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Determination of the Mixed Culture of Faba Bean Varieties and Bread Wheat Growth and Yield Components at Kulumsa, Ethiopia

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Abstract

Faba bean is an important pulse crop in production and consumption in Ethiopia. Its major production is in the mid and high altitude areas. Intercropping is an effective utilization of land that enables farmers to produce two different crops simultaneously. It is a good way of using resources and man power efficiently. This could be due to different rooting characteristics, canopy structure, height, and nutrient requirements or resource use at different times. A field experiment was conducted in 2019 main cropping season at Kulumsa Agricultural Research Center research station, South-eastern Ethiopia with the objectives of assessing the compatibility of faba bean and wheat intercropping and to select suitable varieties of faba bean under different planting ratio in intercropping faba bean with bread wheat in the area. The treatments were three faba bean varieties (Ashebeka, Hachalu and Tumsa) intercropped with bread wheat (variety Hulluka) in three different planting ratios (1W:1FB, 1W:2FB, 2W:1FB) and sole planting of the three faba bean varieties and wheat. The treatments were laid out in randomized complete block design with three replications. Highest days to 50% flowering (50.2 days) and days to 90% maturity (147.6 days) was recorded from variety Tumsa. The highest number of pods per plant (17.7) was obtained from variety Hachalu. Variety Ashebeka gave highest thousand kernel weight (858.7 g). The highest (38.7 g) and lowest (35.5 g) thousand kernel weight of wheat was recorded in 1W:2FB and 2W:1FB planting ratios respectively.

Keywords: Planting ratios; Sole planting; Intercropping; Yield components

Introduction

Faba bean production occupied nearly 2.1 × 10^6 ha worldwide [1]. Its global production is 4.4 million tons. Faba bean is mainly produced in China (1.64 Mt), Ethiopia (0.92 Mt), Australia (0.34 Mt), France (0.27 Mt) and Sudan (0.16 Mt). Faba bean is an important pulse crop in terms of area coverage and volume of annual production in Ethiopia [2]. It is a major staple food crop among pulses and it is mainly grown in the mid and high altitude areas of the country [3]. Some limiting factors of faba bean production are climatic conditions, edaphic factors, disease problem and agronomic practices [4]. One way by which problems associated with soil fertility, disease problem etc. could be solved is through crop diversification such as multiple cropping [5,6].

Ethiopia is the second largest wheat producer in Sub-Saharan Africa next to South Africa. Faba bean ranks second as source of energy, which is approximately 14% following maize [7]. It is widely produced in the country especially in mid altitudes and highland areas of Ethiopia [8]. Single cropping of high yielding and high fertilizer input varieties has been promoted for several decades as an approach to enhance food production in the country and decreased soil fertility [9]. In northern Ethiopia farmers have changed their cropping system from growing a pure crop of wheat to mixed intercropping with a small proportion of faba bean and field pea [10].

Intercropping is an effective utilization of land that enables farmers to produce two different crops simultaneously. It is a good way of using resources and man power efficiently. The most common advantage of intercropping is the production of greater yields on a given piece of land by making more efficient use of the available growth resources. This could be due to different rooting characteristics, canopy structure, height, and nutrient requirements or resource use at different times [11].

Intercropping systems is usually practiced intercropping of legume and cereal crops. This is due to the enhancement of growth of one crop by another crop, and this type of intercropping is a productive and sustainable system [12-14]. Intercropping of faba bean and barley around Debre Birhan indicated that intercropping had economic advantages in land use efficiency [15].

Faba bean and bread wheat are adapted to highland agro ecological niches whereby mono cropping is a dominant crop production system [16]. This system is associated with occurrence of crop diseases, soil acidity and fertility problems [17]. Arsi zone is potential area for both faba bean and wheat [18]. The production of wheat is highly dependent on inorganic fertilizer for plant nutrient, and agricultural pesticides for disease and weed control which increases cost of production [16]. As a result few farmers use crop rotation to reduce fertilizer required and break pest cycle for the next wheat production. However most farmers do not use this rotation as required because of land shortage. They do not want to loss wheat every year. Because of this, alternative cropping system is needed to solve this problem. However, there is lack of information concerning inter-cropping of

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wheat with faba bean in the area. The yield advantage in implementing intercropping could be tested and validated by knowing the complementarity of the component crops in the given area with respect to space and time dimension. Purpose of this experiment was to assess the compatibility of faba bean and wheat intercropping and to select suitable varieties of faba bean under different planting ratio in intercropping faba bean with bread wheat in the area.

Materials and Methods

Description of the study areas

Field experiment was conducted in 2019 main cropping season at Kulumsa Agricultural Research Center (KARC). It is located in Gora Silingo Kebele, Tiyo district of Arsi Zone, Oromia Regional State, Southeastern Ethiopia. The experimental site is located at 8°01'N latitude and 39°09'E longitude, at altitude of 2200 meters above sea level. It receives average annual rainfall of 809.2 mm and has a uni-modal pattern rain fall. The peak season of the rain fall is from July to August. The average annual minimum and maximum temperatures are 9.9 and 23.1°C, respectively [19]. The soil type is luvisol/eutric nitosols with a good drainage system. It contains 5.5% organic matter, 0.25% nitrogen and its pH is 5.5-6.0 [20].

Treatments and experimental design

The treatments consisted of three faba bean varieties (Ashebeka, Hachalu and Tumsa) intercropped with bread wheat (variety Hulluka) 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) and sole planting of the three faba bean varieties and wheat. Randomized Complete Block Design (RCBD) with three replications was used for the experiment.

Experimental procedures

The crops were planted in row in which the inter row spacing for faba bean and wheat was 40 cm and 20 cm respectively where wheat was planted between faba bean rows. In 1:1 ratio wheat was planted between every two faba bean rows, so it was 20 cm apart from faba bean from both sides. In 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 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. The three faba bean varieties and wheat was also planted as sole. Blended NPS fertilizer at recommended rate of 120 $kgha^{-1}$ for faba bean was applied to all treatments except sole wheat which received both blended NPS at the rate of 180 $kgha^{-1}$ and urea at the rate of 100 $kgha^{-1}$ according to recommendation for wheat. The experimental plot size was 2.5 m × 4 m (10 m^2) for all inter-cropped treatments and 2.4 m × 4.17 m (10 m^2) for both sole cropped crops. Plots received different treatments had 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 net plot area of 3.8 m^2 for all treatments.

Soil sampling and analysis

Before plating soil samples were collected from 0-30 cm depth per replication to obtain representative composite soil samples. After harvesting soil samples were taken on plot bases. The samples were air-dried, ground and sieved through a 2 mm sieve and made ready for analysis [21]. Soil samples collected before planting were analyzed for texture, pH, organic matter, total nitrogen and available phosphorus. After harvest bulk density, available P, pH, organic matter, and total nitrogen were analyzed. Soil texture was determined using the Bouyoucos hydrometer method [22]. The pH of the soil was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter by potentiometer method [23]. Organic matter was determined by wet oxidation method as described [24]. Available P was determined by method [25]. Soil total nitrogen was quantified using Kjedahl method [26].

Plant tissue sampling and analysis for nitrogen content

At maturity, five non-boarder wheat plants samples were randomly collected from each plot and partitioned into grain and straw. The straw samples were washed with distilled water to clean the samples from contaminants such as dust. The straw samples were oven dried at 70°C to constant weight. After drying, the samples were ground and passed through 0.5 mm sieve. Then the samples were analyzed for nitrogen following wet digestion method.

Data collected

Phenological and growth parameters for faba bean component

- **Days to flowering:** Number of days from planting to flowering of 50% of plants was recorded by careful observation.
- **Days to maturity:** Number of days from planting to when plants attained 90%physiological maturity was recorded.
- **Leaf area (cm^2):** It was measured just before flowering stage by randomly taking five plants from the destructive sampling rows of each plot using CI-202 leaf area meter.
- **Number of effective nodules per plant:** Was calculated as the ratio of total leaf area per area of land (cm^2) occupied by the plant.
- **Number of effective nodules per plant:** Effective nodules were identified by their pink color when dissected from non-effective nodules. Then they were determined by counting from five randomly taken plants using destructive sampling in a row per plot at 50% flowering stage. Nodulation score was recorded on a 1-4 scale, where 0 indicates no nodule per plant and 4 indicate more than 30 nodules per plant from the aforementioned selected plants per plot.
- **Number of total tillers/plant:** All tillers of a plant with pod and without pods were counted from net plot.

Yield components for faba bean component

- **Pods/plant:** Total number of pods per plant was counted at maturity from 10 randomly taken plants per plot.
- **Seeds/pod:** Average number seeds per pod were counted at harvesting from 10 randomly taken plants per plot.
- **Stand count:** The initial plant stand count was recorded after establishment and at harvest per net plot area when the plant attains maturity and the percentage survival was calculated.
- **Thousand grain weight (gm):** The weight of 1000 seeds was determined by carefully counting the grains, adjusting to 10% moisture content and weighing them using a sensitive balance.

Phenological and growth parameters for wheat component

- **Days to 50% heading:** The number of days from date of sowing to the stage when 50% of the spikes have fully emerged was recorded.
- **Days to 90 % physiological maturity:** The number of days from date of sowing to the stage when 90% of the plants in the plot reached physiological maturity was recorded.

- **Days to grain filling:** The number of days taken from heading to maturity was recorded.
- **Yield components of wheat component**
- **Total tillers:** The number of total tillers per plant was counted from two randomly taken rows of 0.5 m in length from the net area per plot at physiological maturity.
- **Number of productive tillers:** The number tillers bearing spikes were counted for each plant from rows in the net plot area which is 0.5 m long.
- **Number of kernels per spike:** was counted from ten random spikes in a net plot.
- **Thousand kernel weight (gm):** The weight of 1000 kernels was determined by carefully counting the grains, adjusting to 12.5% moisture content and weighing them using a sensitive balance.

Data analysis

The collected data was subjected to analysis of variance (ANOVA) using SAS software version 9.0 [27]. Least Significant Difference (LSD) was used as mean separation method at 5% probability level [28].

Results and Discussion

Physico-chemical properties of soil

The result of soil analysis showed that the soil texture at the trial site was sandy clay loam. Its bulk density was 1.36 gm/cm^3. It had a pH value of 5.5 (strongly acidic) and organic matter 3.9%, (medium organic matter content according to rate) [29]. Total nitrogen was 0.13% (low total nitrogen as per [30].

Physico-chemical properties of soil after harvesting: Post-harvest soil analysis result indicated that main effects of varieties and planting ratio had no significant effect on total Nitrogen (N), Organic Carbon (OC) and Organic Matter (OM). Varieties, planting ratio and their interaction have significantly ($p<0.05$) affected available Phosphorus (P). The highest available phosphorus (18.38 mg/kg) was recorded by variety Hachalu with 1W:2FB planting ratio (Table 1). This is associated with the capability of faba bean to mobilize fixed phosphorus by secretion of acids from its roots. In agreement with this reported that available phosphorus in the soil was higher in faba bean / wheat intercropping [31].

Planting ratio	Varieties		
	Hachalu	Tumsa	Ashebeka
Sole FB	14.32^{abcd}	15.07^{abcd}	13.45^{abcde}
1W:1FB	13.99^{abcde}	17.01^{abc}	12.10^{cde}
1W:2FB	18.38^{a}	12.75^{bcde}	9.25^{e}
2W:1FB	17.16^{ab}	11.41^{de}	14.39^{abcd}
LSD (0.05)	5.01		
CV(%)	20.98		
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 1: Interaction effect of varieties and planting ratio on available phosphorus after harvesting.

Plant tissue sampling and analysis for nitrogen content: Wheat straw nitrogen content was highly significant ($p<0.01$) for interaction effects of varieties and planting ratio. Significantly highest nitrogen in wheat straw (2.70%) was recorded at variety Hachalu with 1W:1FB planting ratio followed by (2.62%) at variety Ashebeka with 1W:2FB planting ratio. The lowest wheat straw nitrogen content (1.87%) was obtained at variety Tumsa with 1W:1FB planting ratio (Table 2). In general, increasing faba bean ratio with decreasing of wheat ratio has increased wheat straw nitrogen content. This is the result of nitrogen fixation by faba bean and decreased competition of wheat for nitrogen. Despite similar agro ecological recommendations of varieties, minor genotypic variability might be attributed to increased wheat straw nitrogen content under intercropping conditions with faba bean, besides to favourable rain fall distribution.

Planting ratio	Varieties		
	Hachalu	Tumsa	Ashebeka
1W:1FB	2.70^{a}	1.87^{e}	2.23^{d}
1W:2FB	2.35^{cd}	2.44^{bc}	2.62^{ab}
2W:1FB	2.03^{e}	1.92^{e}	1.99^{e}
LSD (0.05)	0.18		
CV (%)	4.7		
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 2: Interaction effect of varieties and planting ratio on wheat straw nitrogen content after harvesting.

Faba bean component

Stand count: The highest seedling of faba bean (34.4) at establishment was recorded from variety Hachalu while the lowest seedling of faba bean (28.5) was recorded from variety Ashebeka (Table 3). The highest seedling that was recorded from Hachalu plot may be because of the least thousand kernel weight of the variety which increases the number of seeds per a given weight. When planting ratios are compared similar seedling numbers of faba bean was recorded. This indicates that planting ratio of wheat intercropped in faba bean has no effect on stand count of faba bean [10]. Reported the same result in wheat/faba bean intercropping. Similar result was recorded by in which population density of soybean intercropped in maize had no effect on stand count of maize [32].

Treatments	Stand count	Daysflowering	Days to maturity
Varieties			
Hachalu	34.4[a]	48.8[b]	138.5[b]
Tumsa	29.1[b]	50.2[a]	147.6[a]
Ashebeka	28.5[b]	49.2[b]	138.3[b]
LSD (0.05)	2.07	0.64	1.3
Planting ratio			
Sole FB	31.8	49.7	142.1[a]
1W:1FB	30.5	49.1	141.8[a]
1W:2FB	30.4	49.7	142.1[a]
2W:1FB	30	49.1	140.0[b]
LSD (0.05)	NS	NS	1.5
CV (%)	7.3	1.55	1.08
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 3: Main effects of varieties and planting ratio on stand count, days to 50% flowering and days to 90% maturity of faba bean at Kulumsa in 2019 main cropping season.

Phenology: Days to 50% flowering of faba bean was significantly ($P<0.05$) affected by main effects of varieties but neither by planting ratios nor by interaction effect. Days to 90% maturity of faba bean was highly significantly ($P<0.01$) affected by main effects of varieties and significantl affected by planting ratios ($P<0.05$). Variety Tumsa was significantly late than other varieties (Table 3). Varietal difference of days to maturity relates to their genotypic difference. Planting ratio of 2W:1FB significantly enhanced days to maturity of faba bean (Table 3). Both days to flowering and days to maturity of faba bean was not significantly influenced by interaction effects of varieties and planting ratio. Increasing wheat ratios intercropped in faba bean has accelerated faba bean maturity. This is because of wheat competition for nitrogen which extends vegetative period. This has increased days to maturity of faba bean. Whereas planting ratio do have an effect on either of the component crops with regard to intra and inter induced interaction and competition among plants.

Growth parameters

Leaf area and leaf area index: Leaf Area (LA) was not significantly affected by variety and planting ratio but significantly ($P<0.05$) affected by interaction effects. The highest LA (1162.9 cm^2) was recorded from variety. Tumsa when planted as sole crop (Table 4). Leaf Area Index (LAI) of faba bean was not significantly affected by both main effects of varieties and planting ratios. LAI was significantly ($P<0.05$) affected by interaction effect. The highest leaf area index of faba bean (2.9) was recorded from variety Tumsa when planted as sole (Table 5). The highest leaf area and leaf area index at sole planting were due to the highest faba bean plant density and no competition of wheat at this treatment. As a general a better leaf area and leaf area index recorded might be due to indeterminate growth habit of faba bean that might have favored leaf growth and absorption of solar radiation in this late maturing variety. The higher the leaf area, the better could be the ground cover and retained more moisture to accumulate and partition more dry matter to the plant under sole crop as compared to inter plant competition under intercropping condition (Table 6).

Number of tillers per plant: Number of Total Tillers Per Plant (NTTPP) of faba bean was not significantly affected by main effect of varieties but highly (P<0.01) significantly and significantly (P<0.05) affected by planting ratios and interaction effects, respectively [33]. Reported that faba bean tillers per plant were not significantly affected by varieties. Variety Tumsa gave the highest number of total tillers per plant (2.7 tillers/plant) when planted sole followed by sole Hachalu (2.5 tillers/plant) (Table 7). As number of wheat rows in faba bean increases tillers/plant decreases. This might be the result of intercrop competition for nutrient, moisture and space that result in lower NTTPP [10]. Also got the same results in wheat faba bean mixed intercropping.

Faba bean varieties	Hachalu	Tumsa	Ashebeka
Planting ratio			
Sole FB	1101.8^{abc}	1162.9^{a}	726.7^{cd}
1W:1FB	993.1^{abcd}	653.2^{d}	744.3^{cd}
1W:2FB	712.0^{d}	1029.4^{abcd}	853.2^{abcd}
2W:1FB	768.1^{cd}	857.4^{abcd}	1138.3^{ab}
LSD (0.05)		384.7	
CV (%)		25.38	
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 4: Interaction effects of varieties and planting ratio on leaf area of faba bean intercropped with bread wheat.

Faba bean varieties	Hachalu	Tumsa	Ashebeka
Planting ratio			
Sole FB	2.7^{abc}	2.9^{a}	1.8^{cd}
1W:1FB	2.4^{abcd}	1.6^{de}	1.8^{cd}
1W:2FB	1.7^{d}	2.5^{abc}d	2.1^{abcd}
2W:1FB	1.9^{bcd}	2.1a^{bcd}	2.8^{ab}
LSD (0.05)	0.96		
CV (%)	25.35		
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 5: Interaction effects of varieties and planting ratio on leaf Area iIndex (LAI) of faba bean intercropped with bread wheat.

Faba bean varieties	Hachalu	Tumsa	Ashebeka
Planting ratio			
Sole FB	2.5^{ab}	2.7^{a}	2.2^{bcd}
1W:1FB	1.9^{cde}	1.3^{f}	1.8^{e}
1W:2FB	1.9^{cde}	2.1^{bcde}	2.3^{bc}
2W:1FB	1.9^{cde}	1.7^{ef}	1.8^{de}
LSD (0.05)		0.4	
CV (%)		11.77	
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 6: Interaction effect of varieties and planting ratio on total tillers per plant of faba bean.

Yield components of faba bean

- **Number of pods per plant and seeds per pod:** Analysis of variance revealed that number of pods per plant showed highly significant (P<0.01) difference with respect to main effects of varieties. This result agreed with the result of who reported significant difference of faba bean pods per plant among varieties [34]. But pods per plant were not significantly affected by planting ratios and the interaction effects. In line with this reported that there was no significant difference of pods per plant of faba bean when intercropped with wheat [10]. The highest NPPP (17.7) were obtained from variety Hachalu while the lowest PPP (12.9) were obtained from variety Ashebeka (Table 8). This might be due to efficient utilization of moisture in Hachalu under extended rainfall pattern relatively to Ashebeka. Actually, Ashebeka has slightly lower tendency to mid altitude agro ecology to that of the highland adapted variety Hachalu. Seeds per pod were also not significantly affected by main effects of varieties, planting ratio and interaction effects. This result is similar with the report of previous studies. Likewise reported that there was no significant difference of seeds per pod of faba bean between faba bean varieties [34].
- **Thousand seeds weight:** Thousand seeds weight (TKW) of faba bean was highly (P<0.01) significant for main effect of varieties, but not for planting ratios and their interaction effects. The highest mean TKW (858.7 gm) was recorded in variety Ashebeka whereas the lowest TKW of 698.4 g was obtained from variety Hachalu (Table 7). Eventhough thousand seed weight were not significantly affected by planting ratios, the highest TKW of 794.8 g were recorded at sole planting among planting ratios. This could be due to low inter row competition for nutrient and water in row spaced sole cropped faba bean. In agreement with this reported that thousand seed weight of wheat was not significantly affected under different seed rates of faba bean intercropped in wheat [10]. Thousand seed weight of faba bean decreases as the number of rows of wheat intercropped in faba bean increases in relation with competition effect of inter cropped crops.

Treatments	Number of pods per plant	Thousand seeds weight (g)
Varieties		
Hachalu	17.7[a]	698.4[c]
Tumsa	13.9[b]	792.3[b]
Ashebeka	12.9[b]	858.7[a]
LSD (0.05)	2.05	36.89
Planting ratio		
Sole FB	13.2	794.8
1W:1FB	14.9	789.5
1W:2FB	16.3	790.4
2W:1FB	14.9	757.7
LSD (0.05)	NS	NS
Means in column followed by the same letters are not significantly different at 5% level of Significance.		

Table 7: Main effects of varieties and planting ratio on number of pods per plant and thousand kernel weight of faba bean.

Wheat component

Phenology: Days to heading, days to grain filling and days to maturity of wheat were not significantly affected by both main effect of varieties and planting ratio. Only days to grain filling were significantly (P<0.05) affected by the interaction effect of varieties and planting ratio. The highest grain filling days (84.0 days) was recorded when Hachalu and Tumsa were planted in 1W:1FB and 1W:2FB planting ratios respectively. The earliest grain filling (80.6) was recorded when Hachalu was planted in 2W:1FB planting ratio (Table 8). When sole planted and intercropped wheat are compared days to heading, days to grain filling and days to maturity were highly (P<0.01) significantly affected (Table 9). Sole cropped wheat was earlier than intercropped wheat by days to heading, days to grain filling and days to maturity of wheat (Table 8). This might be the result of shading effect of faba bean on wheat and nitrogen delivered to wheat during the growing period [35]. Reported that intercropping increases availability of soil N for wheat. This increase may be due to a lower interspecific competition between legume and wheat than intra-specific competition between wheat plants and fixation of the atmospheric nitrogen. As nitrogen availability increases days to maturity of wheat increased [36].

Cropping system	Days to heading	Days to grain filling	Days to maturity
Sole cropped	70.0[b]	76.0[b]	146.0[b]

Intercropped	72.3[a]	82.3[a]	154.7[a]
LSD (0.05)	0.18	1.23	1.32
CV (%)	0.07	0.44	0.24
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 8: Effects of cropping system on days to 50% Heading (DH), Days to Grain Filling (DGF) and days to 90% Maturity (DM) of wheat.

Faba bean varieties	**Hachalu**	**Tumsa**	**Ashebeka**
Planting ratio			
1W:1FB	84.0[a]	83.0[abc]	81.6[bcd]
1W:2FB	81.0[cd]	84.0a	82.6[abcd]
2W:1FB	80.6[d]	82.6[abcd]	83.3[ab]
LSD (0.05)	2.23		
CV (%)	1.56		
Means in column followed by the same letters are not significantly different at 5% level of Significance.			

Table 9: Interaction effects of varieties and planting ratio on days to grain filling of wheat.

Growth parameters

- **Tillers:** Total Tillers Per Plant (TTPP) and productive tillers per plant (PTPP) were not significantly affected by main effects of varieties, intercropping ratios, interaction and cropping system.
- **Leaf area and leaf area index:** Leaf area was not significantly affected by main effect of varieties, intercropping ratios, interaction and cropping system. Leaf Area Index (LAI) of wheat was also not significantly affected by main effect of varieties, interaction and cropping system, but highly significantly ($P<0.01$) affected by main effect of intercropping ratios. Highest (2.4) and lowest (1.0) LAI were recorded at 2W:1FB and 1W:2FB respectively (Table 10). The LAI due to 1W:2FB was significantly lower than that of 1W:1FB and 2W:1FB. This occurred as a result of population density difference leading to aerial resource competition.

Treatments	**Leaf area index**
Varieties	
Hachalu	1.7
Tumsa	2
Ashebeka	1.6
LSD(0.05)	NS
Planting ratio	
1W:1FB	1.9[a]
1W:2FB	1.0[b]
2W:1FB	2.4[a]
LSD (0.05)	0.74
CV (%)	40.8
Means in column followed by the same letters are not significantly different at 5% level of Significance.	

Table 10: Main effects of varieties and planting ratio on leaf area index of wheat.

Yield components and yield of wheat

Number of kernels per spike: Number of Kernels Per Spike (NKPS) was not significantly affected by main effect of varieties and interaction but highly significantly (P<0.01) affected by planting ratio. Similar results of kernels per spike of wheat were counted and recorded among the different faba bean varieties. This implies that faba bean varieties had no effect on kernels per spike. Planting ratio 2W:1FB gave the highest kernels per spike (41.5) while the lowest (36.0) kernels per spike were recorded at 1W:1FB planting ratio (Table 11). No significant difference was observed among intercropped and sole planted wheat for kernels per spike.

Thousand kernel weight: Thousand Kernel Weight (TKW) was none significantly affected by faba bean varieties and interaction effects whereas, planting ratio had highly (P<0.01) significant effect on TKW of wheat. None significant difference was observed in TKW of maize intercropped with different common bean varieties [36]. The highest TKW of wheat (38.7 g) was recorded in 1W:2FB planting ratio. The minimum TKW of wheat (35.5 g) was observed at 2W:1FB (Table 11). In comparing sole cropped to intercropped wheat, TKW was significantly affected by cropping system. This study indicates that when competition for resources is increased TKW showed gradual decrease.

Treatments	Number of kernels per spike	Thousand kernels weight (g)
Varieties		
Hachalu	39.2	37.4
Tumsa	38.3	37.2
Ashebeka	39.5	37.3
LSD (0.05)	NS	NS
Planting ratio		
1W:1FB	36.0^{b}	38.0^{a}
1W:2FB	39.5^{a}	38.7^{a}
2W:1FB	41.5^{a}	35.5^{b}
LSD (0.05)	2.6	0.77
CV (%)	6.68	2.08
Cropping system		
Sole cropped	39.9^{a}	
Intercropped	37.4^{b}	
LSD(0.05)	2.3	
CV(%)	1.7	
Means in column followed by the same letters are not significantly different at 5% level of Significance.		

Table 11: Main effects of varieties and planting ratio on kernels per spike and thousand kernel weight of wheat.

Conclusion

Though non-significant, there was a slight modification on some of the physico-chemical properties of the soil after harvesting for main and interaction effects of verities and planting ratios. On average, available phosphorus was 15.17 mg/kg in intercropping and 11.13 mg/kg in sole planted wheat. Total nitrogen was 0.15 in intercropping and 0.12 in sole planted wheat. The highest available phosphorus (18.38 mg/kg) was recorded in variety Hachalu and 1W:2FB planting ratios. For faba bean component, stand count at establishment and days to 50% flowering were significantly affected by main effects of varieties, but influenced neither by planting ratios nor by interaction effects. Days to 90% maturity was highly significant for main effects of varieties and significantly different for planting ratios. Leaf area and leaf area index was significantly affected by interaction effects of varieties and planting ratios. Number of total tillers per plant was not significantly affected by main effect of varieties, but highly significantly and significantly affected by planting ratios and interaction effects, respectively. Plant height and number of effective nodules per plant was not significantly affected neither by main effects of varieties and planting ratio nor by their interaction effects. Number of pods per plant and thousand seed weight were significant with respect to main effects of varieties, but not for planting ratios and their interaction effects. For wheat component, days to heading, days to grain filling and days to maturity of wheat were not significant for both main effects of varieties and intercropping ratios. Days to grain filling were significantly affected by the interaction effect of varieties and planting ratios. Stand count at establishment was not significantly affected by main effect of varieties, but highly significant for planting ratios. Total tillers per plant and productive tillers per plant were not significantly affected by both main effects of varieties and planting ratios. Plant height was not significantly affected by main effect of varieties, but it was significant for planting ratios. Leaf area index was

not significant for main effect of varieties, but highly affected by main effect of planting ratios. Number of kernels per spike was not significantly affected by main effect of varieties, but highly affected by planting ratios. Planting ratio had highly significant effect on thousand kernel weight, but not for main effect of varieties.

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