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# Intercropping of Haricot Bean *(Phaseolus vulgaris L.*) with stevia *(Stevia rebaudina L.)* as Supplementary Income Generation at Wondo Genet Agricultural Research Center, South Ethiopia

Belstie Lulie[1] and Tesfa Bogale[2]

[1]Ethiopian Institute of Agricultural Research, Wondo Genet Agricultural Research Center,
[2]Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center

***Abstract:*** **Field experiment was conducted in the consecutive two cropping seasons (2011-2012 and 2012-2013) to investigate Haricot Bean based farming system by inclusion of Stevia. The experiment was laid out in randomized complete block design with five replications. The results showed that the yields of haricot bean were not significantly decreased with the increase of stevia population. Sole planting of stevia was superior to other intercropped treatments and produced 20035.3 kgha$^{-1}$, 41859 kgha$^{-1}$ and 30947 kgha$^{-1}$ above ground biomass yield (total of three harvesting cycle), 12439.47 kgha$^{-1}$, 26296.2kgha$^{-1}$ and 19367.8 kgha$^{-1}$ leaf fresh weight (total of the three harvesting cycle) and 3450.71kgha$^{-1}$, 7570.3kgha$^{-1}$ and 5510.5kgha$^{-1}$ leaf dry weight (total of the three harvesting cycle) in the consecutive two cropping season and the pooled mean respectively. The LER and MAI indicating the practice of intercropping of haricot bean with stevia was more advantageous than the conventional monoculture crop. Even if significant yield difference was not observed for haricot bean among the treatment, haricot bean intercrop with 80% stevia mix proportion with LER of 1.43 and MAI of 88278 followed by 60% stevia mix proportion with LER of 1.34 and MAI of 62027 proved to be best than planted at sole indicating the practice of haricot bean –stevia intercropping was more advantageous and profitable than the conventional monoculture crop.**

***Keywords:*** **Haricot Bean, Intercropping, Land Equivalent Ratio, Monetary Advantage, Stevia rebaudiana, Supplementary.**

## I. INTRODUCTION

Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time, is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labor (Lithourgidis et al., 2011). 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 [(Usmanikhail et al., 2012).]

The pulse industry has developed significantly with little intervention, and great potential exists to increase the production and impact of pulses through proactive and targeted support. Rough calculations suggest that Ethiopia could expand its foreign market presence by at least doubling its current exports of ~140,000 tons (USD 90 million) through increased production levels [CSA, 2008] ,[Anderson and Schneider, 2010].

Twelve pulse species are grown in the country. Of these, faba bean (Vicia *faba* L.), field pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), lentil (*Lens cultinaris* Medik.), grass pea (*Lathyrus sativus* L.), fenu greek (*Trigonella foenum-graecum* L.) and lupine (*Lupinus albus L.*) are categorized as highland pulses and grown in the cooler highlands. Conversely, haricot bean (*Phaseolus vulgaris* L.), soya bean (*Glycine max* L.), cowpea (*Vigna unguiculata* L.), pigeon pea (Cajanus cajan L.) and mung beans are predominantly grown in the warmer and low land parts of the country. Among the individual varieties, faba beans (broadly known as horse beans) accounts for the greatest portion of production at 36 percent, followed by haricot beans (17 percent) and chickpeas (16 percent). Other pulses (e.g., lentils, peas, lupines, and mung beans) account for the remaining 32 percent (Shahidur et.al. 2010).

Recently**,** Ethiopia is now one of the top ten producers of total pulses in the world, the second-largest producer of faba beans after China, and the fifth or sixth largest producer of chickpeas. Within Ethiopia, pulses are the third-largest crop export behind coffee and oil seed, and represent a USD 90 million export industry (Shahidur et.al. 2010).

Among legumes, haricot bean, *Phaseolus vulgaris,* constitute a significant part of human diet in Ethiopia (Ali et al., 2003). Apart from this, haricot bean has been cultivated as a field crop for a very long time and hence, it is the important food legume produced in the country (Ali et al., 2003). Haricot bean is a principal food crop particularly in Southern and Eastern part of Ethiopia, where it is widely intercropped with maize and sorghum, respectively, to supplement farmers income (EPPA,2004).

Haricot Bean is considered as the main cash crop and protein source of the farmers in many low lands and mid altitude zones of Ethiopia [Rahmeto Negash, 2007). In addition to the domestic markets, Ethiopia is supplying white beans into the export canning industry in European Union (EU) and other eastern European markets. In the past two to three years, Ethiopia has also been a major supplier of red beans into northern Kenya and this market has shown most rapid growth (Ferris and Kaganzi, 2008).

There are three main haricot bean types grown in Ethiopia, based on color: red, speckled beans and white beans. The main production areas in the country are within the Rift Valley area, which runs diagonally across Ethiopia from top right to bottom left of the country. The two major bean producing regions are Oromia and Southern Nations, Nationalities and People's Region (SNNPR), which produce 70 and 60 thousand tones, respectively. These two regions make up 85% of the production (CSA, 2005).

For the most part, bean production zones are clearly defined, white beans being produced north of Lake Ziway and red beans produced south of the lake. There are some pockets of white bean production in the southern Sidama area, but this is mainly for local consumption (Ferris and Kaganzi, 2008).

Regional demand for red beans is also growing, although demand is less stable and is typically dependent upon levels of drought. However, there are prospects that exports of red beans may increase as the bean export market expands (Ferris and Kaganzi, 2008).

Stevia rebaudiana (Bertoni) is a herbaceous perennial plant of the Asteraceae family, native to Paraguay (South America). Stevioside, the major sweetener present in leaf and stem tissues of stevia, was first seriously considered as a sugar substitute in the early 1970s by a Japanese consortium formed for the purpose of commercializing stevioside and stevia extracts (Ashock et.al, 2010). Diterpene glycosides produced by stevia leaves are many times sweeter than sucrose. They can be utilized as a substitute to sucrose (Ashock et al., 2010); they are natural sources of non-caloric sweetener and alternatives to the synthetic sweetening agents that are now available to the diet conscious consumers. The potential uses of Stevia rebaudiana, which produces stevioside, a non-caloric sweetener that does not metabolize in the human body (Science Tech, 2004).

There is no research conducted in the area regarding with haricot bean-stevia intercropping before this study conducted and it has been very difficult to address the increased demand for food security and a need for a natural non-caloric sweetener with acceptable taste and health properties. Therefore, this study was undertaken to determine haricot bean based farming system by inclusion of stevia for supplementary income generation and to know optimum percentage of stevia in haricot bean based farming system.

## II. MATERIALS AND METHODS

The experiment was conducted for two years (2011-2012 and 2012-2013 cropping season) at Wondo Genet Agricultural Research center, experimental site under irrigated condition. The experimental site was located at $7^0$19'N latitude, $38^0$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(1:2.5 soil water suspension) and total nitrogen 0.18. The average annual rainfall in the area during the consecutive cropping season is 93.48 mm, which is ample and even in distribution. The site has a mean maximum temperature of $26.21^o{}_c$ and mean minimum temperature of 11.52°C (FAO, 2005.New-Locclim.local climate Estimator).

The cropping history of the experimental site before the start of this experiment was different aromatic and medicinal plants with uniform cultural practices. Stevia was raised at nursery for three months and transplanting to the actual field after three months for both cropping seasons. Haricot Bean seed (variety 'Nasir') was used for intercropping. The yield of Haricot Bean and the component crop were collected based on the recommended harvesting seasons for each crop. Moreover, agronomic growth characters data were collected for both Haricot Bean and the component crop. Even if the component crop is perennial, three harvesting cycle of Stevia was used due to the annual nature of the main crop.

The experimental design was randomized complete block design (RCBD) in additive series with six (6) treatments and five (5) replications. Plot size was 3m*4$m^2$.Haricot Bean was the principal crop and spaced at a distance (10*40)$cm^2$ and the plant population was 250000$ha^{-1}$.The sole stevia population was taken as 83333$plantha^{-1}$ and was spaced at a distance(30*40)$cm^2$ and also four stevia populations 80%,60%,40% and 20% as a companion crop. In every alternate row of haricot bean with a plant to plant distance of 37.5, 50, 75,150cm for 80, 60, 40 and 20% stevia population were used respectively. The land was fertilized with 50 kg Urea/ha and 100kgDAP/ha as source of nitrogen and phosphorous. Split application (first half during planting and the remaining half before flowering of the main crop) was used to apply nitrogen fertilizers (urea) and basal application for phosphorus fertilizers (DAP). All required intercultural operations were done as and when required. Haricot Bean was germinated and flowered (100%) after 6 and 60 days of planting respectively.

The local market price of haricot bean and leaf fresh weight of stevia was 8 birr/kg and 20 birr/kg respectively during the two consecutive harvesting seasons.

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)

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where,
Yab = Intercrop yield of crop 'a'
Yba = Intercrop yield of crop 'b'
Yaa = Pure stand crop yield of 'a'
Ybb = Pure stand crop yield of 'b'

**Monetary Advantage (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 (MA). It is expressed as

$$MAI = (Pab+pba) * \frac{LER-1}{LER}$$

Where, Pab = Pa ×Yab; Pba =Pb ×Yba; Pa = Price of species 'a' and Pb = 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 to collect yield and yield contributing characters such as plant height, number of pods/plant, number of seeds/pod, thousand seed weight, and grain yieldplant$^{-1}$ of Haricot Bean. Haricot Bean was harvested after 95 days of planting (3 months of planting). Stevia was harvested periodically at 90 days (first harvest), 180 days (second harvest) and 270 days (third harvest) of planting during the consecutive two (2011-2012 and 2012-2013) cropping seasons. The collected data were statistically analyzed using SAS computer soft ware version 9.0 English and the difference between means was tested by LSD.

## III. RESULTS AND DISCUSSION

### 3.1 Stevia

#### 3.1.1Above ground biomass, leaf fresh weight and leaf dry weight

Sole planting of stevia gave significantly higher($p<0.001$) above ground biomass, leaf fresh weight and leaf dry weight than the intercropped treatments in all individual harvests at each consecutive harvesting seasons(Table1,2,3 and Figure 1,2 &3).The significant variation was consistent in 2011-2012 and 2012-2013 harvesting seasons. The total above ground biomass, leaf fresh weight and leaf dry weight in each harvesting seasons and the pooled mean in both harvesting years also showed significant variation ($p<0.001$) at sole planting of stevia (Table1,2,3 and Figure 1,2&3). Table 1, 2, 3 and consecutive figures also revealed intercropping haricot bean with different mix proportion of stevia significantly depressed above ground biomass, leaf fresh weight and leaf dry weight. The significant variation at sole planting 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 turmeric-maize and onion intercropping systems (Sivaraman and Palaniappan, 1995).

**TABLE 1: Above ground biomass (kg/ha) of stevia at different harvests as influenced by intercropping systems in consecutive two cropping seasons (2011-2012 to 2012-2013)**

| Treatments | 2011-2012 | | | | 2012-2013 | | | | Pooled mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1st harvest | 2nd harvest | 3rd harvest | Total biomass | 1st harvest | 2nd harvest | 3rd harvest | Total biomass | |
| 100% stevia (sole) | 5427.66 [a] | 3729.31 [a] | 10878.38 [a] | 20035.3[a] | 16251.3 [a] | 15360.3 [a] | 10247.0 [a] | 41859 [a] | 30947[a] |
| 100%HB:80% stevia | 2451[b] | 3341.9 [b] | 9997.43 [b] | 15790.3[b] | 2361.3 [b] | 11073.6 [b] | 6804.0 [b] | 20239 [b] | 18014.6[b] |
| 100%HB:60% stevia | 1225.48 [c] | 2026.56 [c] | 6875.5 [c] | 10127.5[c] | 2235.7 [b] | 8783.4 [c] | 5261.0 [c] | 16280 [c] | 13203.8[c] |
| 100%HB:40% stevia | 932.72 [d] | 929.27 [d] | 4031.71 [d] | 5893.7[d] | 1231.2 [c] | 5759.2 [d] | 3964.8 [d] | 10955 [d] | 8424.4[d] |
| 100%HB:20% stevia | 574.5 [e] | 364.97 [e] | 1706.34 [e] | 2645.8[e] | 657.3 [c] | 2683.7 [e] | 1907.6 [e] | 5249 [e] | 3947.2[e] |
| CV (%) | 6.58 | 7.20 | 1.88 | 3.12 | 14.53 | 16.17 | 13.72 | 12.21 | 7.92 |
| LSD@0.05 | 187.5 | 200.72 | 169.1 | 456.13 | 885.82 | 1893.4 | 1037.4 | 3096.9 | 1582.8 |
| F-Test | *** | *** | *** | *** | *** | *** | *** | *** | *** |

*Significant at $p<0.05$, ** highly significant at $p<0.01$, ***very highly significant at $p<0.001$, ns= non significant

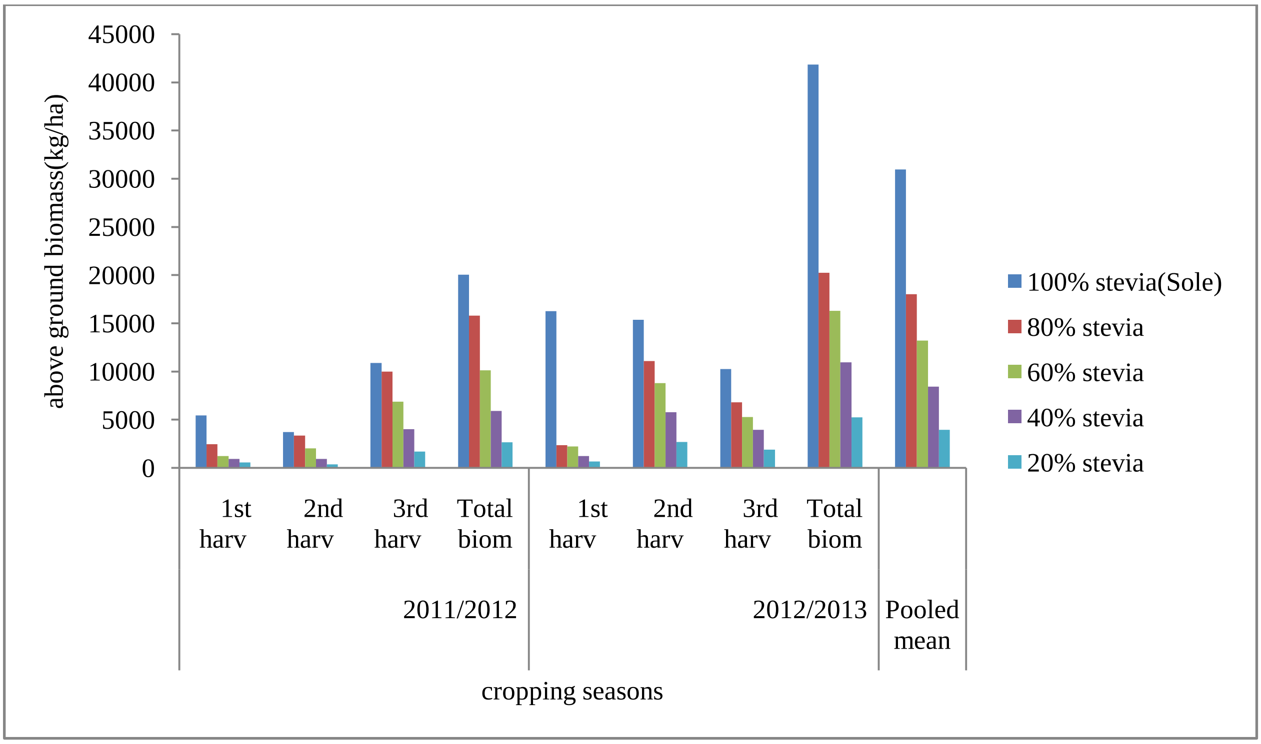


**Fig.1:** Influence of haricot bean- stevia intercropping on stevia above ground biomass (kg/ha) in the consecutive two cropping seasons

**TABLE 2: Leaf fresh weight (kg/ha) of stevia at different harvests as influenced by intercropping systems in consecutive two cropping seasons (2011-2012 to 2012-2013)**

| 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 | |
| 100% stevia (sole) | 3457.25 $^{a}$ | 2388.82 $^{a}$ | 6593.4 $^{a}$ | 12439.47$^{a}$ | 10404.2 $^{a}$ | 9466.3 $^{a}$ | 6425.7 $^{a}$ | 26296.2$^{a}$ | 19367.8$^{a}$ |
| 100%HB:80% stevia | 1365.19 $^{b}$ | 2150.29 $^{b}$ | 5864.62 $^{b}$ | 9380.09$^{b}$ | 1169.0 $^{b}$ | 6936.0 $^{b}$ | 4302.4 $^{b}$ | 12407.4$^{b}$ | 10893.7$^{b}$ |
| 100%HB:60% stevia | 630.27 $^{c}$ | 1270.75 $^{c}$ | 4206.5 $^{c}$ | 6107.52$^{c}$ | 1289.7 $^{b}$ | 5461.6 $^{c}$ | 3342.8 $^{c}$ | 10094.1$^{c}$ | 8100.8$^{c}$ |
| 100%HB:40% stevia | 567.61 $^{c}$ | 558.44 $^{d}$ | 2220.79 $^{d}$ | 3346.84$^{d}$ | 661.0 $^{c}$ | 3640.0 $^{d}$ | 2445.5 $^{d}$ | 6746.5$^{d}$ | 5046.7$^{d}$ |
| 100%HB:20% stevia | 334.59 $^{d}$ | 225.94 $^{e}$ | 1080.17 $^{e}$ | 1640.69$^{e}$ | 370.2 $^{d}$ | 1716.2 $^{e}$ | 1216.7 $^{e}$ | 3303.1$^{e}$ | 2471.9$^{e}$ |
| CV (%) | 6.51 | 5 | 2.11 | 2.34 | 7.37 | 15.68 | 14.15 | 10.25 | 6.54 |
| LSD@0.05 | 110.89 | 88.439 | 112.72 | 206.94 | 274.72 | 1144.6 | 672.9 | 1617.8 | 805.3 |
| F-Test | *** | *** | *** | *** | *** | *** | *** | *** | *** |

*Significant at p<0.05, ** highly significant at p<0.01, ***very highly significant at p<0.001, ns= non significant
HB-haricot bean

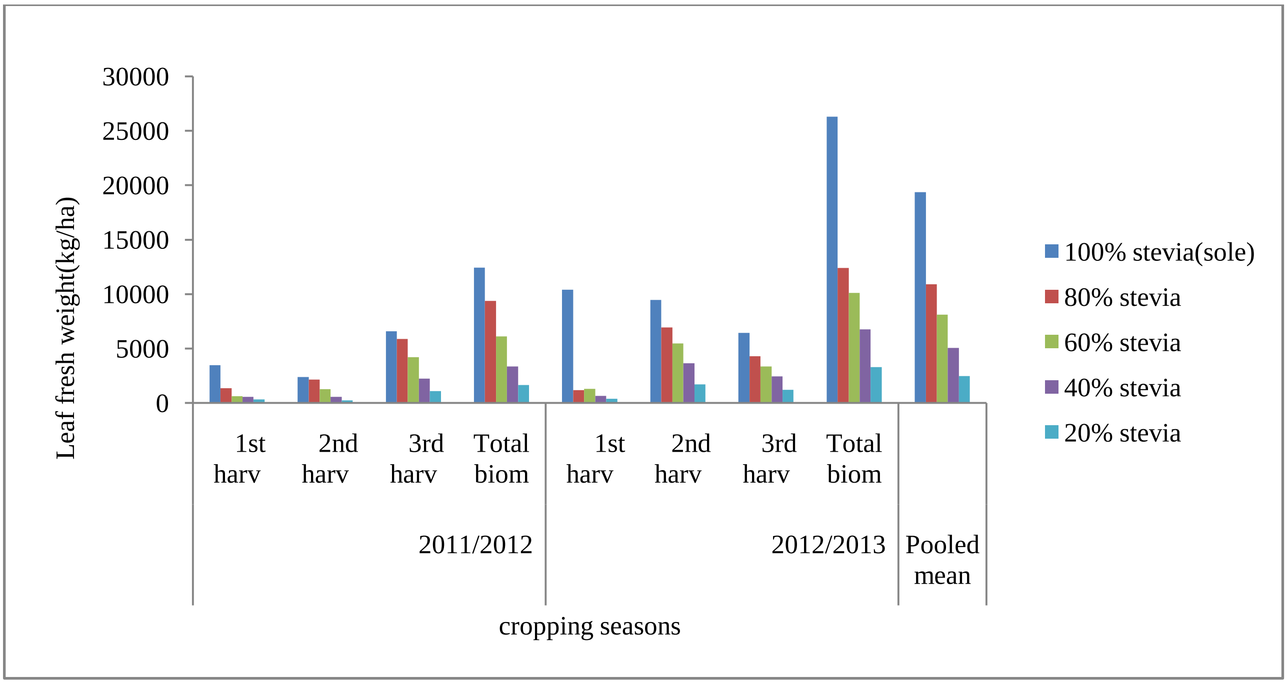


**Fig. 2:** Influence of haricot bean-stevia intercropping on stevia leaf fresh weight (kg/ha) on the consecutive two cropping seasons

**TABLE 3: Leaf dry weight (kg/ha) of stevia at different harvests as influenced by intercropping systems in consecutive two cropping seasons (2011-2012 to 2012-2013)**

| Treatments | 2011-2012 | | | | 2012-2013 | | | | Pooled mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1st harvest | 2nd harvest | 3rd harvest | Total biomass | 1st harvest | 2nd harvest | 3rd harvest | Total biomass | |
| 100% stevia (sole) | 873.07 a | 704.79 a | 1872.86 a | 3450.71a | 3121.25a | 2349.7 a | 2099.4 a | 7570.3a | 5510.5a |
| 100%HB:80% stevia | 419.55 b | 479.66 b | 1532.89 b | 2432.10b | 350.69b | 1721.6 b | 1460.4 b | 3532.7b | 2982.4b |
| 100%HB:60% stevia | 216.05 c | 383.14 c | 1102.67 c | 1701.85c | 386.92 b | 1476.1 b | 1131.7 b | 2994.7b | 2348.3c |
| 100%HB:40% stevia | 163.36 d | 160.47 d | 551.28 d | 875.11d | 198.30c | 903.5 c | 747.6 c | 1849.4c | 1362.2d |
| 100%HB:20% stevia | 104.61 e | 58.94 e | 250.96 e | 414.51e | 111.05 d | 426.0 d | 566.6 c | 1103.6d | 759.1e |
| CV (%) | 9.33 | 6.89 | 3.25 | 2.82 | 7.37 | 19.96 | 22.44 | 13.72 | 9.33 |
| LSD@0.05 | 44.43 | 33.028 | 46.41 | 67.18 | 82.415 | 368.11 | 361.35 | 627.29 | 324.22 |
| F-Test | *** | *** | *** | *** | *** | *** | *** | *** | *** |

*Significant at p<0.05, ** highly significant at p<0.01, ***very highly significant at p<0.001, ns= non significant

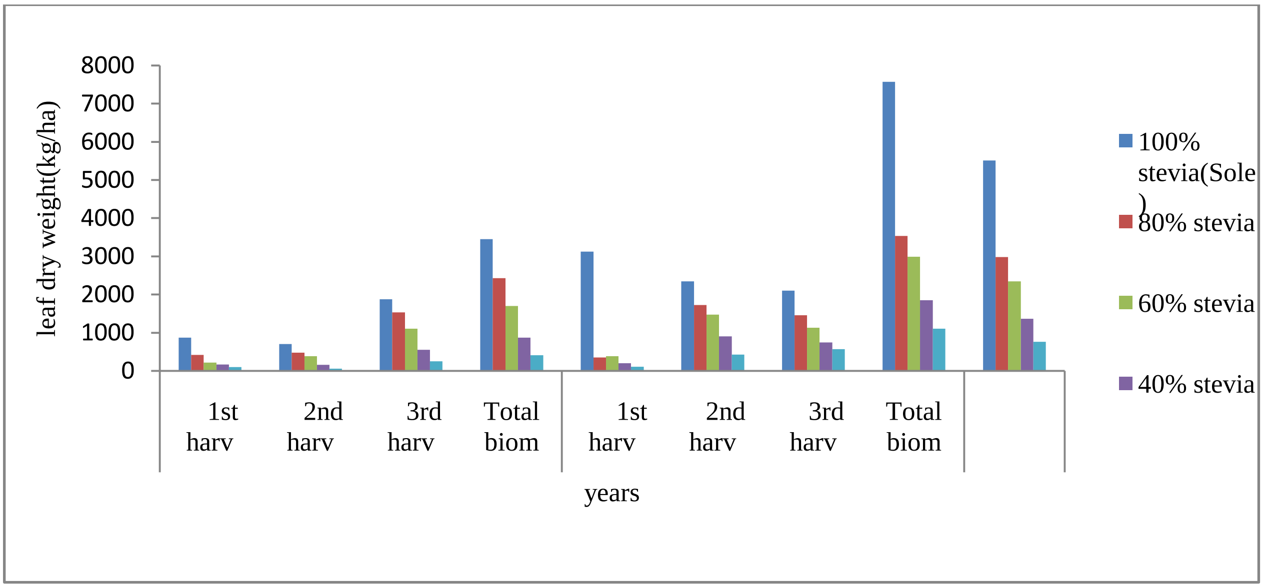


**Fig.3:** Effect of haricot bean-stevia intercropping systems on stevia leaf dry weight (kg/ha) on the consecutive two cropping years

### 3.2 Haricot bean

#### 3.2.1 Plant height (cm)

In 2011-2012 cropping season, significantly higher ($p<0.001$) plant height was recorded at sole planting of the main crop compared to intercropped treatments. However, the significant variation was inconsistent to the coming cropping year (2012-2013) which showed no significant variation ($p>0.05$) whether it intercropped or sole planted (Table4). The overall pooled mean, consistent to the first cropping season, showed there was significant variation ($p<0.001$) on plant height of haricot bean at sole planting (Table4).This possibly due to high competition between each haricot bean plant for light than the intercropped mix proportions. The result was slightly differ from the previous finding reported significant variation at intercropped treatments in baby corn with legumes intercropping(Bali et al. 2009) and cowpea and bean intercropping (Geren et al.2008).

#### 3.2.2 Thousand seed weight (THSW) and grain yield (kg/ha)

In all the cropping years and the pooled mean of thousand seed weight showed non significant ($p>0.05$) variation whether haricot bean intercropped or sole planted (Table4).

Similar to thousand seed weight, grain yield of haricot bean revealed non significant ($p>0.05$) yield variation in the consecutive cropping seasons and the pooled mean of overall years (Table4 and figure 4).

Although there was no significant yield variation, there was yield increment percentage in the sole planting of haricot bean compared to intercropped treatments in the consecutive cropping years and the pooled mean except40% and 20% stevia mix proportion in 2012-2013cropping seasons which was vice versa. Yield increment of haricot bean at sole planting was 20.05% (compared to 80% stevia intercropping), 19.33% (compared to 60% stevia intercropping), 6.00% (compared to 40% stevia intercropping) and 12.81% (compared to 20% stevia intercropping) in 2011-2012 cropping seasons. Whereas in 2012-2013cropping years sole planting of haricot bean showed yield increment by 14.41 and 7.03 as compared to 80% and 60% stevia intercropping and yield decreasment by 0.11% and 6.11% as compared to 40% and 20% stevia intercropping respectively. Similar to the two consecutive cropping years, the pooled mean of haricot bean showed yield increment at sole planting by 17.55% (compared to 80% stevia intercropping), 13.88% (compared to 60% stevia intercropping), 3.29%(compared to 40% stevia intercropping) and 4.24%(compared to 20% stevia intercropping). Similar finding was reported by Sivaraman & Palaniappan (1994), Prasad and Brook, 2004 who observed that maize yields were not affected by turmeric and soybean in maize-turmeric and maize- soybean intercropping systems respectively.

Due to the dual benefits obtained from this intercropping and non significant yield variation of sole and intercropped treatments of the main crop, planting haricot bean with stevia mix proportion is advisable than sole planting of haricot bean.

**TABLE 4: Yield of haricot bean in haricot bean-stevia intercropping systems in consecutive two cropping seasons (2011-2012 to 2012-2013)**

| Treatments | PH(cm) | | Pooled mean | THSW(gm) | | Pooled mean | GY (kg/ha) | | Pooled mean |
|---|---|---|---|---|---|---|---|---|---|
| | 2011-2012 | 2012-2013 | | 2011-2012 | 2012-2013 | | 2011-2012 | 2012-2013 | |
| 100% HB(Sole) | 80.75 [a] | 57.440 | 69.095[a] | 326.32 | 315.44 | 320.88 | 12885 | 10274.0 | 11579.5 |
| 100%HB:80% stevia | 65 [b] | 57.940 | 61.472[b] | 294.8 | 311.12 | 302.96 | 10302 | 8793.1 | 9547.6 |
| 100% HB:60% stevia | 67.25 [b] | 56.584 | 61.917[b] | 304.4 | 310.16 | 307.28 | 10394 | 9551.5 | 9972.8 |
| 100% HB:40% stevia | 65.03 [b] | 59.400 | 62.214[b] | 286.32 | 315.52 | 300.92 | 12112 | 10285 | 11198.5 |
| 100% HB:20% stevia | 61.61 [c] | 54.900 | 58.256[c] | 298.56 | 303.68 | 301.12 | 11234 | 10943 | 11088.5 |
| CV (%) | 3.05 | 8.54 | 3.59 | 7.87 | 7.43 | 5.13 | 24.48 | 15.15 | 13.96 |
| LSD@0.05 | 2.78 | ns | 3.0149 | ns | ns | ns | ns | ns | ns |
| F-Test | *** | ns | *** | ns | ns | ns | ns | ns | ns |

*Significant at p<0.05, ** highly significant at p<0.01, ***very highly significant at p<0.001, ns= non significant PH-plant height, THSW-thousand seed weight, GY-grain yield

**Picture:** pictorial presentation of haricot bean-stevia intercropping as supplementary income generation after three months (field view)

### 3.3 Intercropping indices

### 3.3.1 Land Equivalent Ratio (LER)

In general, partial LER for 2011-2012 was higher than unity at 80% and 60% stevia mixtures that revealed advantage of intercropping than sole planting. Whereas lower than unity at 40% and 20% stevia mix proportion which showed disadvantage of intercropping at these proportion of intercropping in regard to the use of environmental resources. Whereas, in 2012-2013 cropping years and the 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 5 and figure 5). The range of yield advantage in 2011-2012 cropping season was between 63% and 54% at 80% stevia mix proportion followed by 60% stevia mix proportion respectively. Similarly in 2012-2013 cropping year, the range of yield advantage over sole cropping of haricot bean was between 4 and 39 % with the highest in case of 60% stevia intercropped with 100% haricot bean (39 %) followed by 80% stevia intercropped with 100% haricot bean (30%). The overall pooled mean, consistent to the individual harvesting years, showed yield advantage over sole cropping of haricot bean between 4 and 43% with the highest in case of 80% stevia intercropped with 100% haricot bean (43 %) followed by 60% stevia intercropped with 100% haricot bean(35%) 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, corn mint, faba bean were also reported by Takim (2012), Egbe (2010), Abdul *et al.* (2009), Rajesware Rao(2002), Tolera and Daba (2009).

### 3.3.2 Monetary advantage Index (MAI)

The MAI was significantly higher at 80% stevia mix proportion followed by 60% stevia mix proportion intercropped with haricot bean in all the consecutive cropping years and the pooled mean (Table 6), which might be due to higher LER value. The significant lowest monetary benefit was recorded in 20% stevia mix proportion with haricot bean in both the years and pooled mean. In 2011-2012 cropping season, the MAI value was negative at 40% and 20% stevia mix proportion due to LER value less than unity. The result is in line to the previous study in grass-legume intercropping systems (Mhapatra, 2011).

**TABLE 5: Land equivalent ratio (LER) and monetary advantage (MA) of haricot bean–stevia intercropping in the year 2011-2012 to 2012-2013**

| Treatments | LER | | | MAI | | |
|---|---|---|---|---|---|---|
| | 2011-2012 | 2012-2013 | Pooled mean | 2011-2012 | 2012-2013 | Pooled mean |
| 100% HB (Sole HB) | | | | | | |
| 100% stevia (Sole) | | | | | | |
| 100% HB:80% stevia | 1.63[a] | 1.30 [b] | 1.43 [a] | 104510 [a] | 73331 [a] | 88278 [a] |
| 100% HB:60% stevia | 1.54[b] | 1.39 [a] | 1.34 [b] | 72112 [b] | 77243 [a] | 62027 [b] |
| 100% HB:40% stevia | 0.96[c] | 1.21 [c] | 1.19 [c] | -5593 [c] | 36537 [b] | 30973 [c] |
| 100% HB:20% stevia | 0.95[c] | 1.04 [d] | 1.04 [d] | -7008 [c] | 5116 [c] | 5774 [d] |
| CV | 4.64 | 3.64 | 4.20 | 22.63 | 20.02 | 18.98 |
| LSD@0.05 | 0.08 | 0.06 | 0.07 | 12790 | 13260 | 12237 |

## IV. CONCLUSION

The study indicates that there is no adverse effect in the yield of haricot bean whether it intercropped or sole planted. The yield of the main crop was comparable whether intercropped or not. The LER shows haricot bean-stevia intercropping practice is more efficient in utilization of resources by intercropping under stress condition than the conventional monoculture crop.

Even if significant yield difference was not obtained for the main crop, yield advantage and economic benefit assessment method shows advantage of intercropping than sole planting. Therefore, intercropping haricot bean with 80% stevia mix proportion with LER of 1.43 and MAI of 88278 followed by 60% stevia mix proportion with LER of 1.34 and MAI of 62027 proved to be best than planted at sole indicating the practice of haricot bean –steva intercropping was more advantageous and profitable than the conventional monoculture crop.

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