

Intercropping of Maize (*Zea mays L.*) with Spear mint (*Mentha spicata L.*) as Supplementary Income Generation at Wondo Genet Agricultural Research Center, South Ethiopia

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Abstract: Field experiment was conducted in 2011 up to 2013 cropping season to investigate maize based farming system by inclusion of spearmint. The experiment was laid out in randomized complete block design with four replications. The result showed that sole planting of spearmint gave significantly higher essential oil yield, leaf fresh weight, above ground biomass than planting as intercropped with maize. However, intercropping didn't show significant variation on plant height, shelling percentage and grain yield of the main crop. Land equivalent ratio (LER) indicated yield advantages for all intercrop combinations, especially at 42cm inter row spacing of spearmint intercropped with maize followed by 36cm inter row spacing of spearmint intercropped with maize. Similarly, Maize intercrop with spearmint at 42cm inter row spacing of spearmint gave higher monetary advantage index (41747) followed by 36cm inter row spacing of spearmint intercropped with maize (37496) than planted at sole. This indicate that intercropping maize at 42cm inter row spacing of spearmint followed by 36cm inter row spacing of spearmint is biologically efficient, economically feasible and more profitable than planting alone.

Keywords: Intercropping, Land Equivalent Ratio, *Mentha spicata*, Monetary Advantage, Supplementary, *Zea mays*

1. INTRODUCTION

Ethiopia's crop agriculture is complex, involving substantial variation in crops grown across the country's different regions and ecologies. Five major cereals (teff, wheat, maize, sorghum and barley) are the core of Ethiopia's agriculture and food economy, accounting for about three-quarters of total area cultivated, 29 percent of agricultural GDP in 2005/06 (14 percent of total GDP) and 64 percent of calories consumed [Alemayehu Seyoum et al., 2011].

Intercropping is the growing of two or more cultivars simultaneously in the same land by utilizing resources such as soil, water, nutrients and solar radiation more efficiently [Rana et al., 2013]. Intercropping with medium duration companion crops ensure better utilization of land and sunlight [Bali Reddy, 2009]. It is a wide spread agronomic practice in the tropics because it reduces the losses caused by pests, diseases and weeds, as well as also guarantee better yield. With increasing pressures on agricultural land arisen out of population growth, farmers have to explore new ways to intensify production per unit area of land. Mixed cropping is one of the methods of this crops intensification. Spatial arrangement in the intercropping is one of the most important factors for better yield advantages [Usmanikhail et al., 2012].

Maize is a member of Poaceae family having annual life cycle. It is grown in many countries as an important food grain crop (Khan et al., 2012). Maize an important food crop in Ethiopia, cultivated mainly in the highlands of mixed farming system, with some production in the cereal root crop mixed system of western Amhara. The majority of Ethiopia's maize

comes from three regions: Oromia (61%), Amhara (20%) and SNNPR (12%). [Anderson, 2010]. Average productivity of maize is 19 q/ha, while the potential productivity is 70 to 120 q/ha [Adugna Negeri and Melaku Adisu, 2001].

According to FAO data, Ethiopian maize yield exceeds East African and African average yields, but remain well below world average yields (Anderson, 2010). On average between 1993 and 2008, Ethiopia obtained only 39.5% of world averages, with the only exception in 2006 when it yielded 55% of the world average. Yields have remained well over the East African yields, averaging 126% of the regional mean yield and achieving as much as 186% in 2006 [Anderson, 2010].

In 2008, Ethiopia cultivated 1,767,389 hectares of maize. Similarly, if Ethiopia were producing at world average yield levels (5,109 kilograms per hectare in 2008); it would produce 159% of current domestic supply. According to Anderson 2010 explanation, Soil fertility depletion and biotic constraints such as Turicum leaf blight, weeds, grain weevils, grain borers, maize stem borer and grey leaf spot account estimated 272 kilograms per hectare loss or 15% for more of the yield gap than farm management practices. Low soil fertility is the primary constraint to maize productivity accounting for an estimated 122 kilograms per hectare loss or seven percent of the total smallholder yield gap.

Maize is the primary food staple in Ethiopia, averaging slightly more than 20% of daily caloric intake. The Ethiopian Commodity Exchange reports that three-quarters of maize produced is used for household consumption, only about ten percent is marketed and the remainder is used for seed, in-kind payments for labor, and animal feed [Anderson, 2010].

Close to 95% of the marketed quantity comes from smallholders and the rest from commercial and state farms. Other market participants in the maize trade include producers (smallholders and commercial farms), wholesalers, retailers, part-time farmer traders, brokers, agents, assemblers, processors, cooperatives and consumers. Prices generally follow the annual pattern of relatively low post-harvest January prices followed by rising prices. Ethiopia also exports some maize regionally. In 2005/06, Sudan received 67% of Ethiopian maize exports with the remainder exported to Djibouti [Anderson, 2010].

In the recent past, there is greater demand for medicinal and aromatic plants as they are the raw material for pharmaceutical, perfumery, cosmetics and confectionery industries [Karnataka, 2007].

Spearmint is the one which is used either in the herb form or in the essential oil form and used for flavoring, perfume production, and medicinal purposes. The global mint market exceeds billions of dollars. In the US alone, import Mint leaf, 3000 ton and 798.2 ton essential oil. Spearmint the farm-gate price of the commercialized mint reached 16 million U.S. Dollars in 2005, which is converted to in finished products [Abd El-Wahab and Mohamed, 2009].

It is reported that the use of variety, row arrangement, planting date, spacing and plant population are some of the strategies that may prompt the yield of intercropping [Kothari *et al.*, 2000], [Sujatha *et al.* 2011], [Verma *et al.*, 2010].

Documented information on intercropping of maize varieties with spearmint is scanty. Also information on the profitability of maize-spearmint cropping system is lacking elsewhere. So there is a need for developing technology suitable for maize-spearmint intercropping. Therefore this study was undertaken to determine maize based farming system by inclusion of Spearmint for supplementary income generation.

2. MATERIALS AND METHODS

The field experiment was conducted for two years (2011-2012 and 2012-2013 cropping season) at Wondo Genet Agricultural Research center, experimental site, south Ethiopia. The experimental site was located at 7°19'N latitude, 38°38'E longitude and an altitude of 1780m.a.s.l. The texture of the top soil (0-25cm) was sandy clay loam with PH 8.84(1:2.5soil water suspension) and total nitrogen 0.18(Kjeldahl Digestion & distillation). The previous crop in the experimental site was different aromatic and medicinal plants with uniform cultural practices. Maize (BH540) and Spearmint (*Mentha spicata* L.) was planted on well tilled land in each consecutive year. The experiment was laid out in randomized complete block design (RCBD) with seven (7) treatments and four replications. Gross plot size was 3.75*4.2m². Maize was the principal crop and spaced at a distance 30*75cm² with 44444ha⁻¹ plant population. The companion crop was Spearmint and planted at 30cm, 36cm, 42cm, 48cm, 54cm, and 60cm inter-row spacing using its stolons. The two intercropped crops were planted at the same time on each consecutive experimental year. The land was

fertilized with 50 kg Urea and 100kgDAP as source of nitrogen and phosphorous. Split application of Urea(1/3 during planting,1/3 at knee height and the remaining 1/3 before flowering of maize) and full quantity of DAP were applied at the time of planting and the remaining half of Urea was top dressed at knee height and flowering stage of maize. All required intercultural operations were done as and when required. The local market price of maize and leaf fresh weight of spearmint were 5.5 birr/kg and 5birr/kg respectively during the two consecutive harvesting seasons.

The yield advantage and economic benefits of intercropping over sole cropping were determined in terms of land equivalent ratio (LER) and monetary advantage index (MAI).

Land equivalent ratio which verifies the effectiveness of intercropping for using the resources of the environment compared to sole planting. The LER values were computed using the following formula described by [Abdul et.al. 2009], [Takim, 2012], [Sullivan, 2003, [Willey et al.1983]

$$LER = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

Where,

Y_{ab} = Intercrop yield of crop 'a'

Y_{ba} = Intercrop yield of crop 'b'

Y_{aa} = Pure stand crop yield of 'a'

Y_{bb} = Pure stand crop yield of 'b'

Monetary Advantage Index (MAI): The most important part of recommending a cropping pattern is the cost: benefit ratio more specifically total profit, because farmers are mostly interested in the monetary value of return. The yield of all the crops in different intercropping systems and also in sole cropping system and their economic return in terms of monetary value were evaluated to find out whether haricot bean yield and additional stevia yield are profitable or not. This was calculated with monetary advantage index (MAI). It is expressed as

$$MAI = (P_{ab} + p_{ba}) * \frac{LER - 1}{LER}$$

Where, $P_{ab} = P_a \times Y_{ab}$; $P_{ba} = P_b \times Y_{ba}$; P_a = Price of species 'a' and P_b = Price of species 'b'. The higher the index value, the more profitable is the cropping system [Mahapatra, 2011].

Five (5) plants were selected randomly from each plot by excluding the borders to collect yield and yield contributing characters such as plant height, shelling percentage, thousand seed weight and grain yield plant⁻¹ of maize. On average of the two years data maize was harvested after 150days of planting (5 months of planting). Spearmint was harvested periodically at 90 days (first harvest), 150 days (second harvest) and 210 days (third harvest) of planting during 2011-2013 cropping season. Harvesting activities of both crops were performed manually. After recording leaf fresh weight of spearmint at every harvest, the leaf fresh weight of the crop was distilled separately at wondo genet agricultural research center plant laboratory distillation unit operating on hydro steam distillation principle. The temperature was adjusted at 100 °c to remove moisture from the plant. The distilled oil was filtered by hydro distillation system and recorded as respective essential oil (economic) yields.

The collected data were statistically analyzed using SAS computer soft ware version 9.0 English and the significance difference between any two treatments means were tested by least significant difference (LSD) at 5% probability level. It must be noted that data for each trait measured for the two years were pooled and analyzed to determine the year effect.

3. RESULTS AND DISCUSSION

3.1 Spearmint

3.1.1 Above ground biomass and leaf fresh weight

Sole planting spearmint at 30cm inter row spacing gave significantly higher ($p < 0.001$) above ground biomass than the intercropped at different inter row spacing in all individual harvests at each consecutive harvesting seasons (Table 1 and Figure 1). The significant variation was consistent in 2011-2012 and 2012-2013 harvesting seasons. The total above ground biomass in each harvesting seasons and the pooled mean in both harvesting years also showed significant variation ($p < 0.001$) at sole planting (Table 1 and Figure 1). Table 1 and figure 1 also revealed intercropping maize with spearmint at different inter row spacing of spearmint significantly depressed above ground biomass. This finding was in line with previous similar findings in rose-scented geranium intercropped with vegetables [Rajesh, 2011].

Similar to above ground biomass, leaf fresh weight at all individual harvests at each harvesting season, except in the third harvest of 2011-2012 cropping season which didn't show significant variation ($p > 0.05$), showed significant variation ($p < 0.05$ and $p < 0.001$) at sole spearmint (30cm inter row spacing) (Table 2 and Figure 2). The total leaf fresh weight of both harvesting seasons and pooled mean of overall harvesting seasons also revealed significant variation ($p < 0.05$ and $P < 0.001$) at sole spearmint. This could be due to more number of plants per unit area, more efficient utilization of applied inputs such as irrigation water, fertilizers by the crop plants which otherwise over utilized by the two intercropped plants. This finding was in line with previous similar findings in rose-scented geranium intercropped with vegetables [Rajesh, 2011] and in medicinal and aromatic plants intercropped with teak [Karnataka, 2007].

TABLE1: Above ground biomass (kg/ha) of spearmint at different harvests as influenced by intercropping systems in different years

Treatments	2011-2012				2012-2013				Pooled mean
	1 st harvest	2 nd harvest	3 rd harvest	Total biomass	1 st harvest	2 nd harvest	3 rd harvest	Total biomass	
Sole maize	--	--	--	--	--	--	--	--	--
30cm IRSSP(sole)	7123.5 ^a	10112.7 ^a	5125.8 ^a	22152 ^a	12160.0 ^a	28072.9 ^a	23292 ^a	66041.3 ^a	44175.7 ^a
Maize +36cm IRSSP	3182.08 ^b	4301.3 ^b	5162.8 ^a	13766 ^b	5249.8 ^c	6372.2 ^b	8580.4 ^b	22760 ^b	15363.6 ^b
Maize +42cm IRSSP	2483.07 ^c	3615.3 ^{cd}	3669.8 ^b	11416 ^{bc}	5727.0 ^b	5582.5 ^b	7934.9 ^b	19290.2 ^c	14852.4 ^b
Maize +48cm IRSSP	2068.96 ^d	3527.2 ^d	3301.7 ^c	9194 ^c	4551.9 ^d	4341.9 ^c	8215.1 ^b	17684.7 ^d	13650.4 ^c
Maize+ 54cm IRSSP	2198.87 ^d	3784.4 ^c	4940.9 ^a	10205 ^{bc}	3649.4 ^e	3351.3 ^d	7615.6 ^b	14738 ^f	12389.3 ^d
Maize +60cm IRSSP	1500.67 ^d	3226.7 ^e	3341.1 ^c	7704 ^c	3251.9 ^f	3356.6 ^d	8411.3 ^b	16561.8 ^e	12460 ^d
LSD(0.05)	185.36	241.49	327.71	4188.8	339.02	879.9	1637	1051.8	1029
CV (%)	3.97	3.37	5.11	22.40	3.90	6.86	10.18	2.67	3.63
F-test	***	***	***	***	***	***	***	***	***

IRSSP=inter-row spacing of spearmint, *** very highly significant at $p < 0.001$,

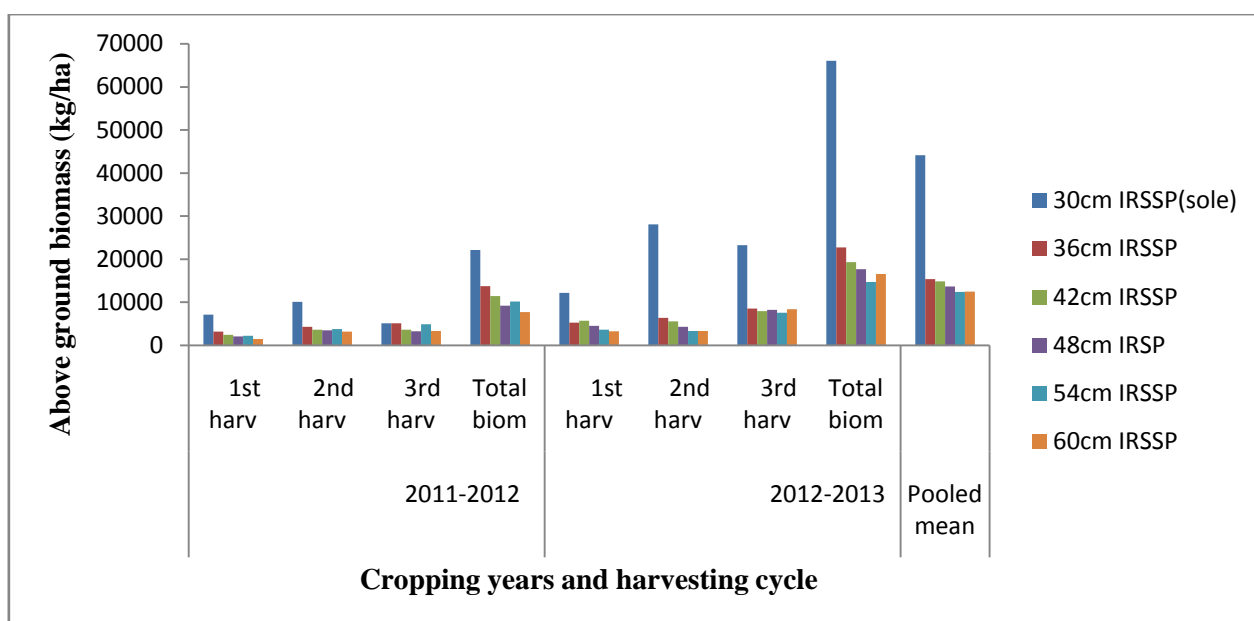


Fig. 1: Influence of maize-spearmint intercropping on above ground fresh biomass of spearmint on the consecutive two harvesting seasons

TABLE2: Leaf fresh weight (kg/ha) of spearmint at different harvests as influenced by maize intercropping systems

Treatments	2011-2012				2012-2013				Pooled mean
	1 st harvest	2 nd harvest	3 rd harvest	Total LFW	1 st harvest	2 nd harvest	3 rd harvest	Total LFW	
Sole maize	--	--	--	--	--	--	--	--	--
30cm IRSSP(sole)	3960.26 ^a	4960.74 ^a	3270.4 ^b	12107 ^a	8115.6 ^a	14058.7 ^a	13708.0 ^a	36544.5 ^a	24882.8 ^a
Maize +36cm IRSSP	2288.52 ^b	3179.01 ^c	3691.3 ^a	10110 ^{ab}	3563.0 ^b	3629.2 ^b	5557.0 ^b	14975.9 ^b	11293.8 ^b
Maize +42cm IRSSP	1951.33 ^c	3397.04 ^b	3522.5 ^a	9964 ^{ab}	3577.8 ^b	3703.5 ^b	5477.2 ^b	13023.1 ^c	10994 ^b
Maize +48cm IRSSP	1967.67 ^c	2695.79 ^d	2994.1 ^b	9812 ^b	3366.7 ^b	2780.5 ^c	5238.6 ^b	11531.7 ^d	10422 ^c
Maize+ 54cm IRSSP	2018.08 ^c	3280 ^{bc}	3655.3 ^a	10901 ^{ab}	2335.8 ^c	2004.1 ^d	5416.1 ^b	9621.2 ^e	10886.4 ^b
Maize +60cm IRSSP	1174.21 ^d	2539.22 ^d	3089 ^{bc}	10176A ^b	2368.9 ^c	2363.1 ^{dc}	4941.1 ^b	8672.7 ^e	10306.9 ^c
LSD(0.05)	124.42	182.57	247.98	2237.3	342.28	672.05	748.73	980.13	408.3
CV (%)	3.71	3.62	4.88	14.12	5.84	9.38	7.39	4.13	2.06
F-test	***	***	***	*	***	***	***	***	***

IRSSP=inter-row spacing of spearmint, * Significant at p<0.05,*** very highly significant at p<0.001

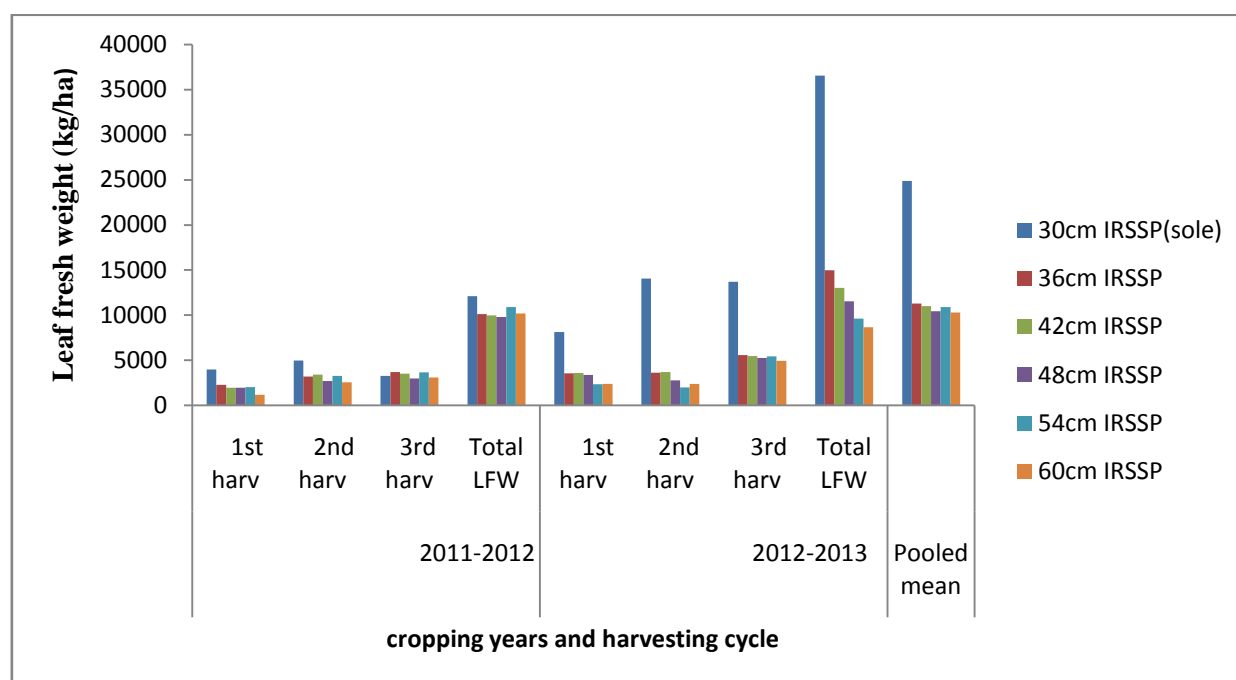


Fig. 2: Influence of maize-spearmint intercropping on leaf fresh weight of spearmint on the consecutive two harvesting seasons

3.1.2 Essential oil yield (EOY) and essential oil content (w/w, wet based)

In 2011-2012 cropping season, essential oil yield was not extracted at the first harvest due to less leaf fresh weight (<300gm) obtained in the sampled area (Table3 and figure 3). In the second harvest of this harvesting season, significant ($p < 0.05$) yield reduction was gained in intercropped treatments in comparison with sole spearmint planting. However, there was no significant yield variation in the third harvest of 2011-2012 harvesting year (Table3 and figure 3).

Intercropping of maize with spearmint led to significant reduction in oil yield at all harvesting cycle in 2012-2013 harvesting season in comparison to sole crop (Table3). But at all harvesting seasons, total essential oil yield was significantly ($p < 0.05$) reduced in intercropping as compared to sole planting (Table3 and figure 3).

Similar to total essential oil yield, pooled mean yield revealed significant ($p < 0.001$) yield reduction in intercropping than sole planting (Table3 and figure 3). Essential oil yield (mean of the two cropping year) reductions were 46.7, 54.4, 54.51, 54.74 and 67.61% in 36cm, 42cm, 48cm, 54cm and 60cm inter-row spacing of spearmint intercropped with maize compared to sole planting of spearmint respectively. This reduced oil yield of spearmint may possibly be due to the reduction of biomass yields in the intercropped treatments. Rose-scented geranium intercropped with vegetables [Rajesh et al., 2011] and rose-scented geranium as influenced by row spacing and intercropping with corn mint [Rajeswara Rao, 2002] produced similar results.

Essential oil content of the two consecutive harvesting cycle and total of the two harvesting cycles in the first harvesting seasons (2011-2012) and in the third harvesting cycle of the second harvesting season (2012-2013) showed significant ($p < 0.01$ and $p < 0.001$) variation at sole planting of spearmint (Table 4). Rajesh et al, 2011 obtained similar findings in the percentage of geraniol in the consecutive two harvesting cycles in rose scented geranium intercropped with vegetables.

Whereas the first and second harvesting cycle and total essential oil content of the second year (2012-2013 cropping year) showed no significant ($p > 0.05$) variation (Table 4).

However, in contrary to essential oil yield, the pooled mean of these two cropping season showed there was no significant variation ($p > 0.05$) in the essential oil content of spearmint whether it sole planted or intercropped (Table4 and figure 4). The geraniol percentage in palmarosa oil was similarly not influenced by intercropping with legumes [Rajeswara Rao et al., 1993b].

TABLE 3: Essential oil yield (kg/ha) of spearmint at different harvests as influenced by maize intercropping systems

Treatments	2011-2012				2012-2013			Pooled mean
	2 nd harvest	3 rd harvest	Total EOY	1 st harvest	2 nd harvest	3 rd harvest	Total EOY	
Sole maize	--	--	--	--	--	--	--	--
30cm IRSSP(sole)	33.54 ^a	25.12 ^b	58.66 ^a	37.74 ^a	47.81 ^a	33.16 ^a	122.56 ^a	88.95 ^a
Maize +36cm IRSSP	14.54 ^b	26.64 ^{ab}	41.18 ^b	15.58 ^b	12.34 ^b	27.72 ^b	48.08 ^b	46.18 ^b
Maize +42cm IRSSP	12.96 ^b	9.1 ^d	22.06 ^c	13.64 ^c	12.97 ^b	22.77 ^c	48.38 ^b	34.72 ^c
Maize +48cm IRSSP	9.31 ^c	14.93 ^c	24.24 ^c	12.87 ^c	7.63 ^c	17.39 ^d	41.67 ^c	36.71 ^c
Maize54cm IRSSP	9.37 ^c	30.34 ^a	39.71 ^b	9.61 ^d	7.51 ^c	19.50 ^d	36.75 ^d	44.49 ^b
Maize +60cm IRSSP	7.93 ^c	12.27 ^{cd}	20.20 ^c	8.73 ^d	5.54 ^c	19.87 ^d	35.28 ^d	25.96 ^d
LSD(0.05)	2.06	4.69	5.55	1.09	2.51	2.86	3.06	3.51
CV (%)	9.38	15.78	10.73	4.44	10.61	8.12	3.66	5.04
F-test	***	***	***	***	***	***	***	***

IRSSP=inter-row spacing of spearmint, *** very highly significant at p<0.001,

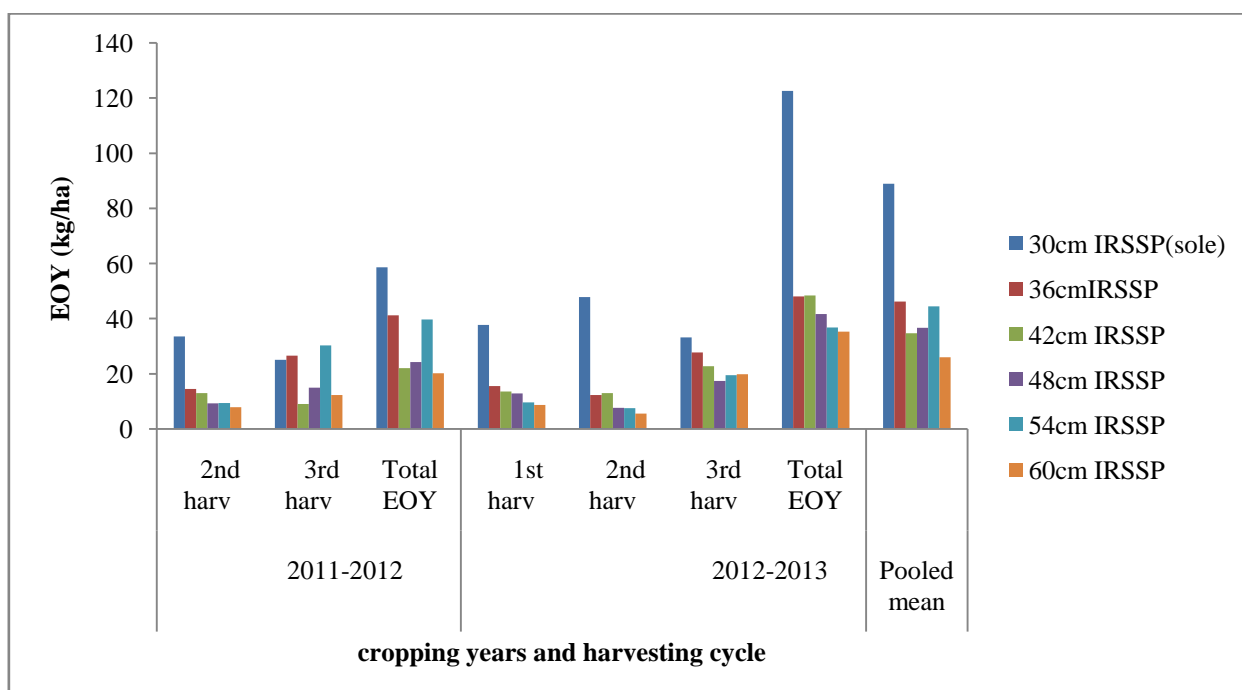


Fig. 3: Influence of maize-spearmint intercropping on essential oil yield of spearmint on the consecutive two harvesting seasons

TABLE 4: Essential oil content (w/w, wet based (%)) of spearmint at different harvests as influenced by maize intercropping systems

Treatments	2011-2012				2012-2013			Pooled mean
	2 nd harvest	3 rd harvest	Total	1 st harvest	2 nd harvest	3 rd harvest	Total	
Sole maize	--	--	--	--	--	--	--	--
30cm IRSSP(sole)	0.77 ^a	0.47 ^a	1.24 ^a	0.30	0.38	0.41 ^{bc}	0.97	1.12
Maize +36cm IRSSP	0.53 ^{bc}	0.38 ^b	0.91 ^b	0.43	0.28	0.47 ^a	1.15	1.08
Maize +42cm IRSSP	0.57 ^b	0.32 ^c	0.88 ^{bc}	0.36	0.34	0.40 ^{bc}	1.05	0.96
Maize +48cm IRSSP	0.5 ^c	0.40 ^b	0.9 ^{bc}	0.33	0.30	0.34 ^d	0.95	0.97
Maize54cm IRSSP	0.53 ^{bc}	0.32 ^c	0.85 ^{bc}	0.37	0.35	0.37 ^{dc}	1.08	0.98
Maize +60cm IRSSP	0.43 ^d	0.37 ^{bc}	0.8 ^c	0.41	0.27	0.43 ^{ab}	1.08	0.96
LSD(0.05)	0.06	0.055	0.102	ns	ns	0.05	ns	ns
CV (%)	7.48	9.78	7.29	27.18	20.32	8.91	21.53	16.05
F-Test	***	***	***	ns	ns	**	ns	ns

IRSSP=inter-row spacing of spearmint, ns- non significant,** highly significant at p<0.01,*** very highly significant at p<0.001

3.2 Maize

3.2.1 Growth attributes: Plant height (cm)

The two consecutive cropping years and overall pooled mean showed there was no significant difference (p>0.05) on plant height of maize whether it intercropped or sole planted (Table5 and figure 4).This possibly due to less competition from spearmint and also better availability of water and nutrients. A similar observation was made in sugarcane intercropped with various mint species [Kothari et al., 1987]; [Singh, 1998] and rose-scented geranium as influenced by row spacing and intercropping with corn mint [Rajeswara, 2002].

TABLE 5: Yield of maize in maize-mint intercropping at Wondo Genet Agricultural Research Center, 2011-2012 to 2012-2013

Treatments	PH(cm)		Pooled mean	SHE (%)		Pooled mean	1000 SW		Pooled mean	GY (kg/ha)		Pooled mean
	2011-2012	2012-2013		2011-2012	2012-2013		2011-2012	2012-2013		2011-2012	2012-2013	
	sole maize	185.00	216.825	200.913	67.513	82.660	75.086	365.13	629.10	497.11	6737.6	11026.8
Sole spearmint	--	--	--	--	--	--	--	--	--	--	--	--
Maize +36cm IRSSP	209.25	201.050	205.150	65.498	81.998	73.748	400.30	596.60	498.45	7441.6	11238.6	9340.1
Maize +42cm IRSSP	207.75	211.100	209.42	66.993	82.495	74.744	389	632.10	510.55	7132.0	12333.8	9732.9
Maize +48cm IRSSP	200.25	208.850	204.550	70.29	81.075	75.683	361.80	593.70	477.75	6735.8	11414.3	9075.0
Maize+ 54cm IRSSP	196.5	221.45	208.975	66.820	81.980	74.400	449.68	615.40	532.54	5406.7	12167.6	8787.1
Maize +60cm IRSSP	204.5	214.875	209.688	68.053	82.083	75.068	422.81	621.80	517.50	7616.4	11796.4	9688.1
LSD(0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV	5.74	6.13	4.13	6.21	2.26	3.51	12.38	3.53	4.94	18.77	7.2	7.92

ns=non significant, PH- plant height, SHE-shelling percentage,1000 SW-thousand seed weight, GY-Grain yield

3.2.2 Yield attributes of maize: Shelling Percentage (SHE %) and thousand seed weight (THSW)

In both cropping years, shelling percentage and thousand seed weight of maize didn't significantly ($p>0.05$) vary whether the plant is intercropped or not (Table 5 and figure 4). Each individual harvesting years and the pooled mean of overall years consistently confirm non significant variation of shelling percentage and thousand seed weight of maize as compared to intercropped and sole plantings.

Though non significant variation was observed among the treatments, yield increment was obtained at 42cm spear-mint intercropped with maize as compared to other intercropped and sole treatments (Table 5 and figure 4). Similar finding was reported by Bheemasenrao Koppalkar, 2007 who studied planting geometry and nutrient management in companion cropping of pigeonpea and ashwagandha.

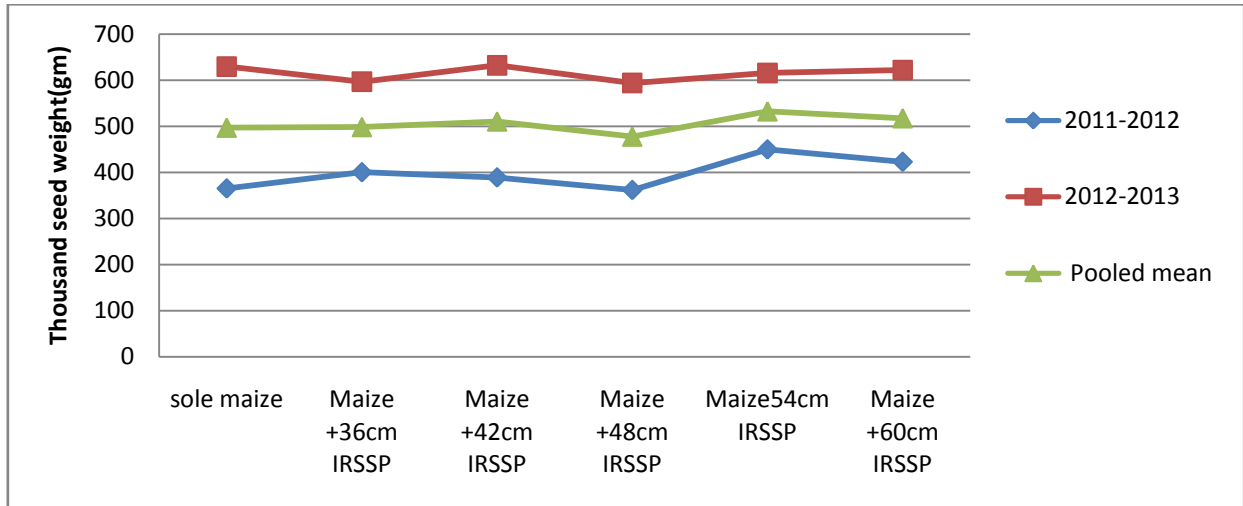


Fig. 4: Influence of maize-spear-mint intercropping on thousand seed weight (gm) of maize on the consecutive two harvesting seasons

3.2.3 Grain yield (kg/ha)

There was no significant ($p>0.05$) yield variation in the two consecutive two cropping years. Similarly, the overall pooled mean showed there was no significant variation between intercropped and sole treatments and between each intercropped treatments (Table 5 and figure 5). Even if no significant variation was observed in the pooled mean, the highest yield was recorded at 42cm inter row spacing of spear-mint intercropped with maize which was similar to the individual harvesting seasons. This was possibly due to no shading effect of spear-mint on maize and less competitiveness for the resources from the associated crops. Similar finding was reported by Prasad and Brook, 2004 who observed that maize yield were not significantly influenced by soybean in maize- soybean intercropping systems under various densities of maize.

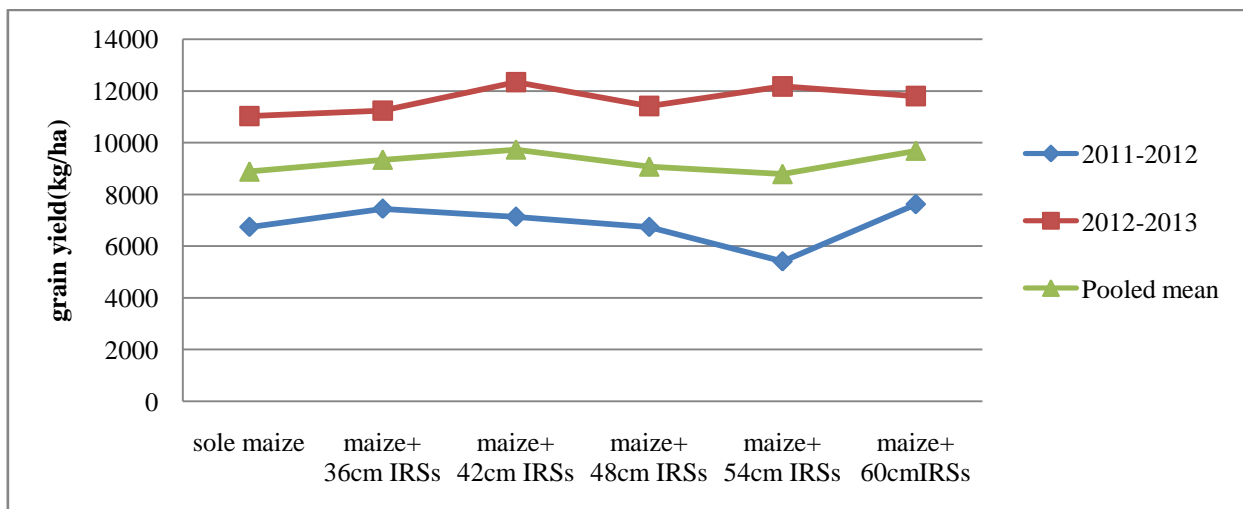
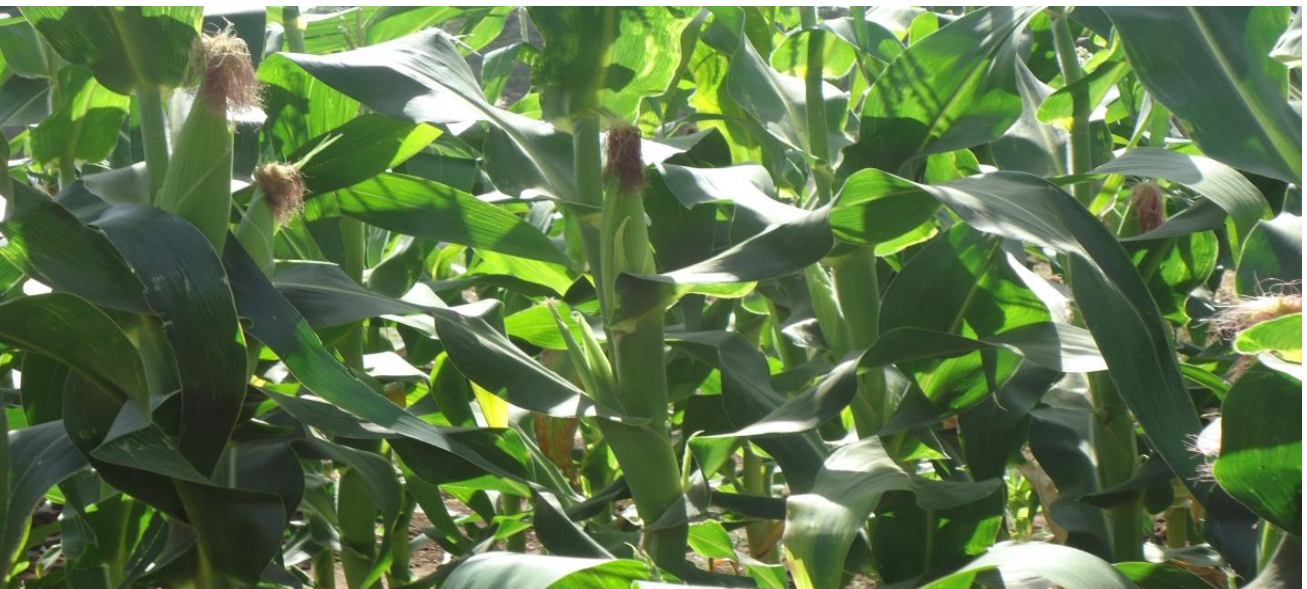


Fig. 5: Influence of maize-spear-mint intercropping on grain yield of maize on the consecutive two harvesting seasons

Picture: pictorial presentation of maize-spear-mint intercropping as supplementary income generation (field view)



3.3 Yield advantage and economic benefits assessment

3.3.1 Land Equivalent Ratio (LER)

In general, partial LER for each year was higher than unity in all mixtures. Similarly, the data on pooled mean of LER was greater than unity in all intercropping proportion. This showed that the advantage of intercropping over sole cropping in regard to the use of environmental resources for plant growth (Table 6 and figure 9). The range of yield advantage over sole cropping of maize was between 68 and 95 % with the highest in case of 42 cm and 60cm inter row spacing of spearmint intercropping with maize (95 %) followed by 36cm inter row spacing of spearmint with maize (89%) in 2011-2012 cropping seasons. Similarly, The range of yield advantage over sole cropping of maize was between 30 and 58% with the highest in case of 42 cm intercropping of spearmint with maize (58 %) followed by 36cm inter row spacing of spearmint with maize (45%) in 2012-2013 cropping seasons. In the pooled mean also, the highest LER was obtained at 42cm inter row spacing of spearmint intercropped with maize (63%) followed by 36cm inter row spacing of spearmint intercropped with maize(50%). The highest LER value at 42cm inter row spacing of spearmint was similar to the yield increment of the main crop at this intercropping mixture. Among all the mix proportion, the highest LER obtained in the pooled mean of 42cm inter row spacing of spearmint with maize followed by 36cm inter row spacing of spearmint intercropped with maize proved to be the best because of their relatively higher yield potential and mutual complementation. Higher LER in intercropping treatments compared to mono cropping was attributed to better utilization of natural (land, CO₂ and light) and added (fertilizer and water) resources. Higher LER in intercropping compared to monocropping of maize, sorghum, rice, cornmint, faba bean were also reported by [Takim ,2012], [Egbe ,2010], [Abdul *et al.* 2009], [Rajesware,2002], [Tolera and Daba 2009]

3.3.2 Monetary advantage index (MAI)

To confirm the economic feasibility of intercropping monetary advantage index is the one. Therefore, in all cropping seasons and the pooled mean, significant highest net monetary advantage index was obtained at 42cm inter row spacing of spearmint intercropped with maize followed by 36cm inter row spacing of spearmint intercropped with maize (Table 9). The lowest monetary benefit was recorded at 48 cm inter row spacing of spearmint intercropped with maize in the consecutive cropping years and the pooled mean. The significant highest and lowest monetary advantage index might be due to the value of land equivalent ratio. These finding is in line to the previous study in grass-legume intercropping systems [Mhapatra, 2011].

TABLE 6: Land equivalent ratio (LER) and monetary advantage index (MAI) of maize-spearmint intercropping systems

Treatments	LER			MAI		
	2011-2012	2012-2013	Pooled mean	2011-2012	2012-2013	Pooled mean
Sole maize						
Maize +30cm IRSSP(Sole spearmint)						
Maize +36cm IRSSP	1.89 ^{ab}	1.45 ^b	1.5 ^b	44292 ^a	42487 ^b	37496 ^{ab}
Maize +42cm IRSSP	1.95 ^a	1.58 ^a	1.63 ^a	47349 ^a	48709 ^a	41747 ^a
Maize +48cm IRSSP	1.68 ^c	1.3 ^d	1.41 ^c	30587 ^b	27892 ^c	29421 ^d
Maize54cm IRSSP	1.8 ^b	1.36 ^c	1.45 ^{bc}	35809 ^b	30390 ^c	32053 ^{dc}
Maize +60cm IRSSP	1.95 ^a	1.33 ^{dc}	1.5 ^b	43449 ^a	26922 ^c	35207 ^{bc}
LSD@0.05	0.11	0.05	0.08	6258.5	4544.7	5302.9
CV	3.88	2.44	3.57	10.08	8.36	9.78

4. CONCLUSION

Sole planting of spearmint gave significantly higher essential oil yield, leaf fresh weight, above ground biomass than planting as intercropped with maize. Though intercropping didn't show significant variation on plant height, shelling percentage and grain yield of the main crop, land equivalent ratio(LER) indicated yield advantages, efficient in utilization of resources, resulting in higher productivity for all intercrop combinations, mainly at 42cm inter row spacing of spearmint intercropped with maize. Similar to land equivalent ratio, Maize intercrop with spearmint at 42cm inter row spacing of spearmint gave higher monetary advantage index (41747) followed by 36cm inter row spacing of spearmint intercropped with maize (37496) than planted at sole. These result suggest that intercropping maize at 42cm inter row spacing of spearmint followed by 36cm inter row spacing of spearmint is biologically efficient, economically feasible, more profitable and provide opportunities for the producers than planting alone.

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