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Effect of Spacing on the Growth Parameters of Common Bean (*Phaseolus vulguris* L.) at Keker, Southwestern Ethiopia

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***Abstract* – Establishment of optimum plant population per unit area of the field is essential to get maximum yield. Field experiment was carried out to select the best spacing that maximize the growth parameters and to compare different spacing effect with recommended spacing on common bean in 2012 cropping season at Keker, Mizan-Tepi University, Southwestern, Ethiopia. The experiment was conducted using randomized complete block design (RCBD) with three replications and with the following treatments. A common bean variety "*Nasir*" seed was used for the experiment. Significant differences in growth parameter were occurred due to the treatments. A common bean planted with 30cm X 5 cm spacing gave significantly higher plant height (105.83cm) compared to the others. However, a common bean planted with 50 cm X 15 cm spacing produced significantly more number of leaves (76.17) than others. The time required to reach 50% date of flowering increase with increase in spacing. A common bean planted with 50 cm X 15 cm, 40 cm X 15 cm, 40 cm X 10cm. 40 cm X 5cm and 30 cm X 5cm reached 50% flowering 34, 36, 38, 39, 40 days after sowing, respectively. Therefore, it could be concluded that the improved common bean variety "*Nasir*" could be planted at optimum spacing of 40 cm X 15 cm to attain maximum yield. It is further recommended that these results are from only one season at one site and hence such studies may be repeated in space and time to reach at concrete recommendations.**

***Keywords* – Common Bean, Growth Parameters, Spacing.**

I. INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an annual herbaceous dicot that belongs to the Fabaceae family. It was originated in tropical America (Mexico, Guatemala, and Peru), but there are also evidences for its multiple domestication within Central America [1]. The crop occupies more than 90% of production areas sown under *Phaseolus* species [2].

It is well adapted to areas that receive an annual average rainfall ranging from 500 – 1500 mm with an optimum temperature range of 16 – 24^{o} C, and a frost – free period of 105 to 120 days. However it does not grow well below 600 m above sea level, due to unable to set pod & pod developmet caused by high temperature [3]. Suitable production areas of beans in Ethiopia has been indicted as areas with altitude between 1200 – 2200 above sea level, with mean maximum and minimum temperature of less than 32^{0}C and greater than 10^{0}C respectively with annual rainfall ranging from 350 – 700 mm well distributed over 70 – 90 days [4 and 5].

Common bean is an important source of protein and energy in human diets in the tropics and subtropical developing countries particularly in the Americans and eastern and southern Africa. The crop is the most important food and export crop in Ethiopia and it is the source of protein and cash for poor farmers [6]. Apart from being food and source of income, common bean also replenishes the soil fertility through nitrogen fixation. According to [7], the current national average yield of haricot bean is one tone per hectare. The total area and total production is estimated to the 231,443 hectare and 241.41 tons respectively.

Low yield of common bean in Ethiopia is attributed to several production constrains which includes lack of improved varieties for the agro ecological zones. Poor cultural practices such as untimely and in appropriate field operations, weed infestation, low soil fertility, water stress disease and insect pests [4 and 5].

Establishment of optimum plant population per unit area of the field is essential to get maximum yield. Under conditions of sufficient soil moisture and nutrients, higher plant population is necessary to utilize all the growth factors efficiently. The level of plant population and should be in such that a maximum solar radiation is utilized. The full yield potential of an individual plants is fully exploited when solon at wider spacing. Yield per plant decreases gradually as plant population per unit area increase. However, the yield per unit area is increased due to efficient utilization of growth factors [9].

High plant density causes certain modification in the growth of the plants like increase in plant height, reduction in leaf thickness, alteration in leaf orientations, erect leaf development, narrow and vertically arranged intervals to intercept more sun light [9]. Too narrow spacing affects grain yield through competition for nutrient, moisture, air, radiation etc. therefore, optimum planting density should be determined [10].

Ethiopian economy is characterized by low levels of productivity and subsistence farming system that has resulted hand to mouth production. The only way to increase the agricultural production from small scale to large scale and export level is to increase the productivity per unit area and time [11]. Under conditions of sufficient soil moisture and nutrient, higher population is necessary to utilize all growth factors efficiently. In order to intercept maximum sunlight to produce high dry matter as the intercepted solar radiation, crop plants should have to cover the soil as early as possible and as plant density increases, the amount of dry matter in vegetative part also

increase [9]. Therefore, by maintaining suitable plant spacing under available resource and suitable agro ecological condition, it's possible to increase the field of common bean and production. Therefore, the objectives of this study are:

- To select the best spacing that maximize the growth parameters.
- To compare different spacing effect with recommended spacing.

II. Materials and Methods

2.1. Description of the Study Site

The experiment was conducted in Southwest Ethiopia, in Southern Nation Nationality People of Region (SNNPR) at Bench Maji zone, Mizan Aman district in Mizan – Tepi University at a site called Keker in its local name. The research was conducted during 2012 cropping season. Mizan town is located 561 km from Addis Ababa, the capital city of Ethiopia and its geographical location is 06^0 59.16N and 039^0 39.83'E in attitude and longitude. The study site is situated at an attitude about 1350 – 1400m above sea level and receive a mean annual rainfall of 1750 – 2000 mm. The average mean minimum and maximum temperature of an area are 21^0c and 30^0c, respectively. The soil of the study site is dark brown in color. The area is suitable for maize, haricot bean, coffee, taro, mango, avocado, papaya, etc. production (personal communication).

2.2. Treatments and Experimental Design

The experiment was conducted using randomized complete block design (RCBD) with three replications and with the following treatments. Letter T was used for treatments.

T_1 = 50 cm X 15 cm
T_2 = 40 cm X 15 cm
T_3 = 40 cm X 10 cm
T_4 = 40 cm X 5 cm
T_5 = 30 cm X 5 cm

The total area of the experimental field was 78 m^2. A plot size of 1m X 2m ($2m^2$) was used and spaced 50 cm a part. A plant population of 140,000, 175,000, 250,000, 500,000 and 700,000 plants per hectare was grown in T_1, T_2, T_3, T_4 & T_5, respectively T_3 was used as control group which is a recommended spacing for common bean

2.3. Material Used, Planting Material and Cultural Practice Material Used

- Seed
- Spade
- fork
- Rope
- Meter
- Peg

A common bean variety called Nasir was used as a planting material and the variety was obtained from Melkassa agricultural research center (MARC), Ethiopia. The land was first ploughed by pair of oxen and made into fine tilt and leveled manually by using spade and fork. Sowing was done at May 11, 2012 according to spacing desired for each treatment. Plots were monitored regularly from weed and insect pest.

2.4. Data Collected

Data were collected from the net plot areas of each treatment which was guarded by one or more border rows as per the treatments description. The parameters adopted for data collection were:

- ✓ Plant height
- ✓ Number of leaf per plant
- ✓ 50% day of flowering

2.5. Data Analysis

Collected data were subjected to the analysis of variance (ANOVA) with the appropriate design as per [12] using SAS version 9.2 computer software program [13]. Mean separation was performed for significant treatment means using Least Significant Difference (LSD) at 5% level of probability.

III. Results and Discussion

The analysis of variance indicated that there is a significant difference due to the different spacing on plant height. Plant height in common bean is a combination of better crop growing condition and varietal characteristics it contributes considerably to increase crop biomass. On the basis of result obtained plant height increase as the spacing become narrow. A common bean planted with 30cm X 5 cm spacing gave significantly higher plant height (105.83cm) compared to the others. The common bean planted in 40cm X 5cm and 40cm X 15cm produced non – significant difference in plant height from recommended spacing 40 cm X 10 cm which produced a plant height of (70.08cm). A common bean planted with (50 cm X 15cm) spacing produced significantly lower plant height of (50.83cm). This finding is concomitant with the finding of [14] which showed that there is an increase in plant height with increased plant density. On the other hand, [15] reported that at a fixed row width, with the increase in plant density, the plant spacing within the row decreases that results in an increase in inter plant competition which results for an increase in plant height.

Table 1: Plant height of common bean as affected by different spacing.

Treatment	Plant Height (cm)
T_1 = 50 cm X 15 cm	50.83^c
T_2 = 40 cm X 15 cm	67.33^b
T_3 = 40 cm X 10 cm	70.08^b
T_4 = 40 cm X 5 cm	75.92^b
T_4 = 30 cm X 5 cm	105.83^a
LSD 0.05% = 9.4	
CVC(%) = 6.62	

LSD=Least significant difference at alpha 5% level, CV (%) = Coefficient of variation,
Means followed by the same letter(s) in a column are not significantly ($p < 0.05$) different from each other

The experiment result also showed that there was a significant difference among the treatments in leaf number per plant (Table 2). Leaf number increased as the spacing

become wider and wider. A common bean planted with 50 cm X 15 cm spacing produced significantly more number of leaves (76.17) than others. A common bean planted with 40 cm X 15 cm has non significant difference in leaf number (66.25) from T_3 (40cm X 10 cm) with leaf number of (59.83). These treatments produced significantly lower leaf number of (46.25 and 38.08) than others. This is due to inter and intra row competition for light, but common bean planted with wider spacing of (50 cm X 15 cm) have adequate space to extend its leaf and intercept more light with less competition.

Results showed there was significant difference due to the variation of spacing. Time required to reach 50% date of flowering increase with increase in spacing. A common bean planted with 50 cm X 15 cm, 40 cm X 15 cm, 40 cm X 10cm. 40 cm X 5cm and 30 cm X 5cm reached 50% flowering 34, 36, 38, 39, 40 days after sowing, respectively. The reduced competition at wider spacing made plants to have optimum growth speed than narrow planted common bean which fasten the growth speed than narrow planted common bean which fasten the growth speed due to an increase in competition for available resources. Plants show extreme plasticity, responding remarkably in size and form to environmental conditions. One of the most potent of these external forces is the presence of competing neighbors, which may reduce a plant to diminutive size. The factors for which competition may occur among plants are water, nutrient, light, oxygen and carbon dioxide and in the reproductive phase, agents of pollination and dispersal. Water, nutrients and light are the factors most commonly deficient. When the immediate supply of a single necessary factor falls below the combined demand of the plants, competition begins.

Table 2: Leaf number of common bean as affected by different spacing.

Treatment	Leaf Number
T_1 = 50 cm X 15 cm	76.17 [a]
T_2 = 40 cm X 15 cm	66.25[b]
T_3 = 40 cm X 10 cm	59.83[b]
T_4 = 40 cm X 5 cm	46.25[c]
T_4 = 30 cm X 5 cm	38.08[c]
LSD 0.05% = 13.14	
CVC(%) = 12.16	

LSD=Least significant difference at alpha 5% level, CV (%) = Coefficient of variation,
Means followed by the same letter(s) in a column are not significantly ($p < 0.05$) different from each other

For a low density of plants of a single species increasing the density increases yield per unit area and intraspecific competition becomes more intense, because greater number of individuals compete for the same common limiting resources. In pure stands, increase in the intensity of competition manifests itself by the reduction of the performance of the individual, e.g. biomass of single plant and/or reduction of grain weight per plant.Too narrow and too wide spacing do affect grain yields through competition and due to the effect of shading. In the case of too wide spacing, yield reduction can occur due to inefficient utilization of the growth factors.

Similarly, [16] reported that wide plant spacing of 50 cm reduced number of days to flower. Also [17] reported that common bean grown at increased population which has inter and intera-specific competition flowered faster than plant at lower population. However, [18] found no significant effect of plant population on days to flowering of common beans. In general the experiment result showed that common bean variety Nasir growth parameters altered by spacing the number of leafs and plant height significantly response to different spacing.

IV. Conclusion

Common bean is a major legume crop that can be grown on a wide range of agro ecological conditions. However, there is less common bean production in Bench Maji zone. Around local village of Mizan, there is a potential of land for common bean production, but the crop is not widely cultivated. A common bean variety Nasir which has an indeterminate growth habit, shown a significant difference in plant height and leaf number. Also 50% flowering date become early with narrowing of spacing this shown that environmental condition at keker is suitable for common bean production. If there is ample resources (moisture, nutrient and light), it is possible to apply narrow spacing (30cm X 5cm and 40cm X 5cm) to increase the yield per unit area and time by efficient resource utilization. Also wider spacing (40cm X 15cm and 50cm X 15cm) can be practiced in arid regions, where there is moisture deficiency and ample radiation, because low plant population minimizes a competition for moisture and interception of large solar radiation for an increase in dry matter production and grain yield. Generally, it is possible to estimate the effect of spacing on the later stage of growth and on the grain yield from results obtained on growth parameters at early stage and to provide a realistic recommendation for farmers growing common bean regarding to the effect of spacing on the yield, but further research should be carried out to reduce the effect of too narrow and wider spacing and to determine the optimum plant population to maintain the grain yield.

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AUTHOR'S PROFILE

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was born in Ghimbo Woreda, Kaffa Zone, Southern Ethiopia, May 26 in 1987. The author attended his Elementary education at Hibret Primary School. Then, the author joined Gimbo Junior and Secondary School in 1998. After taking the Ethiopian General Secondary Education Examination in 2003, the author joined Preparatory Program at Bonga Comprehensive Secondary High School now called Bishaw Woldeyohannes Comprehensive Secondary High School. After taking the Ethiopian Higher Education Entrance Qualification Certificate Examination, the author joined Haramaya University in 2006 and graduated with B. Sc. degree in Plant Sciences in 2008. After graduation the author was employed in Gewata Woreda (district), Kaffa Zone as Plant Science Expert. After serving for six months, the author was employed by Ethiopian Ministry of Education as an instructor for one of newly opening ten Universities and joined Haramaya University, School of Graduate Studies in 2009 to pursue Master of Science Degree in Weed Science sponsored by the Ministry of Education (MOE) and graduated by Master degree in Weed Science in 2011.

He has published two journals; one journal in Ethiopian Journal of Weed Management entitled "Competitive effect parthenium weed on yield and yield components of common" Volume 5, 2012, pp.1-11and one in International Journal of Research in Agricultural Sciences entitled "Nodulation, N and P Uptake as Influenced by Parthenium (*Parthenium hysterophorus* L.) Densities in Common Bean (*Phaseolus vulgaris* L.)" Volume 1, Issue 3, ISSN (Online) : 2348 – 3997). He has 6 months experience as plant sciences expert and 1 year teaching experience as University instructor at Mizan-Tepi University. Currently, he is a second year PhD student in Agronomy field at Haramaya University, Ethiopia and doing a research entitled 'Integrated Nutrient Management for Food Barley (*Hordeum vulgare* L.) Production in Kaffa Zone, South-Western Ethiopia' sponsored by Mizan-Tepi University, Ethiopia.

Mr. Mitiku is active member of Ethiopian Weed Science Society. Mr. Mitiku has got certificate reward in 2013 from Ambo University, Ethiopia by presenting a paper on international conference on integrated agriculture for food security and adaptation to climate change.