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Effect of Different Row Spacing on Common Bean Varieties (*Phaseolus vulgarie. L)* At Mechara Agricultural Research Center, Oromia, Ethiopia

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Abstract: The experiment was conducted at Mechara Agricultural Research center in 2020/2021 with objective of to determine the effect of inter-row spacing on yield components and yield of common bean varieties. The experiment was consisted factorial combination of two common beans (Awash-2 and Chercher) and seven inter-row spacing (25, 30, 35, 40, 45, 50 and 55 cm). Fourteen treatments were laid down in randomized complete block design (RCBD) which replicated three times per treatment. From analyzed data day to flowering, plant height, primary branch, leaf area, seed per pod, biomass, grain yield, hundred seed weight and harvest index were significantly affected by inter row spaces at $p<0.05$. Days maturity, plant height, pod length, primary branch, leaf area, pod per plant and seed per pod were significantly affected by variety difference. at $p<0.05$ and others trait such as plant height, pod per plant, seed per pod, grain yield and hundred seed weight were significantly affected by interaction effect of inter-row spacing and variety at $p<0.05$. From the analyzed result highest grain yield (2913kg ha^{-1}) was recorded from Awash-2 variety when planted at 35cm inter-row spacing and the next highest yield was (2543kg ha^{-1}) was recorded by chercher variety at 50cm inter-row spacing. Therefore sowing Awash-2 varieties at 35cm and chercher variety 50cm inter-row spacing could be appropriate at the in study areas. Since the experiment was done for one year it is better to repeat the experiment over years and location for further recommendation.

Keywords: Main Effect, Interactions Effect, Yield

1. Introduction

Ethiopia is the home land of several crop and ranked 13th among pulse producing countries in the world [1]. Pulse is the main source of food security reduced crop in Ethiopia. Its production and supply increased due to increased demand in both local and international markets [2].

Common bean (Phaseolus vulagris L.) is an annual crop belonging to the family Fabaceae which is grown predominantly by smallholder producers as a source of food and cash crop in Ethiopia [2]. It is one of the fast expanding legume crops that provide an essential part of the daily diet and foreign earnings for most Ethiopians. SNNP, Amhara, Oromia and Tigray are main common producer regions of Ethiopia [3]. The productivity of the Common bean in study areas 16.7Qtha^{-1} which is below the national average productivity 18.22Qtha^{-1}[3]. The low productivity was attributed to different factors like moisture stress, poor agronomic practice, disease, pests and lack of improved technology [4]. In west Hararghe zone, farmers produce Common bean for market and consumptions. However, they did not get enough yields from his land because of lack of appropriate agronomic practice. Such as, seed rate and inter row space is the main problems in study areas from field observations. Different crops have different nature one may grow up and other may grow on field and need more space and the same space were recommended for all pulse crop so this study was conducted with objective of:-

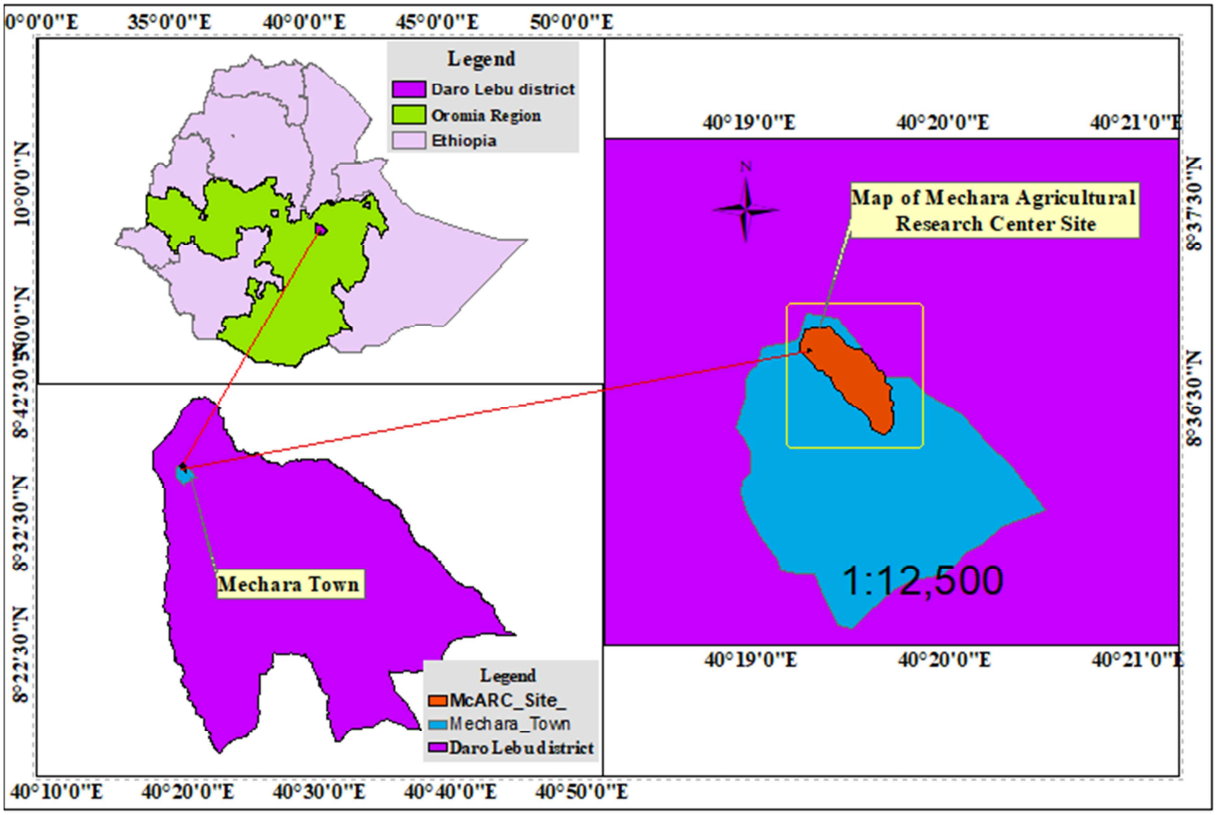
1. To determine effects of different inter row spaces on yield components and yield of common bean varieties.

2. To evaluate performance of common bean varieties at different inter rows spacing's
3. To determine the best inter-row spacing for common bean varieties (Awash2 and Chercher).

2. Material and Methods

2.1. Descriptions of Experimental Site

The experiment was done at Mechara Agricultural research center in 2020/2021 cropping season which is found in west Hararghe zone with latitude $8^0$36'30"N, longitude 40^0 20'E and 434 km away from Addis Ababa at south east direction. The altitude of the area is 1700 meter above sea level and it receives annual rainfall of 871 mm and has average annual minimum and maximum temperatures of 8.9 and 23.4°C, respectively. The soil type of the center classified as sandy loam [5].



Source: my own arc design, 2021

Figure 1. *Location of Mechara Agricultural Research center.*

2.2. Experimental Materials

For study two types of common varieties namely Chercher and Awash-2 varieties were selected according to their agro ecological performance and adaptability.

Table 1. *variety description.*

Character	Common bean variety	
	Awash-2	Chercher
Altitude. a. s. l	1300-1700m	1650-2200
Seed size	Small, medium &large	Medium
seed color	White	White
Yield (Qtha-$^{1)}$ on station	28-31	17-33
yield (Qtha-^{1}) on farmers field	18-22	20-30
Released center	Melkasa ARC	Haramaya University
year of released	2013	2005/2006

Source: [6] and [15]

2.3. Treatments and Experimental Design

The treatments combination consist of two common bean varieties (Awash-2 and Chercher) with seven inter row spacing (25cm, 30cm, 35cm, 40cm, 45cm, 50cm and 55cm). Fourteen (14) treatments combinations were arranged in a factorial experiments using Randomized Complete Block Design (RCBD) with three replications. The experimental field has 34.5 m length and 11m width; thus the gross area of the experiment was 379.5 m^2. Net plot area was 28m length and 9m width which is 252 m^2. 1m and 0.5m distance was used to separate blocks and plots, respectively and the area of one plot was 3m*2m = 6m^2.

2.4. Experimental Procedures and Field Management

Land preparations were done 3 up 4 times in 2020/2021 cropping seasons and leveled manually before sowing. Common bean variety were sown on July 30,2020 by row

planting and was covered by hand on gross plot size of (3m x 2m) accommodating 12, 10, 9, 8, 7, 6 and 5 rows were used. 80kg ha^{-1} seed rate was used during planting was conducted. The outer most rows at both sides of plots within were considered as borders. A 1.5m wide- open strip separated the blocks whereas the plots within a block were 1m apart from each other. Crop was sown by putting two seeds with 10cm intra row spacing and (25, 30, 35, 40, 45, 50 and 55cm) inter row spacing. In accordance with specifications of the design, each treatment was assigned randomly to experimental units. The recommended 100 kg ha^{-1} DAP was applied at planting time. The common bean variety was thinned to one plant per stand weeks after emergency. Weeding was done at any times of the day when the field were emerged to prevent competitions with the crop. After the crop reach fully maturity stage harvesting was done by hand at the grain moisture contents.

2.5. Collected Data

Crop phenology and growth

1. *Days to flowering*: was obtained visually by counting number of days from the sowing up 50% of the plant bear a flower.
2. *Days to physiological maturity*: Days to maturity was determined as the number of days from sowing to the time when the plants reached 90% physiological maturity based on visual observation.
3. *Number of primary branches per plant:* It can be determined at physiological maturity by counting the total number of primary branches from randomly selected five plants and the average was calculated.
4. *Plant height:* Plant height was measured at 90% physiological maturity from the ground level to the tip of plant by using meter from five randomly selected plants and the average was calculated.

Yield Components and Yield

1. *Number of pods per plant:* This was obtained by counting number of pods from each selected sample of five plants and the average was calculated.
2. *Pod length:* was measured by using ruler from five pods of five selected plants or one pod per plant and average was calculated.
3. *Number of seeds per pod:* This parameter counted by taking five plants per plot at harvesting and the number of seed per pod was calculated.
4. *Hundred seed weight*: was measured after harvesting by counting hundred representative seeds from each treatment and the seed was measured by using sensitive balance.
5. *Above ground dry biomass (kg ha^{-1}):* This was done by selecting five plants from each plot randomly, then harvest full above ground and dried, finally weighted and converted to hectare.
6. *Grain yield (kg ha^{-1}):* Five sample plants was randomly selected from each plot and measured by using sensitive balance after adjusting the moisture content of the grain, and then grain yield was converted to per hectare.
7. *Harvest index (%):* Is the ratio of grain yield and biomass yield and multiplied by hundred and formulated as follow*:*

HI= Grain Yield obtained (kg ha^{-1}) X 100% / dry biomass (kg ha^{-1})

Co-relations: by using excel co-relations was done in order to see the relationship of grain yield with other parameters

3. Method of Data Analysis

All the collected data were analyzed by using analysis of variance (ANOVA) procedure using Gene stat (15^{th} edition). A significant difference between treatments was delineated by using Least Significance Difference at 5% level of significance.

4. Result and Discussion

4.1. Phenology and Growth Parameter

Days to 50% Flowering

The result of ANOVA revealed that there was significance difference among the inter-row spacing on days to 50% of flowering, but there was not significance difference between the main effects and the interaction of variety (Appendix Table 1). The delayed days to 50% flowering (69.83) was observed at 55 cm inter-row spacing and the earlier days to 50% flowering (39.17) was observed at 30 cm inter-row spacing (Table 2). This may be due to narrow inter row space was affected by nutrient competition's because of high number of populations per plot. Days to 50% flowering of soya bean was significantly affected by main effect of inter row spacing [7]. But contrary result was reported by [9] and days to flowering was delayed more at wider rows than narrower rows [7].

Days to 90% Physiological Maturity

Days to 90% physiological maturity of haricot bean was affected by the main effect of variety but not significantly influenced by inter-row spacing and their interaction at $p < 0.05$ (Appendix Table 1). The delayed days to 90% physiological maturity (89.62 days) was observed on Awash-2 variety and the earlier days to 90% physiological maturity (87.9 days) was observed on Chercher variety (Table 2) and this may be due to their biological differences. This indicted that Chercher variety was early matured as compared to Awash-2 variety. On soy-bean, main effect of variety has significant effect on days to 90% maturity [8], day to 90% physiological maturity was non-significantly affected by inter row spacing at ($p<0.05$) [9]. Days to maturity linearly increased with row spacing it may be due to plant grown on narrow spacing exposed to sever resource competitions.

Table 2. *The Main Effect of Variety and Inter-Row Spacing on Haricot-bean Phenology, growth and yield components.*

Treatments	Parameters					
Variety	**Days to flowering**	**Days to Maturity**	**Primary Branch**	**Biomass (kg ha^{-1})**	**Harvest Index (%)**	**pod length (cm)**
Awash 2	58.81	89.62a	4.59b	6067.7	38	8.33a
Chercher	60.19	87.9b	5.31a	5572	42	8.01b
LSD (5%)	NS	1.23	0.3	NS	NS	0.3
Row-Spacing (cm)						
25	59.17b	88.67	4.33c	7113a	30.2a	8.22
30	39.17c	88.33	4.13c	6475a	40.84a	8.15
35	61.17b	89.67	4.53bc	6206a	42.02a	7.99
40	58.33b	87.5	4.96b	5401a	39.96a	8.21
45	60.17b	89.5	5.46ab	5289a	42.02a	7.98
50	58.17b	87.83	5.46ab	4744b	51.31b	8.32
55	69.83a	89.83	5.76a	5511a	34.69a	8.23
LSD (5%)	3.488	NS	0.56	2043	19.1	NS
CV (%)	4.9	2.2	9.6	29.6	28	5.8

Means within column followed by the same letter in the column are not significantly different at 5% of probability level. NS= Non-Significant.

Number of Primary Branches (Npb)

The main effect of variety and inter-row spacing was highly significant on number of primary branch at $P < 0.05$. But the interaction of inter-row spacing and varieties on number of primary branch was not significant (Appendix Table 1) and similar result was reported by [10] and [8]. The highest number of primary branches (5.31) was recorded in case of Chercher variety and the lowest number of primary branches (4.59) was recorded in case of Awash 2 variety (Table 2). The highest number of primary branches (5.77) was recorded at 55 cm inter row spacing and the lowest primary branch (4.33) was recorded at 25 cm spacing (Table 2). At narrow spacing the plant bears less number of branches.

Plant Height

Plant height was significantly affected by both main effects; inter row space and varieties, as well as their interaction effect of inter row spaces and variety at $P<0.05$ (Appendix Table 1). The highest plant height (131.4cm) was observed in case Awash 2 variety at 55 cm spacing and the lowest plant height (67.5cm) was observed in case of Chercher variety at 25 cm spacing (Table 3). Similar result was reported by [9]. In this study the plant height has a positive correlation with row spacing (Table 6).

Table 3. *Interaction effect of Inter Row spacing and Variety on plant Height (cm) and pod per plant.*

Parameter	Inter-Row Space (cm)								LSD 5%	CV
	Variety	**25**	**30**	**35**	**40**	**45**	**50**	**55**		
Plant Height	Awash-2	75^{cd}	90.3^{cd}	104.8^{bc}	117.4^{ab}	103..4^{bc}	108.1^{bc}	131.4^{a}	21.58	18.9
	Chercher	67.5^{d}	80.4^{cd}	86.5^{cd}	85.8^{cd}	80.9^{cd}	108.1^{bc}	106.1^{bc}		
Pod per plant	Awash2	18.93^{bc}	20.90^{ab}	26.2^{a}	18.4^{bc}	20.8^{ab}	18.67^{bc}	16.33^{bc}	6.18	19.8
	Chercher	16.07^{bc}	13.27^{c}	12.73^{c}	15.87^{bc}	20.87^{ab}	23.4^{ab}	18.33^{bc}		

Mean flowwed by the same latter in a row is shows non significance at 5% lSD

4.2. Yield Components and Yield Parameter

Pod length

Pod length was affected by the main effect of variety but not affected by inter-row spacing and their interactions at $p<0.05$ (Appendix Table 1). The highest pod length (8.33 cm) was recorded from Awash-2 variety and the lowest pod length (8.01cm) was recorded from Chercher variety (Table 2). This variation of pod length may be due to genetic variation of the variety. The main effect of inter-row spacing was non-significant on pod length [7].

Number of Pods per Plant

There was a highly significant difference among the interaction of inter-row spacing and varieties as well as main effect of variety on number of pods per plant at $p<0.05$ (Appendix Table 1). The highest pod per plant (26.2) was recorded from Awash 2 variety at 35 cm spacing and the lowest pod number (12.73) was recorded in case of Chercher at 35cm spacing with no statistical difference at 30 cm spacing (Table 3) and the same result was reported by [11] and [12].

Number of Seed Per Pod

The interaction of variety and inter-row spacing had significant effect on seed per pod at $P<0.05$ (Appendix Table 1). The highest average number of seeds per pod (6.67) was recorded from Chercher variety at 50cm and Awash 2 variety at 30 cm spacing but the lowest value of seed per pod (4.33) was recorded from Chercher variety at 55cm spacing with no statistical difference with Awash-2 variety at 55 cm spacing (Table 4) and this is result also confirmed with the result of [13].

Table 4. *Interaction effect of Inter-row Space and Variety on Seed per Pod and grain yield.*

Parameter	Variety	Inter-Row Space (cm)							LSD 5%	CV
		25	30	35	40	45	50	55		
seed per pod	Awash-2	5.67^{b}	6.67^{a}	5.33^{bc}	5.67^{b}	5.33^{bc}	5.67^{b}	4.67^{cd}	0.88	9.8
	Chercher	5^{bcd}	5.33^{bc}	5^{bcd}	5^{bcd}	5^{bcd}	6.67^{a}	4.33^{d}		
Grain yield	Awash2	2176^{bc}	2371^{abc}	2913^{a}	2149^{b}	2209^{bc}	2009^{bc}	1318^{d}	588.6	16.3
	Chercher	2067^{bc}	2117^{bc}	2071^{bc}	1983^{bc}	2248^{bc}	2543^{ab}	1808^{cd}		

Means followed by the same letter within the rows and columns are not significantly different at 5% level of significance

Above Ground Dry Biomass (Kg ha^{-1})

Above ground dry biomass was significantly affected by main effect of inter row spacing, whereas variety and their interactions at $p<0.05$ was non-significantly affected above ground dry biomass (Appendix table 1). The highest above ground dry biomass (7113kg ha^{-1}) was recorded by Chercher variety at 30cm spacing and the lowest above ground biomass (2700kg ha^{-1}) was recorded by Awash-2 variety at 55 cm spacing (Table 2). Biomass yield increase with decreasing inter row spacing [7].

Grain Yield (Kg ha^{-1})

Grain yield was significantly affected by the interaction of inter row spacing and varieties at $p< 0.05$ (Appendix table 1). Higher grain yield (2913 kg ha^{-1}) was recorded from Awash-2 variety at 35 cm spacing with no statistical difference with Chercher variety at 50 cm spacing and the lowest grain yield (1318 kg ha^{-1}) was recorded from Awash-2 at 55 cm spacing (Table 4). As row space become wide, population number is reduced, so grain yield obtained from wide row space is also reduced.

Harvest Index (%)

Harvest index was significantly affected by main effect of inter row spacing but variety as well as the interaction effect of inter row spacing and variety was not significant (Appendix Table 1). The highest harvest index (51.3%) was recorded at 50cm inter row spacing and the low harvest index (30.2%) was record at 25cm inter-row spacing. Even if there was no significance difference between the varieties on harvest index of haricot-bean., the highest harvest index (42%) was recorded from Chercher variety and the lowest harvest index (30.2%) was recorded from Awash 2 variety (Table 2).

Hundred Grains Weight (G)

The ANOVA result revealed that, the interaction of inter row spacing and variety has significant difference on hundred grain weight at $p<0.05$ (Appendix Table 1). Higher hundred grains weight (22.33gm) was recorded from Awash 2 variety at 35 cm spacing and the lowest hundred grains weight (17.67gm) was recorded from chercher variety at 55 cm spacing (Table 5) and the same result with this experiment on variety [12], but contrary result was happened at interaction which is non-significant. Similarly variety effects were highly significance. But inter row spacing and the interaction of inter-row spacing and variety was none significantly affect hundred seed weight [8].

Table 5. *Interaction Effect of Inter-Row Spacing and Variety on humdred grain weight (gm).*

Variety	Inter-Row (cm)						
	25	30	35	40	45	50	55
Awash2	19^{bc}	19.67^{bc}	22.33^{a}	18.33^{c}	18.67^{c}	19.33^{bc}	18.67^{c}
Chercher	18^{c}	19^{bc}	18.33^{c}	18.67^{c}	19.33^{bc}	21.33^{ab}	17.67^{c}
LSD 5%		2.183*					
CV		6.8					

Means followed by the same letter within rows and columns are not significantly different from each other at 5% probability level.

Co-Relation Test Between Parameters of Common Bean

There was positive and negative correlation effect among the traits of common bean that has been tested. grain yield of haricot-bean has strong positive correlation (0.92) with pod per plant, good positive correlation (0.69) with pod length, seed per pod (0.74) and week positive correlation (0.3) with hundred seed weight and very weak (0.033) positive correlation effect with harvest index (0.033). There was a negative correlation of grain yield and other parameters such as date of 50% flowering (-0.016), number of primary branch (-0.29), date of 90% maturity (-0.14), haricot-bean leaf area (0.13) and plant height (-0.13) (Table 6). Grain yield has positive co-relations with day to flowering (0.35), day to maturity (0.30), plant Height (0.43), number of seed per pod (0.44) and number of pod per plants (0.63) [14].

Table 6. *Correlation of Yield Component and Yield of Haricot Bean Variety.*

Parameter	DF	NPB	DM	LA	PH	PPP	PL	SPP	GY	HSW	HI
DF	1	0.085	0.67*	-0.1	-0.1	0.115	-0.09	0.06	-0.016	0.23	-0.34*
NPB		1	-0.04	0.15*	0.15*	0.07	0.096	-0.12	-0.29	-0.075	0.03
DM			1	0.05	0.049	0.36*	0.296*	-0.07	-0.14	0.19	-0.39*
LA				1	0.999**	0.21*	0.024	-0.068	0.13	0.094	0.13
PH					1	0.21*	0.23*	-0.01	-0.13	0.09	0.13
PPP						1	0.17	0.89**	0.92**	0.6**	-0.045
PL							1	0.3*	0.69**	0.1*	-0.15

Parameter	DF	NPB	DM	LA	PH	PPP	PL	SPP	GY	HSW	HI
SPP								1	0.74*	0.45*	0.01
GY									1	0.3*	0.4*
HSW										1	0.033
HI											1

Where DF (day of flowering), NPB (number of primary branch), DM (day of physiological maturity), LA (Leaf Area), PH (plant height), PPP (pod per plant), PL (pod length), SPP (seed per pod), GY (grain yield), HSW (hundred seed weight), and HI (Harvest Index)

5. Conclusion and Recommendation

Generally this study reveal that Day to 50% of flowering, plant height, number of primary branch, leaf area, seed per pod, grain yield, hundred seed weight, biomass and harvest index was significantly affected by inter row space at $p<0.05$. But day to 90% physiological maturity, pod per plant, and pod length was non significantly affected by inter row space, similarly variety difference was significantly affect day 90% physiological maturity, plant height, pod length, primary branch, leaf area, pod per plant and seed per pod at $p<0.05$. In addition, plant height, pod per plant, and seed per pod, grain yield and hundred seed weight was significantly affected by interaction effect of inter row spaces and variety differences of haricot bean at $p<0.05$. Therefore, row space and variety difference as well as their interaction has significant effect on yield and yield component of haricot bean. Trail planted by wide inter spaces reach day to flower and day to maturity need more days than narrow inter row spaces. Awash-2 variety gives maximum yield (2915kg ha^{-1}) when planted at 35cm and minimum yield (1318kg ha^{-1}) when planted at 55cm inter row spaces while Chercher variety of haricot bean give high yield (2543kg ha^{-1}) at 50cm and lowest yield (1808kg ha^{-1}) at 55cm space. Therefore practicing appropriate inters row space with variety can increase yield and yield component. So, according to the result of this experiment to recommend that sowing Awash-2 varieties at 35cm inter-row spacing and chercher variety at 50 cm inter row spacing is appropriate for the study area. Since the experiment was done for one year it is better to repeat the experiment over the year and location for further recommendation.

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