot pepper is one of the warm season vegetables commonly produced under the intercropping system. Similarly, basil is one of the versatile annual medicinal plants convenient for intercropping for smallholder producers. Intercropping pepper with basil is common in pepper producers, however, the appropriate way of intercropping is not known. The temporal and spatial arrangement, planting density of the component crops (basil and pepper) were not studied. Even though farmers conduct the intercropping of pepper with basil no research study was conducted to confirm the yield and economic advantage of the intercropping pepper with basil in Ethiopia. Therefore, this study was initiated to determine the yield and economic advantage of intercropping pepper with basil at Hawassa and Halaba, southern Ethiopia.

2. Material and Methods

2.1 Sites description

2.1.1 Hawassa Experimental Site

The experiment was conducted at Hawassa university experimental site. Hawassa is the capital city of the Sidama region. It is located 275 km away south of Addis Ababa, the capital city of Ethiopia. The geographic coordinates of the city are approximately 7º 03' latitude north and 38º 29' longitudes east. It is located at an altitude of, 1650masl. The main crops grown in the area include maize, onion, tomato, potato, and sugarcane under rainfed and irrigated conditions. The temperature of the study area ranges from 13ºC in winter and 27ºC and has 900 mm mean annual rainfall. The experimental site soil type is sandy loam with a pH of 5.5 (Narayanan and Abate, 2017; Dana, 2018).

2.1.2 Halaba Experimental Site

The experiment was also conducted at the Halaba woreda site which is located 314 km south of Addis Ababa and about 85 km southwest of Hawassa City. It lies between 07^{o}20'34.5"to 07^{o}20'21.9"N latitude and 38^{o}06'30.0" to 38^{o}06'31.1"E longitude with an altitude of 1808 m.a.s.l. The Halaba woreda is located west of the Oromiya region, north of Hadiya (Sike), east of KembataTembaro, southeast of Silte and Hadiya zones. The Agro-ecological, Halaba woreda site of the experiment is classified as Weina Dega. The annual rainfall varies from 857 to 1085 mm, while the annual mean temperatures also vary from 13 ^{O}C to 20 ^{O}C. The area receives a bimodal rainfall where the small rains are between March and April while the main rains are from July to September. The major crops grown in the Halaba woreda include maize, tef, wheat, pepper, haricot bean, sorghum, and millet (Ayale, 2016).

2.2 Experimental Material

Sweet basil and hot pepper were the experimental materials. A promising candidate variety of sweet basil from Wondogenet agricultural research and a hot pepper variety called Mareko Fana were used for the intercropping experiment under the rainfed conditions at both locations during the 2018 cropping season. Pepper was treated as the main crop, while sweet basil was treated as a companion crop.

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2.3 Treatments, Experimental Design and Procedures

The following treatments were used during the experiment.

- Treatment 1. Sole Sweet basil (100% recommended Sweet basil population)
- Treatment 2. Sole Pepper (100% recommended pepper population)
- Treatment 3. 100% pepper with 75%Sweet basil
- Treatment 4. 100% pepper with 50%Sweet basil
- Treatment 5. 100% pepper with 25%Sweet basil

The design of the experiment was RCBD with four replications for both experimental sites. Sweet basil seedling was prepared at Wondogenet agricultural research center using a polyethylene bag of 10 cm diameter. Quality seedlings of the Mareko Fana pepper variety were prepared at a commercial farm. Both main and companion crops were transplanted at the same time at each location according to the treatments listed above. Spacing for sweet basil was 40 cm between plants and 60 cm between rows for sole and 100% sweet basil treatments. Field management practices such as weeding, hoeing, and guarding were conducted during the experimental period when necessary.

2.4 Data collection and Analysis

Central plants excluding the border plants were considered for data collection for both sweet basil and pepper crops in the cropping system. Sweet basil and pepper yield components data were recorded and subjected to analysis of variance using SAS software version 9.3. The least significant difference (LSD at p=0.05) was employed to identify significantly different treatments from each other. The land equivalent ratio was analyzed to evaluate the productive effectiveness of the intercropping of sweet basil with hot pepper for using the resources of the environment compared to sole planting. The LER values were computed Willey *et al.* (1983) as indicated below.

$$\text{LER}=\frac{\text{Intercropping yield of sweet basil}}{\text{Sole yield of sweet basil}}+\frac{\text{Intercropping yield of pepper}}{\text{Sole yield of pepper}}$$

The LER was calculated using dry leaf yield for basil and dry pod yield for pepper. A treatment with more than one (1) LER was considered as more efficient as compared to the sole cropping of the crops (sweet basil and pepper) in the intercropping system.

3. Results and Discussion

3.1 Hot pepper growth and yield parameters

Analysis of variance (ANOVA) showed no significant results of intercropping sweet basil at 75%, 50% and 25% with pepper at both experimental sites for pepper plant height, fruit length, and fruit diameter (Table 1). However, plant height from sole pepper 33.9cm at Hawassa and 48.6cm at Halaba were numerically lower when compared to the pepper height at intercropping in their respective locations (Table 1). This might be due to competition of sweet basil for sunlight with the main crop pepper in the intercropping system. Degri and Ayuba (2016) reported similar lower pepper plant height in their intercropping with cereals such as maize, millet, and sorghum than sole cropping. The possible stated reason was aphid problem on sole pepper than intercropping pepper. Lulie *et al.* (2016) reported non-significant maize plant height from intercropping different proportions of common bean. Besides, Dikir and Tadesse (2021) reported as maize plant height was not significantly affected when intercropped with different common bean varieties. Furthermore, the lower and non-significant results of pepper fruit length and pepper fruit diameter obtained at sole cropping might be due to the advantages of intercropping sweet basil in pest control (Degri and Ayuba, 2016).

Table1. Mean values of hot pepper growth and dry fruit yield in intercropping hot pepper (P) with sweet basil (B) at Hawassa (HW) and Halaba (HL) experimental sites during 2018 cropping season

Treatment	PH(cm)		FL(cm)		FD(cm)		Dry pepper yield (kg/ha)	
	HW	HL	HW	HL	HW	HL	HW	HL
Sole pepper	33.9	48.6	6.45	8.3	14.5	10.6	1562.5	4390[a]
100%P+75%B	41.3	49.7	6.92	8.7	15.2	10.3	1270.8	2234.4[c]
100%P+50%B	42.7	50.4	7.1	8.9	15.0	11.3	1197.9	2751b[c]
100%P+25%B	36.4	54.2	7.5	8.5	14.8	10.3	1489.6	3149[b]
LSD(0.05)	ns	ns	ns	ns	ns	ns	ns	719.9
CV %	13.5	7.6	15.8	9.8	8.1	8.2	18.9	9.8

Where PH= Plant height, FL= Fruit length, FD=Fruit diameter, LER=Land equivalent ratio, P=Pepper, B=Sweet basil, HW=Hawassa, HL= Halaba, ns= not significant, LSD=Least significant difference, CV=Coefficient of variance. Means in a column followed by the same letters are not significantly different at p≤5% level of significance.

Despite the non-significant results, evaluation of the different proportions of sweet basil on hot pepper dry yield at Hawassa showed the possibility of producing numerically higher fruit dry yield of hot pepper when intercropped with sweet basil at 25% proportion (Table 1). A study also showed similar results of the additive proportion of sweet basil effects when intercropped with maize (Tadesse *et al*., 2019). They reported that an increase in sweet basil proportions from 25% to 100% intercropped with maize showed non-significant results on the main crop, maize yield, and yield components. This could be due to variation in growth periods of the two crops, maize competition ability for resources, and variation in growth habit (above ground and below ground). Besides, the fruit length, plant height, and dry fruit yield of hot pepper at the Halaba experimental site were higher than that of the Hawassa experimental site. Hawassa site is warmer than the Halaba site. Variation in climatic conditions of the experimental sites might be the possible reason for the variation in dry fruit yields of the hot pepper. Moreover, the present results from the Halaba site had approved the significant effect of different proportions of sweet basil on dry fruit yield of hot pepper, where an increase in the proportion of sweet basil from 25% to 75% the dry fruit yield reduction was 29%.

3.2 Sweet basil yield and yield parameters

Analysis of variance showed that sweet basil plant height and branch number did not significantly affect due to variation in the proportion of sweet basil, and similar results were obtained between sole cropping and intercropping systems at both experimental sites (Table 2). Sole sweet basil cropping resulted in higher significant dry leaf weight and essential oil yield (Table 2). This might be due to lack of competition for growth resources like nutrients, water, and sunlight during sole cropping. Whereas, an increase in sweet basil proportion from 25% to 75% increased sweet basil dry leaf yield by 642.3 kg/ha and 524.3 kg/ha at Hawassa site and Halaba sites, respectively. The lesser increase in sweet basil dry leaf yield at Halaba site might be the advantage of climatic conditions of the Halaba site favoring hot pepper production. An increase in sweet basil dry leaf weight and essential oil yield from increased proportion in the intercropping system at both experimental sites might be due to higher sweet basil plant stands at higher proportions. This is similar to the findings of Tadesse *et al.* (2019) where a higher intercropping ratio of sweet basil resulted in higher significant dry herbage yield and oil yield in the basil – maize intercropping, whereas 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.

Table 2. Mean values of sweet basil (B) growth and yield parameters in intercropping with hot pepper (P) at Hawassa (HW) and Halaba (HL) experimental sites during 2018 cropping season

Treatment	PH(cm)		Branch number (count)		Dry leaf weight (kg/ha)		Oil yield (kg/ha)	
	HW	HL	HW	HL	HW	HL	HW	HL
Sweet basil	48.1	44.0	16.9	14.3	1279.7a	1064.7a	12.1a	7.48a
100%P+75%B	51.8	43.8	19.2	13.9	854.9b	729.3b	6.3b	6.19a
100%P+50%B	49.8	43.9	19.8	14.9	393.6c	312.4c	2.12c	1.97b
100%P+25%B	51.5	41.5	20.6	14.7	373.2c	308.8c	2.0c	1.73
LSD(0.05)	ns	ns	ns	ns	212.6	205.01	2.6	2.26
CV %	11.6	5.2	22.4	11.7	18.3	21.2	29.1	26

Where PH= Plant height, LER=Land equivalent ratio, P=Pepper, B=Sweet basil, HW=Hawassa, HL= Halaba, ns= not significant, LSD=Least significant difference, CV=Coefficient of variance. Means in a column followed by the same letters are not significantly different at p≤5% level of significance.

3.3 Land equivalent ratio (LER)

Analysis of variance showed the intercropping ratio of sweet basil with hot pepper crop had a significant (P<0.05) effect on the total land equivalent ratio at Halaba experimental site (Table 3.). Better significant productivity of intercropping hot pepper with sweet basil was obtained at a lower proportion (25% sweet basil addition) at Halaba experimental site. The results obtained from the addition of 25% & 75% sweet basil proportion showed statistically similar and significantly higher at Halaba site compared to result from 100% sweet basil treatment. Halaba woreda is known for the higher production of hot pepper in area coverage nationally. Hence, the supplement of 25% sweet basil will be a good opportunity for supplementary income generation for the smallholder hot pepper producers. Similarly, numerically better values of higher productivity were also obtained at the Hawassa site, and the better is from 25% sweet basil addition treatments. Sweet basil at 25% and 50% resulted in the LER above the unity (1.00) indicating the advantages of intercropping over sole cropping that could be because of efficient resource exploitation projecting to greater production.

Table 3.Total land equivalent ratio of intercropping pepper with different proportion of sweet basil at Hawassa and Halaba experimental sites

Treatments	Hawassa experimental site	Halaba experimental site
Sole hot pepper	-	-
Sole sweet basil	-	-
100%P+75%B	0.92	0.98b
100%P+50%B	1.05	1.22[a]
100%P+25%B	1.2	1.38[a]
LSD(0.05)	ns	0.17
CV %	23.15.	8.97

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Conflict of Interest

The authors declare that they have no competing interests

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