Journal of
Plant Sciences

ISSN 1816-4951

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Journal of Plant Sciences

ISSN 1816-4951
DOI: 10.3923/jps.2022.6.13

Research Article
Influence of Intercropping Ratio of Faba Bean with Wheat on Crops Productivity at Kulumsa

Debela Bekele, Dereje Dobocha and Wogayehu Worku

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Ethiopia

Abstract

Background and Objective: Intercropping of legumes with cereal crops provide a significant level of nitrogen through residual nitrogen. In the main growing season of 2019, a field trial was carried out at the Kulumsa Agricultural Research Center in Southeast Ethiopia to select suitable faba bean varieties for mixed cultivation and to assess the economic profitability of the mixed cultivation of faba beans with bread wheat in the study site. **Materials and Methods:** The treatments consisted of the factorial combination of three faba bean varieties (Ashebeka, Hachalu and Tumsa) with three different planting ratios (1W:1FB, 1W:2FB, 2W:1FB) intercropped with bread wheat variety Hulluka and sole planting of the three faba bean varieties and Hulluka variety. A randomized complete block design with three replications was used. **Results:** The planting ratio of 1W:2FB, field beans grown alone and the planting ratio of 1W:1FB with the Hachalu variety resulted in the highest grain yield (3426.3 kg ha^{-1}), the aboveground biomass (11257.3 kg ha^{-1}) and the harvest index the broad bean (36%) or the planting ratio of 2W:1FB resulted in the highest wheat yield (1896.6 kg ha^{-1}). The highest (8057.1 kg ha^{-1}) above-ground biomass yield from wheat was recorded at 2W:1FB. The highest gross monetary value of 100,591 ETB ha^{-1} was achieved with a planting ratio of 1W:2FB with the Tumsa variety. Wheat alone had the lowest gross cash value at 59,752 ETB ha^{-1}. **Conclusion:** Based on the parameters examined and the gross cash value, the intermediate cultivation of the Tumsa variety with a planting ratio of 1W:2FB with bread wheat Hulluka in the study area was therefore very practicable.

Key words: Bread wheat, faba bean, grain yield, gross monetary value, land equivalent ratio, planting ratios, system productivity

Citation: Bekele, D., D. Dobocha and W. Worku, 2022. Influence of intercropping ratio of faba bean with wheat on crops productivity at Kulumsa. J. Plant Sci., 17: 6-13.

Corresponding Author: Dereje Dobocha, Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Ethiopia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Faba bean (*Vicia faba* L.) is an important legume crop that contains high protein[1]. In addition to its great nutrition content, it can fix nitrogen and provide a significant level of nitrogen from the soil air using a symbiotic relationship with Rhizobium bacteria[2]. Faba bean takes the largest share of the area under pulses production in Ethiopia[3]. The annual area coverage of the crop in Ethiopia is 492,271.60 hectares with the total production and productivity of 1.04 million tons and 2.1 t ha^{-1}, respectively[3]. It is mostly grown as a sole crop but in some countries intercropping with cereals is a common practice[4].

Wheat is one of the most powerful cereals in the world in terms of area and production. Global wheat production in 2017 was 744.5 million tonnes[5]. It is one of the most important staple foods in Ethiopia in terms of both production and consumption[6]. An increase in input costs, decrease in farm size and soil quality and increasing challenges with pests, diseases and weeds have threatened the ecological and economic sustainability of wheat production in Ethiopian highlands[7]. Despite this, a resource use study in northern Ethiopia has shown that farmers have changed their cropping system from growing a pure crop of improved varieties of semi-dwarf wheat to mixed intercropping with a small proportion of faba bean and field pea[8].

Intercropping is the agricultural practice of cultivating two or more crops in the same land at the same time[9]. It is relatively common in tropical and temperate areas because of the effective utilization of water[9], nutrients[10] and solar energy[11].

Ouma and Jeruto[12] reported that staggered maturity dates, as well as advancement periods in intercrops, take benefit of differences in peak resource necessitates for nutrients, water and light. Intercropping legumes with cereals contribute some nitrogen to the cereal component through residual nitrogen[13]. The research conducted in the past three years on sorghum intercropping with groundnut and soybean at Asosa (Ethiopia) revealed that the maximum sorghum yield was gained from sorghum/groundnut intercrop at all growing seasons[14]. The gross income and land equivalent proportion indicate greater financial benefit with intercropping of groundnut in 1:1 proportion and simultaneous planting than sole planting[14].

The spatial alignment of faba bean with barley around Debre Birhan indicated that a considerably higher Land Equivalent Ratio (LER) was attained in intercropping than both crops when planted as sole. The 2B:1FB (one row of faba bean intercropped in two rows of barley) was more constructive than other planting patterns (1B:1FB and 1B:2FB)[15].

The increasing price of inputs increased the cost of production of wheat in the Arsi zone which leads to minimum net income. This forced few farmers to use crop rotation in the area. They do this to minimize the amount of fertilizer required and break the pest cycle (disease, weed and insect) for cereal especially wheat. However, most farmers do not use this rotation as required because of land shortage. They do not want to lose wheat every year. Because of this, an alternative cropping system is needed to solve this problem. Therefore, the objective of this study was to assess the compatibility of faba bean/wheat intercropping, to select a suitable variety of faba bean under different spatial patterns of intercropping and to assess the economic feasibility of intercropping faba bean with bread wheat in the area.

MATERIALS AND METHODS

Description of the study area: A field trial was carried out at the Kulumsa Agricultural Research Center (KARC) in the main growing season of 2019. It is located in Gora Silingo Kebele, Tiyo District of the Arsi Zone, Oromia Regional State in Southeast Ethiopia. The test site is located at latitude 801'N and longitude 3909'E at an altitude of 2200 m above sea level. It receives an average annual rainfall of 809.2 mm and has a unimodal rainfall pattern. The main rainy season is from July to August. The average annual minimum and maximum temperatures are 9.9 and 23.1°C. The soil type is Luvisol/Eutric Nitrosol with a good drainage system. It contains 2.5% organic carbon, 0.16% total nitrogen and its pH is 5.8[16].

Treatments and experimental design: Factorial combination of three faba bean varieties (Ashebeka, Hachalu and Tumsa) and three different planting ratios (1W:1FB, one row of wheat and one row of faba bean, 1W:2FB, one row of wheat and two rows of faba bean, 2W:1FB, two rows of wheat and one row of faba bean) were intercropped with bread wheat variety Hulluka. Sole planting of the three faba bean varieties and wheat were also established making up thirteen treatments in total. The treatments were laid out in a randomized complete block design with three replications.

Experimental procedures: The crops were planted in a row in which the inter-row spacing for faba bean and wheat was 40 and 20 cm, respectively where wheat was planted between faba bean rows. In a 1:1 ratio wheat was planted between every two faba bean rows, so it was 20 cm far from faba bean. In a 1:2 ratio wheat was planted between alternate faba bean rows and there was 40 cm between faba bean rows and 20 cm between faba bean and wheat rows. In a 2:1 ratio, faba bean was planted after two wheat rows and there was 20 cm between wheat rows and 20 cm between faba bean and wheat rows. Blended NPS fertilizer (19% nitrogen, 38% P_2O_5 and 7% sulfur) at the recommended rate of 120 kg ha^{-1} for faba bean was applied to all treatments during planting except sole wheat which received both blended NPS during planting at the rate of 180 kg ha^{-1} and urea (46% nitrogen) half at planting and a half at tillering at the rate of 100 kg ha^{-1} according to recommendation for wheat.

The experimental plot size was 2.5×4 m (10 m^2) for all inter-cropped treatments and 2.4×4.17 m (10 m^2) for both sole cropped crops. Plots receiving different treatments had a different number of rows with equal row length (4 m), except sole cropping which was 4.17 m. The gross plot size for all treatments was 10 m^2 with a net plot area of 3.8 m^2 for all treatments.

Data collected

Faba bean component

Biological yield (kg ha^{-1}): Aboveground dry biomass was harvested from the net plot area and weighted after sun drying to constant weight before threshing and converted to kg per hectare.

Grain yield (kg ha^{-1}): It was obtained from each net plot to estimate grain yield kg ha^{-1}. It was weighed and adjusted to 10% moisture content:

$$\text{Grain yield } \left(\text{kg ha}^{-1}\right) \text{ at 10\% moisture base} = \text{Yield obtained } \left(\text{kg ha}^{-1}\right) \times \frac{100-\text{mc\%}}{100-\text{MC\%}}$$

Where:
mc = Measured grain moisture content (%)
MC = Standard moisture content (10%)

Grain moisture content was determined by using a seed moisture tester instrument (Model PL- 10-860 Olsztyn, Owocowa 17).

Harvest Index (HI): It was calculated on a pilot basis, as the ratio of dried grain weight adjusted to 10% moisture content to the dried total aboveground biomass weight and multiplied by 100. Seed moisture content was determined using a seed moisture tester instrument. Then the grain yield of each treatment was adjusted to the standard moisture level by computing the conversion factor for each treatment to get the adjusted yield using the following formula:

$$\text{Adjusted yield} = \text{CF} \times \text{Plot yield}$$

$$\text{Conversion Factor } (\text{CF}) = \frac{100-\text{Y}}{100-\text{X}}$$

where, Y is actual moisture content and X is the standard moisture content to which the yield is to be adjusted (for legumes the standard moisture content is 10).

Wheat component

Biological yield (kg ha^{-1}): Aboveground biomass per net plot was determined before threshing and converted to the hectare.

Grain yield (kg ha^{-1}): It grain yield was obtained from each net plot to estimate grain yield in kg ha^{-1}. It was weighed and adjusted to 12.5% moisture content:

$$\text{Grain yield } \left(\text{kg ha}^{-1}\right) \text{ at 12.5\% moisture base} = \text{Yield obtained } \left(\text{kg ha}^{-1}\right) \times \frac{100-\text{mc\%}}{100-\text{MC\%}}$$

Where:
mc = Measured grain moisture content (%)
MC = Standard moisture content (12.5%)

Harvest Index (HI%): It was calculated on a pilot basis, as the ratio of dried grain weight adjusted to 12.5% moisture content to the dried total aboveground biomass weight and multiplied by 100. Seed moisture content was determined using a seed moisture tester instrument. Then the grain yield of each treatment was adjusted to the standard moisture level by computing the conversion factor for each treatment to get the adjusted yield using the following formula:

$$\text{Conversion Factor } (\text{CF}) = \frac{100-\text{Y}}{100-\text{X}}$$

where, Y is actual moisture content and X is the standard moisture content to which the yield is to be adjusted (for cereals the standard moisture content is (12.5%):

$$\text{Adjusted yield} = \text{CF} \times \text{Plot yield}$$

Land equivalent ratio: To evaluate productivity and profitability of land, the Land Equivalent Ratio (LER) of the crops was estimated as:

$$\text{LER} = L_a + L_b = \frac{Y_a}{S_a} + \frac{Y_b}{S_b}$$

where, L_a and L_b = LERs for individual crops in the mixture and Y_a and Y_b = Individual crop yields in the intercropping situation, S_a and S_b = Yield of species a and b as sole crops.

Gross monetary value: Gross Monetary Value (GMV) was calculated to estimate the economic advantage of intercropping as compared to sole cropping. It was calculated from the yield of faba bean and wheat by multiplying the yields of the component crops by their respective market price. During the harvesting period, the price of faba bean was 25 Ethiopian birr per kilogram and the price of wheat was 14 Ethiopian birr per kilogram at Asella town.

Data analysis: The collected data were subjected to Analysis of Variance (ANOVA) using SAS Software Version 9.0 (SAS Institute Inc., 2004). Significant differences among treatment means were assessed using the Least Significant Difference (LSD) at a 5% level of probability[17].

RESULTS AND DISCUSSION

Faba bean component

Grain yield: The results of the analysis showed that there was no significant effect of varieties and interaction effects on grain yield of faba bean but planting ratio showed a highly ($p<0.05$) significant effect on faba bean yield. Similarly, Merkine and Teshome[18], reported that faba bean did not show a significant difference in grain yield among varieties. On the contrary, Ashenafi and Mekuria[19], reported that there was a variation between varieties for most yield and yield components including grain yield. The planting ratio of 1W:2FB gave the highest grain yield (3426.0 kg ha^{-1}) of faba bean followed by sole planting of faba bean (3393.8 kg ha^{-1}). The lowest grain yield (2487.8 kg ha^{-1}) was obtained when faba bean was intercropped with a 2W:1FB planting ratio (Table 1). This could be due to efficient utilization of growth resources (nutrients, moisture and space) under a higher planting ratio of intercropped faba bean. This might suggest that increasing rows of faba bean under the intercropping condition with wheat gave better yield whenever the growing conditions are satisfied. Likewise, Klimek-Kopyra *et al.*[20] reported that faba bean yield was significantly affected by the seeding rate of naked oat and the highest yield of faba bean was recorded when faba bean was intercropped with the least seed rate of naked oat. Increasing wheat rows in faba bean decreased its grain yield. It was also stated that the growing of faba bean as a companion crop with wheat reduced the productivity of wheat and vice-versa[8].

Aboveground biomass: The analysis of variance indicated that there was no significant effect of varieties on the Aboveground Biomass (AGBM) of faba bean. In line with this Tekle *et al.*[21] reported that there was no significant variation between faba bean varieties for biological yield. On the contrary, Abdalla *et al.*[22] reported that dry biomass varied among faba bean varieties. Aboveground biomass was highly ($p<0.05$) significant for planting ratios. Unlike grain yield, sole planted faba bean gave significantly ($p<0.05$) highest AGBM (11257.3 kg ha^{-1}) of followed by 1W:2FB ratio (10029.2 kg ha^{-1}). The lowest AGBM (7631.6 kg ha^{-1}) was obtained when faba bean was intercropped with a 2W:1FB planting ratio (Table 1). Generally, extended rainfall distribution increased the biomass obtained as faba bean has indeterminate growth habit either insole or in intercropped faba bean with wheat.

Harvest index: Harvest Index (HI) was highly significantly ($p<0.05$) affected by the main effects of varieties and planting ratios as well as interaction effects of varieties and planting ratios. The highest HI (36.0%) was recorded by variety Hachalu and at 1W:1FB planting, ratio followed by Ashebeka at 1W:1FB planting ratio (34.6%). Lowest HI (26.8%) was recorded at Ashebeka when planted sole (Fig. 1).

Lowest HI (26.8%) was recorded at Ashebeka when planted sole (Fig. 1). This could be related to inherent characteristics of the varieties and rainfall distribution. Ashenafi and Mekuria[19], reported that the harvest index of faba bean had been significantly affected by faba bean varieties. Better HI means better yield efficiency of the plant under the given management practices.

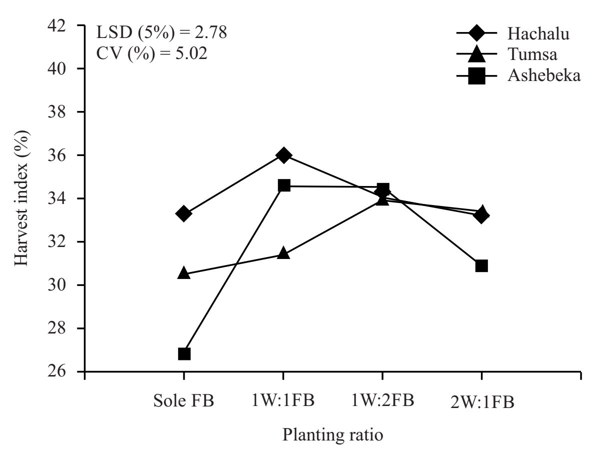

Fig. 1: Interaction effect of varieties and planting ratio on harvest index of faba bean

Table 1: Main effects of varieties and planting ratio on grain yield and aboveground biomass of faba bean at Kulumsa

Treatments	Grain yield (kg ha^{-1})	Aboveground biological yield (kg ha^{-1})
Varieties		
Hachalu	3190.1	9342
Tumsa	3018.9	9364.1
Ashebeka	2969.5	9429.9
LSD (0.05)	NS	NS
Planting ratio		
Sole FB	3393.8^{a}	11257.3^{a}
1W:1FB	2930.3^{b}	8596.6^{b}
1W:2FB	3426.0^{a}	10029.2^{a}
2W:1FB	2487.8^{c}	7631.6^{b}
LSD (0.05)	419.85	1289
CV (%)	14.04	14.05

LSD (0.05): Least significant difference at 5% level, CV: Coefficient of variation, W: Wheat, FB: Faba bean, NS: Non-significant and means in a column followed by the same letters are not significantly different at the 5% level of significance

Table 2: Main effects of varieties and planting ratio on grain yield, aboveground biomass and harvest index of wheat

Treatments	Grain yield (kg ha^{-1})	Aboveground biomass	Harvest index (%)
Varieties			
Hachalu	1343.5	4852.2	30.2^{a}
Tumsa	1343.5	6115.8	22.2^{b}
Ashebeka	1343.5	4805.0	28.9^{a}
LSD (0.05)	NS	NS	6.65
Planting ratio			
1W:1FB	1422.6^{b}	4560.9^{b}	32.7^{a}
1W:2FB	711.3^{c}	3154.9^{b}	23.8^{b}
2W:1FB	1896.6^{a}	8057.1^{a}	24.8^{b}
LSD (0.05)	120.6	1535.7	6.65
CV (%)	8.98	29.22	24.53
Sole cropped versus intercropped			
Cropping system			
Sole cropped	4268.0^{a}	10088^{a}	42.1^{a}
Intercropped	1343.5^{b}	5258^{b}	27.1^{b}
LSD (0.05)	1693.4	3747.9	6.84
CV (%)	17.18	13.90	5.62

LSD (0.05): Least significant difference at 5% level, CV: Coefficient of variation, W: Wheat, FB: Faba bean, NS: Non-significant and means in a column followed by the same letters are not significantly different at the 5% level of significance

Wheat component

Grain yield: The analysis result revealed that the planting ratio showed a highly ($p<0.05$) significant difference in grain yield, but the main effects of varieties and their interaction effects did not. The planting ratio of 2W:1FB gave the highest wheat grain yield (1896.6 kg ha^{-1}). The lowest wheat grain yield (711.3 kg ha^{-1}) was recorded in the 1W:2FB planting ratio. The mixture with a higher sharing of wheat (2W:1FB) achieved a highly significantly higher yield regardless of the type of variety (Table 2). This attributed to the highest population density of wheat at 2W:1FB planting ratio which allowed better resource use efficiency. The same bread wheat variety Hulluka was intercropped with different varieties of faba bean so that the same yield of 1343.5 kg ha^{-1} was obtained (Table 2). This indicates that faba bean varieties had no varietal effect on intercropped wheat grain yield. Practically, sole wheat outsmarted intercropped wheat as it has high solar absorption efficiency and low intercrop competition. When the number of rows of intercropped wheat increased grain yield of wheat was also increased. Klimek-Kopyra *et al.*[20] reported that the highest grain yield of faba bean was obtained from the highest seed rate of faba bean in faba bean naked oat intercropping. Klimek-Kopyra *et al.*[20], further reported that the highest grain yield of faba bean 1.57 t ha^{-1} was recorded at 75:25 faba bean/naked oat cropping ratio. Similarly, Agegnehu *et al.*[8] gained a significant difference in wheat grain yield in wheat and faba bean mixed intercropping. He described that the highest grain yield of wheat (3601 kg ha^{-1}) was observed at the lowest seeding rate sharing of faba bean (100:12.5 wheat/faba bean).

Aboveground biomass: The results of the analysis showed that Aboveground Biomass (AGBM) yield was not significantly affected by the main effects of varieties and interaction effect but was highly ($p<0.05$) affected by the main effects of inter-cropping ratio and cropping system, respectively. The

Table 3: Partial land equivalent ratio of faba bean versus bread wheat and total land equivalent ratio

Treatments	PLERFB	PLERW	TLER
Varieties			
Hachalu	0.85	0.31	1.09
Tumsa	0.99	0.31	1.22
Ashebeka	0.95	0.31	1.18
LSD (0.05)	NS	NS	NS
Planting ratio			
Sole FB	1.00[ab]	-	1.00[b]
1W:1FB	0.88[bc]	0.33[b]	1.21[a]
1W:2FB	1.11[a]	0.16[c]	1.27[a]
2W:1FB	0.73[c]	0.44[a]	1.18[a]
LSD (0.05)	0.19	0.0001	0.19
CV (%)	21.16	0.02	16.89
Sole cropped versus intercropped			
Cropping system			
Sole cropped	1.00[a]		
Intercropped	0.31[b]		
LSD (0.05)	0.02		
CV (%)	1.22		

LSD (0.05): Least significant difference at 5% level, CV: Coefficient of variation, W: Wheat, FB: Faba bean, PLERFB: Partial land equivalent ratio of faba bean, PLERW: Partial land equivalent ratio of wheat, TLER : Total land equivalent ratio, NS: Non-significant and Means in a column followed by the same letters are not significantly different at the 5% level of significance

highest (8057.1 kg ha^{-1}) and the lowest (3154.9 kg ha^{-1}) AGBM yield of wheat was recorded in 2W:1FB and 1W:2FB plating ratios, respectively (Table 3). The higher seeding rate of wheat resulted in greater aboveground biomass yield than the lower seeding rate of wheat. In addition to this wheat was seriously affected by the shading effect of faba bean which decreased wheat performance. The AGBM yield of sole planting was significantly higher than the intercropped (Table 3). Teshome *et al.*[23] reported that there was a significant difference in AGBM yield of soybean in soybean maize intercropping and the higher seeding rate treatment gave the significantly greater AGBM yield of soybean. Likewise, Klimek-Kopyra *et al.*[20] reported that the biological yield of beans increased as the plant population increased under sorghum/bean intercropping.

Harvest index: Harvest Index (HI) of wheat was significantly ($p<0.05$) affected by variety, planting ratio and cropping system but, not by their interaction effects. The highest HI (32.7%) was obtained from 1W:1FB and the lowest wheat harvest index (23.8%) was obtained from 1W:2FB (Table 2). This could be related to the late maturing nature of the variety whereby it consumes more time to accumulate more dry matter. The highest HI recorded in 1W:1FB planting ratio might be due to the high grain yield to biomass as a result of the high partitioning of dry matter to the grain.

System productivity

Land Equivalent Ratio (LER): Differences among faba bean varieties were not significant for all three (partial LER of faba bean, partial LER of wheat and total LER) land equivalent ratios. Faba bean varieties did not show any influence on the partial land equivalent ratio of wheat. Differences among planting ratios were highly ($p<0.05$) significant for both partial LER of faba bean and partial LER of wheat. The highest partial LER of faba bean (1.11) and partial LER wheat (0.44) was recorded at 1W:2FB and 2W:1FB, respectively (Table 3). As the ratio of intercropped wheat increased PLERW and PLERFB increased and decreased, respectively. The Total Land Equivalent Ratio (TLER) was significantly affected by planting ratios. Statistically highest TLER was registered in 1W:1FB (1.21) and 1W:2FB (1.27) for efficient utilization of growth resources. The highest TLER (1.27) was obtained from the 1W:2FB intercropping ratio and the lowest TLER (1.00) were recorded in sole faba bean (Table 4). A 21 and 27% additional yield advantage were obtained at 1W:1FB and 1W:2FB planting ratios than planting a sole crop, respectively. So it seems optimistic in resource-poor and small landholding farmers. As the ratio of faba bean decreased total land equivalent ratio decreased. In line with this Nargis *et al.*[24] reported that the total land equivalent ratio decreased from 1.17 to 1.12 when the planting ratio was changed from 1W:1L to 1W:3L in wheat/lentil intercropping.

Gross monetary value: Gross Monetary Value (GMV) was significantly ($p<0.05$) affected by interaction effects of faba bean varieties and planting ratio. The highest gross value (100591 ETB ha^{-1}) was achieved with a planting ratio of 1W:2FB with the Tumsa variety. The Hachalu variety yielded 89,381 ETB ha^{-1} when planted 1W:2FB. A GMV of 96,854 ETB ha^{-1} was obtained when Ahebeka was planted with a planting ratio of 1W:2FB. Wheat alone gave the lowest

Table 4: Effect of varieties and planting ratio on gross monetary value (ETB ha^{-1})

Planting ratio	Hachalu	Tumsa	Ashebeka
Sole FB	93647^{ab}	82694^{ab}	78197^{b}
1W:1FB	98417^{a}	86793^{ab}	94317^{ab}
1W:2FB	89381^{ab}	100591^{a}	96854^{a}
2W:1FB	93993^{ab}	88241^{ab}	84013^{ab}
Sole wheat	59752^{c}		
LSD (0.05)	18239		
CV (%)	12.27		

LSD (0.05): Least significant difference at 5% level, CV: Coefficient of variation, W: Wheat, FB: Faba bean, NS: Non-significant and means in a column followed by the same letters are not significantly different at the 5% level of significance

gross cash value of 59,752 ETB ha^{-1} (Table 4). Thus, 18.5 and 40% additional income can be gained than planting sole faba bean and wheat, respectively. This could be due to the high price and better competition ability of faba bean with good rainfall distribution in the growing season. Nevertheless, irrespective of faba bean varieties, a 1W:2FB planting ratio could be tentatively recommended in the area. However, further economic analysis might be necessary for calculating the actual yield benefit of intercropping from this trial.

Monoculture is widely practised in the study site. The result of this study suggests that the mixed cultivation of broad beans and wheat has additional advantages than growing only one crop because it increases land productivity. The mixed cultivation of broad beans and wheat can easily be applied to small farms with manual operation of agronomic practices. Based on this study result, mixed cultivation of broad beans and wheat in a planting ratio of 1W:2FB could be recommended in this area. However, because this research is done in a single season, further studies may be needed for the best recommendation. Farmers are unwilling to adopt these practices as mechanization is difficult unless there is an innovative machine for the cover crop system.

CONCLUSION

The current study revealed that the highest seed yield (3426.0 kg ha^{-1}) and aboveground biomass yield (10029.2 kg ha^{-1}) of faba bean were recorded at the planting ratio of 1W:2FB whereas the greatest grain yield (1896.6 kg ha^{-1}) and aboveground biomass yield (8057.1 kg ha^{-1}) of bread wheat were obtained when planting with the planting ratio of 2W:1FB. Significantly the peak HI (36.0%) faba bean was recorded from variety Hachalu and at 1W:1FB planting ratio while the uppermost HI (32.7%) of bread wheat was found from 1W:1FB planting ratio. The highest total land equivalent ratio (1.27) was obtained from the 1W:2FB planting ratio. This indicates intercropping is better than sole cropping. The top gross monetary value, which was 100,591 ETB ha^{-1} was attained with a planting ratio of 1W:2FB with a variety of Tumsa. Generally, based on the studied parameters, land equivalent ratio and gross monetary value intercropping of Tumsa faba bean variety at planting ratio of 1W:2FB with Hulluka bread wheat variety was economically feasible in the study area.

SIGNIFICANCE STATEMENT

The current study discovered the influence of the beneficial effects of intercropping planting ratio of faba bean with wheat for increased yield by enhanced yield components for the productivity of component crops. This study will help the researchers to uncover the critical areas of selecting the best faba bean variety with the right planting ratio intercropped with wheat that many researchers were not able to explore. Therefore, the significant finding of this study could add to the knowledge regarding planting ratio versus intercrop that responds to the yield and productivity of component crops.

REFERENCES

1. Elsheikh, E.A.E. and E.I.A. Ahmed, 2000. A note on the effect of intercropping and rhizobium inoculation on the seed quality of faba bean (*Vicia faba* L.). UK. J. Agric. Sci., 8: 157-163.
2. Yucel, D.O., 2013. Optimal intra-row spacing for production of local faba bean (*Vicia faba* L. major) cultivars in the mediterranean conditions. Pak. J. Bot., 45: 1933-1938.
3. Fekadu, E., K. Kibret, A. Melese and B. Bedadi, 2018. Yield of faba bean (*Vicia faba* L.) as affected by lime, mineral P, farmyard manure, compost and rhizobium in acid soil of Lay Gayint district, Northwestern highlands of Ethiopia. Agric. Food Secur., Vol. 7. 10.1186/s40066-018-0168-2.
4. Dhima, K.V., I.B. Vasilakoglou, R.X. Keco, A.K. Dima, K.A. Paschalidis and T.D. Gatsis, 2013. Forage yield and competition indices of faba bean intercropped with oat. Grass Forage Sci., 69: 376-383.
5. Pardo, J.J., A. Martínez-Romero, B.C. Léllis, J.M. Tarjuelo and A. Domínguez, 2020. Effect of the optimized regulated deficit irrigation methodology on water use in barley under semiarid conditions. Agric. Water Manage., Vol. 228. 10.1016/j.agwat.2019.105925.

6. Shiferaw, B., M. Kassie, M. Jaleta and C. Yirga, 2014. Adoption of improved wheat varieties and impacts on household food security in Ethiopia. Food Policy, 44: 272-284.
7. Singh, R. and G.S. Singh, 2017. Traditional agriculture: A climate-smart approach for sustainable food production. Energy Ecol. Environ., 2: 296-316.
8. Agegnehu, G., A. Ghizaw and W. Sinebo, 2008. Yield potential and land-use efficiency of wheat and faba bean mixed intercropping. Agron. Sustainable Dev., 28: 257-263.
9. Xu, B.C., F.M. Li and L. Shan, 2008. Switchgrass and milkvetch intercropping under 2:1 row-replacement in semiarid region, Northwest China: Aboveground biomass and water use efficiency. Eur. J. Agron., 28: 485-492.
10. Xia, H.Y., Z.G. Wang, J.H. Zhao, J.H. Sun and X.G. Bao *et al*., 2013. Contribution of interspecific interactions and phosphorus application to sustainable and productive intercropping systems. Field Crops Res., 154: 53-64.
11. Yang, F., S. Huang, R. Gao, W. Liu and T. Yong *et al*., 2014. Growth of soybean seedlings in relay strip intercropping systems in relation to light quantity and red: Far-red ratio. Field Crops Res., 155: 245-253.
12. Ouma, G. and P. Jeruto, 2010. Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops: A review. Agric. Biol. J. North Am., 1: 1098-1105.
13. Adu-Gyamfi, J.J., F.A. Myaka, W.D. Sakala, R. Odgaard, J.M. Vesterager and H. Hogh-Jensen, 2007. Biological nitrogen fixation and nitrogen and phosphorus budgets in farmer-managed intercrops of maize-pigeonpea in semi-arid Southern and Eastern Africa. Plant Soil, 295: 127-136.
14. Dereje G., T. Adisu, M. Mengesha and T. Bogale, 2016. The influence of intercropping Sorghum with legumes for management and control of striga in Sorghum at Assosa Zone, Benshangul Gumuz region, Western Ethiopia, East Africa. Adv. Crop Sci. Technol., Vol. 4. 10.4172/2329-8863.1000238.
15. Taddese, G., A. Eshete, D. Wondaferew, K. Ababu and S. Gashaw, 2019. Effect of barley (*Hordeum vulgare* L.) and fababean (*Vicia fabae* L.) intercropping on barley and fababean yield components. Forest Res. Eng. Int. J., 3: 7-13.
16. Dobocha, D., G. Abera and W. Worku, 2019. Grain quality and nitrogen use efficiency of bread wheat (*Triticum aestivum* L.) varieties in response to nitrogen fertilizer in Arsi highlands, Southeastern Ethiopia Afr. J. Agric. Res., 14: 1544-1552.
17. Gomez, K.A. and A.A. Gomez, 1984. Statistical Analysis for Agricultural Research. 2nd Edn., John Wiley & Sons, Inc., Toronto Singapore, ISBN: 978-0-471-87092-0 Pages: 704.
18. Mogiso, M. and T. Mamo, 2018. Evaluation of faba bean (*Vicia faba* L.) varieties for yield performance in Kaffa Zone, Southwestern Ethiopia. Int. J. Curr. Res. Biosci. Plant Biol., 5: 68-74.
19. Mitiku, A. and M. Wolde, 2015. Effect of faba bean (*Vicia faba* L.) varieties on yield attributes at sinana and agerfa districts of Bale Zone, Southeastern Ethiopia. J. Biol. Sci., 8: 281-286.
20. Klimek-Kopyra, A., B. Kulig, A. Oleksy and T. Zajac, 2015. Agronomic performance of naked oat (*Avena nuda* L.) and faba bean intercropping. Chil. J. Agric. Res., 75: 168-173.
21. Kubure, T.E., R. Cherukuri, C. Arvind and I. Hamza, 2015. Effect of faba bean (*Vicia faba* L.) genotypes, plant densities and phosphous on productivity, nutrients uptake, soil fertility changes and economics in central high lands of Ethiopia. Int. J. Life Sci., 3: 287-305.
22. Abdalla, A.A., A.M. El Naim, M.F. Ahmed and M.B. Taha, 2015. Biological yield and harvest index of faba bean (*Vicia faba* L.) as affected by different agro-ecological environments. World J. Agric. Res., 3: 78-82.
23. Gutu, T., T. Tana and N. Geleta, 2015. Effect of varieties and population of intercropped soybean with maize on yield and yield components at Haro Sabu, Western Ethiopia. Sci., Technol. Arts Res. J., 4: 31-39.
24. Akter, N., M.A. Alim, M.M. Islam, Z. Naher, M. Rahman and A.S.M.I. Hossain, 2004. Evaluation of mixed and intercropping of lentil and wheat. J. Agron., 3: 48-51.