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Effect of inter and intra specific Plant Densities on Yield Performance of Broad Bean (Vicia faba L.) at Jarte District, Western Oromia Ethiopia

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Research Article

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Abstract

In the study area the yield of faba bean crop was declined mainly due to improper plant density, and biotic factors. The field experiment was conducted to evaluate the effect of inter and intra row spacing on the yields of faba bean crop. The field experiments consist of 16 treatment combination having four inter-rows spacing (20, 30, 40 and 50 cm) and intra-row (10, 15, 20 and 25 cm) spacing of Dagaga variety of faba bean. The treatment was arranged as Randomized Complete Block Design (RCBD) and replicated three times. The analysis of variance was revealed that the main effect of inter and intra row spacing was showed significant difference on days to 50% flowering, days to 90% maturity, pod length, hundred seed weight and harvest index of faba bean, but plant height, number of pods per plant, and number of seeds per pod was non significantly affected. The longest pod length per plant (8.55 cm and 8.67 cm) were recorded at 13 cm intra and 50 cm inter row spacing. Similarly, the maximum number of pods per plant and number of seeds per pod was recorded at 13 cm intra and 50 cm inter row spacing. Maximum seed yield 4117.11 kg/ha and 3853.17 kg/ha was recorded at 40 cm inter and 10 cm intra row spacing, respectively. But the lowest grain yield 3386.22 kg/ha and 3378.25 was obtained at 50 cm and 13 cm inter and intra row spacing respectively.Therefore, it can be recommended that sowing faba bean crops at 40 cm inter and 10 cm intra-row attain maximum and economic yield at the study area and similar agro ecology.

INTRODUCTION

Faba bean (*Vicia faba* L.) is an annual legumes crop which belongs to the family of Fabaceae. The name of faba bean is varying from area to area, however its large seed broad bean, horse bean [1]. The crop has traditional cultivated in high land areas of Ethiopia for a long period. The plant can withstand harsh and cold climates [2]. Hot and dry spells will result in wilting of the plants and may reduce the seed yield [3]. Unlike most legume crops, the faba bean can be grown in soils with high salinity, as well as in clay soil [4]. The crops prefer a soil pH range of 6.5-9. However, a soil pH below 5 may hinder growth and nodule formation. In the study area farmers select fertile soil for faba bean cultivation and apply cow dung before sowing the seed. Faba bean should not be grown on the same field for more than once every four years, and should not follow oilseeds or other legume as crop rotation because of high potential to create soil-borne diseases [3].

Faba bean crops have high economic value, the grain contain high amount of protein, amino acids, and energy as compared to other legumes like lentils 100 g bean contain 341 calories per 100g [5]. The grain contains plentiful of health benefit such as antioxidants, vitamins, minerals, tyramine and plants sterols. The seed used as Ethiopian diet like shiro-weiti, nufuro and also the plant fix nitrogen fertilizer, used as crop rotation, and the straw used for animal feeds [6].

Raw broad beans also contain the alkaloids vicineand convince which can induce hemolytic anemia in patients with the hereditary condition glucose-6-phosphate dehydrogenase deficiency [7]. This potentially fatal condition is called favism after the fava bean Some epidemiological and *in vitro* studies

suggest the hemolysis resulting from favism acts as protection from malaria, because certain species of malarial protozoa, such as *Plasmodium falciparum*, are very sensitive to oxidative damage due to deficiency of the glucose-6-phosphate dehydrogenaseenzyme, which would otherwise protect from oxidative damage via production of glutathione reductase [8].

The yield of legumes crops was lower as compared to other legumes producing country in the world. The main challenges for low production of seed yields are poor agronomic practices such as; improper plant density, shortage of improved seeds, broad cast sowing method it creates un even distribution of seed on the field, none application of chemical fertilizer and incidence of biotic factors are the main yield limiting factors in the country.Among the yield limiting factors, improper plant density per hectare mainly reduce production because it develops competition among the plants, expose the plants for lodging and made conduce environment for the occurrence of plant pathogen.

In addition to this a wider spacing or low plant population help to air circulation and reduce competition, but the number of plants per plot low and it set low number pods per plant and lower seed yield. Using appropriate sowing methods and optimum number of plant density per hectare the main and important point to increased seed yield of faba bean. However, the producers are used broadcast sowing methods, the plant population per hectare not maintained, this it creates conducive environment for the development of insect pest, pathogen and the plant highly exposed to weed competition final the amount of yield obtained per hectare low. Therefore, the aim of this study was to solve the problems of poor plant density on faba bean plant by setting the following objectives.

- To evaluate the effect of inter row spacing on yield and yield component of faba bean crop.
- To assess the effect of plant density on yield performance of faba bean crop at the study area.

MATERIAL AND METHODS

2.1. Description of Experimental Site

The field experiment was conducted at Horro Guduru Wollega Zone Jardega Jarte district Suxe –katali kebele Agaro farmer field, during 2024 main cropping season. The altitude of the study site is 2420 masl. The study area is characterized by mono-modal rain fall distribution for eight months from April to October.The averages annual rainfall ranges from 1200-1700mm. The annual mean temperature of 18–25˚c and soil of the study site is characteristic as clay loam textural class (Jarte wordas Agriculture profile).

2.2. Experimental Materials

Dagaga variety of faba bean (line designation R-878-3) was developed through research collaboration between the International Center for Agriculture in the Dry Areas (ICARD) and Ethiopia Agriculture Research Institution. The seeds were maintained by Qulumisa Agricultural Research Center and obtained collected as an experimental material. In the country, the plants highly cultivated at an altitude of 18000

to 3000 masl for human consumption. The Dagaga variety relatively high yielder, and dominantly cultivated by farmers. The plant partial resistance to faba bean gall diseases.

2.2. Treatment and experimental design

The factorial experiment consisted of 4 x 4 = 16 treatment combination, the first factors have four inter row spacing of (20 cm, 30 cm, 40cm and 50 cm) and the second factors have (10 cm, 15 cm, 20cm and 25 cm) with Dagaga variety of faba bean. The field experiment was laid out as Randomized Complete Block Design (RCBD) and three times replicated. The treatment was randomly assigned to experimental plot. The seed of faba bean crop was sown at 2m length and 2m width having 5 rows and 0.5m and 1 m spacing between plot and block respectively.

2.3. Experimental Procedures

Experimental field was tilled two to three times starting from April to June using animal power. When the experiment site soil is fine experimental plot was prepared by using daily labor. Improved dagaga variety of faba bean was sown in the last week of June at different inter (20, 30, 40, and 50 cm) and intra row spacing of (10, 15, 20 and 25 cm). Urea fertilizer was applied at 23 kg per hectares at sowing period to initiate root growth. All the field management practices were carried out uniformly. When the crop was reaching physiological maturity stage harvesting was done through human labor. Other field parameter data were collected according their physiological stage. The harvested crop was thrashed on plastic material and weighed per plot in kg/m2, while the measured seed converted in to kg/ha. Crop phenology, growth parameters, and yield component and yield data were collected at different growth stage.

Data Analysis

The collected data was subjected to the analysis of variance using statically procedures SAS 9.4 version. When the Anova showed significant difference treatments means were compared using least significance difference (LSD) test at 5% level of significant.

RESULT AND DISCUSSION

3.1. The main effect of inter and intra row spacing on crop phenology

The main effect of inter and intra row spacing were showed a significant effect ($p < 0.05$) on days to 50% flowering of faba bean (Table 1). But the interaction of intra and inter row spacing was not significantly influence on crop phenology (Table 1). Wider inter and intra row spacing or low plant densities were delayed the days to fifteen percentage flowering, but at narrow spacing or high plant population the flowering dates of faba bean plant was fast. This attributed to due to competition effect for growth resource like space, nutrient, water and solar light. Statically, non-significant difference between 50 cm, 40 cm and 30 cm inter row spacing on days to fifteen percentage flowering of faba bean plant. Increasing inter row spacing no effect on days to flowering, because all plants get adequate number of resources. The current result aligns with [9]. reported that high plant density significantly influenced on

days to fifteen percentage of flowering. [10] found that denser plant population enhance the flowering period of faba bean.

In contrast to this finding [11] Teklu and Solomon days to fifteen percent flowering significantly influenced by plant density and the longest days to flowering was recorded at narrow spacing however, the plant set flower early as the competition for solar decrease.

Days to nineteen percentage of physiological maturity was significantly ($p < 0.05$) affected by the main effects of inter and intra row specific plant densities, but not affected by the interaction effect. Early physiological maturity dates (148.22 and 150.33) were recorded at narrow inter row spacing and (148.83) intra row spacing, respectively. Narrower inter row (20 and 30cm) enhance the physiological maturity period, due to shortage of growth resources the plant matured early, therefore at 5 cm intra row spacing the maturity dates of faba bean crops was faster, this might be due to the fact that competition effect among plants for-growth resource and the plant matured early to sustain their life. Whoever, faba bean plant prolonged days to matured at wider row spacing this attributed to the plant get ample amount of resource and growth vegetatively for long period. In contrast to this finding [12] who reported that wider row spacing enhance the maturity dates of faba bean plant.

Table 1
The main effect of inter and intra row spacing on days to 50% flowering and 90% physiological maturity of faba bean

Treatment	Days to 50% Flowering	Day to 90% physiological maturity
Inter-row		
20 cm	62.00b	148.22a
30 cm	66.22a	150.22a
40 cm	67.67a	155.33b
50 cm	67.67a	156.56b
Lsd (0.05%)	1.87	1.55
Inter-row		
7 cm	64.00c	148.83a
10 cm	65.67b	153.08b
13 cm	67.25a	155.83c
Lsd (0.05%)	1.56	2.76
Cv%	2.69	2.03
AxB	NS	NS

Mean followed by the same letters are non-significant difference at $p < 0.05$% probability levels

3.2. Effect of inter and intra row spacing on growth parameter of faba bean

Plant height (cm)

The main effect of inter and intra row spacing or plant densities significantly influence on plant height, while the interaction effect was non-impact on plant height (Table 2). Tallest height was measured at narrower intra row spacing. This might be to compete light energy plants extend to towards solar radiation. [13] Who reported that taller plant height was recorded at narrow spacing. But at wider spacing the plant get ample amount of resource and taller in height. In addition, at few plants population solar radiation is easily circulated and elongate the plant height. Align with this result [14] and [15] reported that plant height was significantly influenced by plant density and tallest height recorded at wider inter and intra row spacing. At wider row spacing luxurious plant growth and the height of a plant not too much longer as compared to narrow spacing. [16] noted that tallest plant height was recorded at narrower spacing. [17] reported that plant height was not affected by plant density.

Number of branches

The number of branches per plants were significantly affected ($p < 0.05$) by the main effect of plant density (inter and intra row spacing), but the interaction effect did not impact on number of branches per plant (Table 2). Maximum number of branches per plant (4.88 and 4.98) was recorded at wider iter and intra row spacing, but minimum number of branches (3.42 and 4.01) was recorded at narrow spacing. As the competition between plants decreased the number of branches produced per plant was increased i.e ample amount of resource available to plant and increased the number of branches.

In line with [14]; [19]; [15] who reported that increasing the space between plants it raised the number of branches produced per plant. [20] Reported that increasing plant density vestige negatively influenced number of branches per plant. In general number of branches produced per plant is directly proportion to grain yield of the crop. In line with this [21] noted that plant densities of rapeseed were significantly influenced the number of branches produced per plant.

Table 2
The main effect of inter and intra row spacing on plant height and number of branches of faba bean

Treatment	Plant height (cm)	Number of branches
Inter-row (A)		
20 cm	99.22a	3.42c
30 cm	94.67b	4.01b
40 cm	90.33ab	4.56a
50 cm	86.11c	4.88a
Lsd (0.05%)	4.6	0.43
Inter-row (B)		
7 cm	90.25c	4.01b
10 cm	94.50ab	4.38b
13 cm	96.75a	4.98a
Lsd (0.05%)	3.87	0.36
Cv%	4.66	9.48
AxB	NS	NS

Mean followed by the same letters across the column did not significantly different at $p < 0.05$ probability levels

3.3. Effect of inter and intra row spacing on yield components and yields of faba bean

The main effects of inter and intra row spacing showed a significantly influenced on yield components of faba bean plants, but their interaction effect was not- significantly affected the yield components (Table 3). The tallest pod length (8.67 cm) was recorded at wider inter row spacing of 50cm, but shortest height (6.67 cm) record at narrow inter row spacing of 20 cm. This difference in pod length on faba bean plants might be due to the number of plant population within plot it causes competition for growth resource. Similarly, a wider spacing set longer pod length than narrow spacing. Similarly, [9]; [11] reported that the pod length of faba bean plant was significantly affected by plant density and maximum pod length was measured at wider plant spacing. The current result agreed with [22]; [10] noted that high plant density decreased the pod length of faba bean plant due to competition effect on growth resource.

Number of pods per plant

Number of pods per plant was significantly affected ($p < 0.05$) by the main effect of plant spacing, however, the interaction effect did not impact on pods per plant (Table 3). The maximum number of pods per plant was counted at wider inter and intra row spacing. Increasing the inter row spacing from 20 cm into 50 cm it raised the number of pods per plant from 10.89 to 19.33. The number of pods produced per plant was positively associated with maturity dates and plant height of faba bean. As the maturity dates of a plant extend and elongated in height the number of pods per also raised.

In addition to water and nutrient determine the number pods per plants, the rates of light energy required by plant also influence the number of pods produced per plants. Similarly, [22] who reported that the number of pods produced per plant reduced as the plant grown crowdedly. The present result agreed with [13] noted that a pod per plant was significantly affected by plant density of faba bean. [14] Noted that maximum numbers of pods were recorded from the narrower spacing.

Number of seeds per plant

Number of seeds per plant was significantly affected by the main effects of inter row-spacing, but their intra row spacing and interaction effect did not influence on number of seeds per plant (Table 3). At wider inter row spacing, maximum number of seeds per plant were recorded. Increasing the inter row-spacing of faba bean from 20 cm into 50 cm were increased the number of seeds per plant from 3.33 to 4.57. Wider spacing reduce inter competition among plants, and utilizer resource for metabolic activities which leads to increased seeds per pods. Number of seeds produced per pods positively associated with seed yield. The current result agreed with [9] [14] who reported that increasing inter row spacing increased the number of seeds per plant.

Hundred seed weight (g)

Unlike other agronomic parameters hundred seed weight of faba bean plants were non-significantlyinfluenced by the main effects of inter and intra row spacing and by their interaction effects (Table 3).

Table 3
The main effect of inter and intra row spacing on pod length, number of pods per plant number of seeds per pods and hundred seed weight of faba bean

Treatment	Pod length (cm)	Number of pods per plant	Number of seeds per pod	Hundred seed weight (g)
Inter-row				
20 cm	6.67d	10.89d	3.33b	62.14
30 cm	7.44c	13.33c	3.58b	62.22
40 cm	8.11b	18.67ab	4.67a	62.38
50 cm	8.67a	19.33a	4.38a	62.41
Lsd (0.05%)	0.58	0.95	0.43	NS
Intra-row				
7 cm	7.50c	13.58b	4.14	62.38
10 cm	8.06b	15.96a	4.37	62.69
13 cm	8.55a	15.75a	4.55	62.87
Lsd (0.05%)	0.48	0.81	NS	NS
Cv%	7.16	5.96	8.85	0.95
Interaction (AxB)	NS	NS		NS

The mean followed by the same letter across the column did not significantly different at ($p < 0.05$) probability levels

Above ground dry biomass (kg/ha)

The main effect of spacing (inter and intra row-spacing) was significantly influence on above ground dry biomass yield. Maximum above ground dry biomass (12715 kg/ha and 12217 kg/ha) was recorded at (40 cm and 20 cm) inter row spacing and the lowest dry biomass yield (9722 kg/ha) at wider row spacing. Similarly, at narrow intra row-spacing (11749 and 11592 kg/ha) dry biomass yield was recorded but the lowest dry biomass yield was registered at wider row spacing or 13 cm intra row spacing. At wider row spacing the plant grow sparsely, and weighed low above ground dry biomass yield than narrow spacing. Statically, there was non-significant difference at 20, 30 and 40 cm the inter row spacing on dry biomass yield. On the other side increasing the intra row space from 5 cm into 13 cm, it decreases the above ground dry biomass, this might be attributed to the competition effect for resource.

Above ground dry biomass yield was positively associated with plant height, and other yield component parameters. The current result agreed with [5] noted that maximum above ground dry biomass yield was recorded from narrower spacing on soya bean plants. Similarly, [23] reported that the above ground dry biomass of faba bean plants were reduced as the space between plants and rows were increased. In contrast to this finding [16] Tesfaye et al. reported that the above ground dry biomass of faba bean was increased 5035 into 6041 kg/ha as the inter row spacing of faba bean plants increased from 30 cm into 50 cm.

Seed yield (kg /ha)

The seed yield of faba bean plant was significantly affected by the main effects of inter and intra row spacing, but not influenced by their interaction effects (Table 4). The maximum seed yield (4117.11 kg) and (3853.17 kg/ha) was recorded from 40 cm inter and 10 cm intra row-spacing. At wider inter row spacing give more light interception and help for photosynthesis to occur. Whoever the lowest seed yields (3386.22 kg/ha and 33.78.25 kg ha) were recorded from 50 cm inter row and 13 com intra row spacing.Widely spaced plants obtained more resource and well perform which leads to more photosynthesis efficiency and develop the probability of accumulating high dry matter that portioned to grain filling.

Maximum yield was recorded from the individual plants at higher plant population, while at wider spacing the number of plants lower and the amount of yield collected per hectare very low. At wider spacing pulse crops not produce much number of tillers like cereal crops therefore the amount of yield obtained lower, while the problem of narrow spacing or high plant population where it favors for the occurrence of lodging. The current result agreed with [24] reported that maximum seed yield was obtained at the intra row spacing of 10 cm on faba bean plants. [25] reported that faba bean seed yield significantly affected by plant density. Similarly, [26] reported that the seed yield of common bean plant was significantly affected by the plant spacing and the maximum seed yield 1219 kg/ha and the lowest 733 kg/ha was recorded at 30 cm x 10 cm and 20 x5 cm inter and intra row-spacing, respectively. Also, [27] Biabani, noted that chick pea plants set maximum seed yield at plants spacing of 45x 7.5 cm and lowest yield at 35 x5 cm.

Harvest index (%)

Only the main effect of inter row spacing was showed a significant difference on harvest index (Table 4). Maximum harvest index (34.80% was recorded from narrower inter row spacing of 20 cm, but the lowest (32.73%) was recorded from wider inter row spacing of 50 cm, respectively (Table 4).Harvest index was not only affected by agronomic factors like plant spacing, seed rates, fertilizer application but also influenced by whether condition and managemental activities. Align with [28] reported that maximum harvest index on tef plant was recorded at narrower row spacing of 10 cm, but low harvest index at wider inter row spacing of 30 cm. [11] noted that harvest index of faba bean plants were significantly affected

by plant spacing. Increased the space between plants and rows raised the harvest index of faba bean plant. [29] Found that high harvest index was registered at narrower plant spacing.

Lodging effect (%)

Lodging is one of the factors which reduce the yield of crops. Both inter and intra row spacing was significantly influence on harvest index of faba bean plant (Table 4). Maximum lodging (%) (4.02)and 3.49%) was recorded at narrow inter and intra row spacing, but the lowest lodging of 2.52% and 3.00%) were recorded at wider inter and intra row spacing, respectively.

Lodging is the most common problems in cereals, but also sometimes it observed on different crops. Overcrowded plant highly exposed to lodging due to soft root and shoot system or mutualshedding effect of one plant over the other it aggravates the chance of lodging with the help of wind force. Different agronomic practices aggravate the problems of lodging. Among that excess fertilizer application, high seed rates, excess water application, over-crowded plant population, and agro-ecological condition. Therefore, to minimize such production limiting factors utilizing optimum seed rates or plant spacing are more recommendable. [11] Reported that maximum lodging effect was observed at crowded plant population than sparely cultivated faba bean crops. Also, [9] noted that faba bean plant was significantly affected by plant density.

Table 4
The main effect of inter and intra row spacing on dry biomass, yield, harvest index and lodging

Treatment	Above ground dry biomass (kg/ha)	Yield kg/ha	Harvest index (%)	Lodging (%)
Inter-row (A)				
20 cm	12217ab	4042.56ab	34.80a	4.02a
30 cm	12096ab	3902.78b	33.78b	3.60b
40 cm	12715a	4117.11a	29.96c	2.81c
50 cm	9722c	3386.22d	32.73b	2.52d
Lsd (0.05%)	658.7	78.86	1.87	0.25
Inter-row (B)				
7 cm	11749a	3633.42b	32.38	3.49a
10 cm	11592a	3853.17a	33.38	3.22b
13 cm	10908b	3378.25c	33.48	3.00c
Lsd (0.05%)	553.4	78.28	NS	0.2
Cv%	5.47	1.99	5.37	7.29
A x B	NS	NS	NS	NS

The mean followed by the same letters did not significantly different at $p < 0.05\%$ probability levels.

CONCLUSION AND RECOMMENDATION

Faba bean plants werewidely adapted to high land areas;however, the amount of yield obtained per hectares bases are still very low because of poor plant spacing, shortage of improved seeds and occurrence of plant diseases. High number of plants per plot area favor the occurrences of disease and insect pest which leadslowin the amount of yield per hectares. So that using the recommended plant spacing is the best option for yield increment through minimizingbiotic factors and reduce competition among the plants. In general, faba bean plants were highly affected by the main effects inter and intra row-spacing. The faba bean plant was set high amount of seed yield at 40 cm inter and 10 cm intra row spacing. But the lowest grain yield was obtained at wider inter and intra row spacing, respectively. Form this point, using optimum amount of plant spacing was increased the growth and yield component parameters which leads to increased seed yield. Therefore, using 40 cm x 10 cm inter and intra row-spacing can be recommended for faba bean crops.

Declarations

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Conflict of interest

The authors decline no conflict of interest

Ethical clearance:

Before conducting an experiment the author's give awareness creation for the community in clear language, respect for person and informed for what purpose the experimental conducted on his farm field. Who benefited from these research output. Based on their positive response of the farmer the experimental site was used. During conducting an experiment the author not influences the moral, norms, and value of community. When conducting an experiment under field condition the materials or chemicals used for these trials not affect on environment, human being, animals and any organism.

Data availability:

The row data is available on my hand, when the paper gets acceptance and its request by reviewer it's possible to submit immediately.

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Author Contribution

Starting from proposal preparation, field designing and works, data collection and analysis and manuscript preparation all the activities were done by the research.

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