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Research Article

Response of Haricot Bean (*Phaseolus vulagris* L.) Varieties to Different Growth Parameters at Hawassa, Southern Ethiopia

Dasta Tsagaye[1, *], Nimona Fufa[1], Desta Bekele[2]

[1]Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center, Assella, Ethiopia

[2]Ethiopian Institute of Agricultural Research, Asossa Agricultural Research Center, Asossa, Ethiopia

Email address:

6dasta2@gmail.com (D. Tsagaye)

[*]Corresponding author

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Abstract: Haricot bean (*Phaseolus vulagris* L), locally known as 'Boleqe' is a very important legume crop grown worldwide. The study was initiated to assess the performance of haricot bean cultivars in relation to growth parameters and to estimate the analysis of growth characteristics. The experiment was conducted during November 2016 up to January 2017 at the compound of Hawassa University in the College of Agriculture during of season. The treatment consists of three Haricot varieties namely; Hawassa Dume, Omo-95 and Red Wolayta were used for test. The experiment was arranged in RCBD with four replications. The data were collected are Days to 50% emergence, Leaf area (cm^2), Stem and leaf dry weight (gm) and calculated on Specific leaf area, leaf area ratio, net assimilation ratio and relative growth rate and Biomass dry weight were collected. Analysis of variance showed that the collected data were significantly different with respect to varieties. From the result in terms of (specific leaf area and leaf area ratio) the varieties which show higher value at the first sampling will show also increased value at the second sampling and vice versa. Growth parameters showed increment from the first sampling to the last sample which indicates difference varieties in growing environment. Generally growth parameters showed an increment from emergency to maturity.

Keywords: Growth Parameters, Different Haricot Bean Varieties, Haricot Bean

1. Introduction

Haricot bean (*Phaseolus vulagris* L.) is an annual crop belonging to the family Fabaceae [1] which is grown predominantly by smallholder producers as a source of food and cash in Ethiopia [2]. Haricot bean (*Phaseolus Vulagris* L), locally known as 'Boleqe' also known as dry bean, common bean, kidney bean and field bean is a very important legume crop grown worldwide. It is an annual crop which belongs to the family Fabaceae. It grows best in warm climate at temperature of 18°C to 24°C [3]. The adaptability of this crop can range up to 3000 meters above sea level depending on the selected variety and does not grow well below 600 meters above sea level [4]. It is source of protein and energy in human diets [5]

In our country Ethiopia it is grown under smallholder farmers and important crops for the daily diet and foreign earnings [6].

According Zelalem [7] reported that haricot bean stands out among the pulses and is also known as "the poor man's meat" due to its high protein content, which compensates for the deficiency that could have occurred in a population with low income. Different types of haricot beans are grown in Ethiopia. These include white pea beans, grown in the central Ethiopia (Shoa) as cash crop, colored beans grown in the southern part of Ethiopia for local consumption and climbing beans grown in the northwest (Metekel) and western Ethiopia (Wollega). Climbers are planted along fences and on the borders of maize fields. The productivity of the crop around the study area (15.7

kg ha^{-1}) is reported to be below the national average productivity (17.0 kg ha^{-1}) [8].

It covers the dominant pulses export. However, the share has been limited by external demand for quality [9]. Its production was limited because of lack of high yielding varieties which have high resistance to disease and other biotic and abiotic factors [10].

Plant growth analysis is approach to interpreting plant form and function. It uses simple primary data to investigate processes within and involving the whole plant [11]. Plant growth analysis first illuminated plant physiology, then agronomy and now physiological and evolutionary plant ecology [12].

The relative contribution of different growth parameters to change growth of the crops depends on the genetic contents of the crops. Therefore the significance of the study was to estimate how different varieties of haricot bean can response to different to growth parameters. The study was designed or proposed to know the response of haricot bean varieties to different growth parameters.

2. Materials and Methods

2.1. Description of the Study Site

The experiment was conducted during November 2016 up to January 2017 at the compound of Hawassa University in the College of Agriculture. Hawassa is the regional capital of Southern Nation Nationalities and People's Regional State (SNNPRs), which is found 275 km south of the capital Addis Ababa. The site is located 6°42'N and 38° 29'E of latitude at an altitude of 1650 m.a.s.l with mean annual rainfall of 900 mm, mean annual temperature maximum and minimum of 13°C and 27°C respectively. The soil of the experimental site is sandy loam with pH of 5.5. The research was done under controlled irrigation since it off cropping season. The lab experiment was conducted at the department of plant and horticultural Sciences in the Physiology laboratory.

2.2. Treatment and Experimental Design

Hawassa Dume, Omo-95 and Red wolayta haricot bean varieties were used for test crop to compare its response to growth parameters. The treatments were arranged in RCBD with four replications. A Spacing of 40 cm between rows and plants were spaced 10 cm apart. To ascertain full stand in a plot, two seeds per hill were planted and thinned to appropriate stand after emergence. A plot of five rows each 2 m long (2m x 2m) was used, and 50 kg/ha DAP fertilizer was applied at the time of planting. All necessary agronomic practices have been done uniformly as per the recommendations. The experiment was planted on Nov 9, 2016 and harvested on Jan20, 2017. The correct stand count (20 plants per row) was maintained after thinning. Data on date of emergence was recorded on plot bases when 50% of plants in the plot are emerged the first leaf. Two consecutive destructive sampling at 20 and 33 days after emergence was taken by randomly selecting three plants per plot to measure leaf area, leaf dry weight, and stem dry weight. During sampling, a representative row from the plot was selected and all above ground part was harvested. After separating leaf and stem, the leaf area was measured by portable leaf area meter. Leaf and stem dry weight was separately obtained after dried in oven dry for 48 hour at 70°C and recorded as biomass dry weight during both sampling. Final sampling was taken at 72 day after emergence; sun dried and recorded as total biomass.

2.3. Data Collected

1. Days to 50% emergence were recorded as the number of days from sowing to when 50% of the plants emerged in each plot.
2. Leaf area (cm^2) was recorded by taking a destructive sample of three plants from the second and fourth row per plot. Leaf area was measured just before flowering using leaf area meter. The average leaf area of the three plants was taken for statistical analysis.
3. Stem and leaf dry weight (gm): - The average of three randomly taken plants measured in gram and average weight of the three plants were taken for statistical analysis.
4. Biomass dry weight: it was measure the central rows taken per plot and the converted biomass weight (gm^{-2}) used for statistical analysis.

Methods of computing certain parameters that describe growth parameters that are commonly used in agricultural research are measured as follows:

Leaf Area is the area of photosynthetic surface produced by the individual plant over a period of interval of time and expressed in cm^2 $plant^{-1}$.

Specific leaf area (SLA) is a measure of the leaf area of the plant to leaf dry weight and expressed in cm^2g^{-1} [13].

$$LAR = \frac{leaf\ area}{leaf\ weight}\ [13]$$

Leaf Area Ratio (LAR) was suggested by [14], expresses the ratio between the areas of leaf lamina to the total plant biomass or the LAR reflects the leafiness of a plant or amount of leaf area formed per unit of biomass and expressed in $cm^{-2}g^{-1}$ of plant dry weight.

$$LAR\frac{Leaf\ area\ per\ plant}{plant\ dry\ weight}\ [14]$$

Net Assimilation Rate (NAR) is defined as dry matter increment per unit leaf area or per unit leaf dry weight per unit of time. The NAR is a measure of the average photosynthetic efficiency of leaves in a crop community [15].

$$LAR = \left(\frac{W2-W1}{T2-T1}\right)\ X\ \left(\frac{Log\ e\ L2-Log\ e\ L1}{L2-L1}\right)\ [15]$$

Where, W1and W2 is dry weight of whole plant at time t1 and t2 respectively

L1 and L2 are leaf weights or leaf area at t1 and t2 respectively; t1 – t2 are time interval in days

NAR is expressed as the grams of dry weight increase per unit dry weight or area per unit time (g $g^{-1}day^{-1}$)

Relative Growth Rate (RGR) expresses the total plant dry weight increase in a time interval in relation to the initial weight or Dry matter increment per unit biomass per unit time or grams of dry weight increase per gram of dry weight and expressed as unit dry weight / unit dry weight / unit time (g g $^{-1}$day^{-1})

$$RGR = \frac{Log\ e\ W2 - Log\ e\ W1}{t2 - t1}\ [15]$$

2.4. Statistical Analysis

All the measured parameters were subjected to analysis of variance (ANOVA) using Mixed Model procedure of SAS version 9.0 [16]. Coefficient of variation, least significance difference (LSD) test at 5% probability level as described in [17] and the mean were compared with standard error.

3. Result

Table 1. *Mean of days to 50% emergence of three haricot bean varieties.*

Varieties	Days to 50% emergence
Awassa Dume	11.25a
Omo-95	9.25b
Red Wolayta	9b
LSD 0.05	0.9564
CV	5.621398

CV=Coefficient of variation, least significance difference (LSD) test at 5% probability level as described in [17]

Table 2. *Growth analysis on the specific leaf area (SLA), leaf area ratio (LAR) net assimilation rate (NAR) and Relative growth rate (RGR).*

Variety	SLA_1 (cm^2 g^{-1})	SLA_2 (cm^2 g^{-1})	LAR_1 (cm^2 g^{-1})	LAR_2 (cm^2 g^{-1})	NAR (mgdm^{-2})	RGR (mg g^{-1} day^{-1})
Omo 95	219.1	278.55	143.74	185.56	0.4146	0.0824
Red wolayta	214.63	264.69	140.01	177.29	0.4458	0.01853
Hawassa Dume	197.88	259.76	134.19	173.16	0.435	0.08185
SE (±)	6.1855	9.9185	7.4289	5.6465	0.01853	0.01337

Where, SpLA1=specific leaf area first harvest, SpLA2=specific leaf area second harvest, LAR1=first harvest leaf area ratio, LAR2=second harvest leaf area ratio, NAR=net assimilate rate, RGR=relative growth rate.

Table 3. *ANOVA for final biomass dry weight.*

Treatments	Mean (g/m^2)	Letter Group
Hawassa Dume	266.81	A
Omo 95	215.22	B
Red woliata	187.97	B
LSD 0.05	49.342	
CV	12.76896	

CV=Coefficient of variation, least significance difference (LSD) test at 5% probability level as described in [17].

4. Discussion

4.1. Days to 50% Emergency

From the above table it shows that there is significant difference between the haricot bean three varieties (Hawassa Dume, and Omo 95). Red Wolayta shows the least mean comparative the other two varieties whereas Hawassa Dume showed the highest mean of 50% emergency date.

4.2. Specific Leaf Area

According to Wallace *et al*. [18] genetically different crops plant show different leaf area and this parameter is an important physiological parameter because it associated with crop yield.

Yield increament can be achieved by extending photosynthesis per unit land area [19]. From the above table it shows that there is mean difference between the haricot bean varieties (Hawassa Dume, and Omo 95). At the first sample variety one (Omo 95) show high specific leaf area (219.1) while cultivar Hawassa Dume show the lowest (197.88). At the second sample and also variety Omo 95 scores the highest (278.55) as compare to the other two varieties as shown (Table 2).

4.3. Leaf Area Ratio (LAR)

From the above table it shows that there is mean difference between the haricot bean varieties (Hawassa Dume, and Omo 95). At the first sample variety one (Omo 95) show high specific leaf area ratio (143.74) while variety Hawassa Dume shows the lowest (134.19) as compared to other. At the second sample cultivar (Omo 95) scores the highest (185.56) leaf area ration (Red Wolayta (177.29) and Hawassa Dume score the lowest (173.16) as compared to Omo 95 as shown on the above table (Table 2). Highest leaf area ratio of a crop indicates that it has larger leaf area and this helps the crop to have highest efficiency of light harvesting which means higher photosynthetic rate.

4.4. Net Assimilation Rate (NAR)

Studies on field crops Watson [20] showed that E differed from species to species with respect to growing condition and in controlled environments [21]. Net assimilation rate indicates that the increment of plant material per its assimilatory material in a given time. So the cultivar with highest NAR will tend to have highest plant material in a given area and time and it have high assimilate rates. Therefore cultivar (Red Wolayta) have greater assimilate rates (0.4458). Rakesh *et al*. [22] reported that higher RGR indicates increment in dry matter per unit leaf area.

4.5. Relative Growth Rate

From the above table it shows that there is significant difference between the haricot bean varieties (Hawassa Dume, and Omo 95). The above table shows that Omo 95 has relative growth rate (0.0824) as compared to the other varieties of haricot bean. Rakesh *et al*. [22] Reported that higher RGR indicates increment in dry matter per unit dry matter.

4.6. Biomass Dry Weight

According to Escalante *et al*. [23] the relationship between the seed yield and biomass with growth parameters are have directly proportional to each other; with respect to growing environment and the fertility of the soil. From the above table it shows that there is significant difference between the haricot bean three varieties (Hawassa Dume, and Omo 95) in terms of biomass dry weight. The above ANOVA (table 3) of biomass dry weight shows that there is no significant difference between the three varieties and Omo 95 show Hawassa Dume, Omo 95 and Red Wolayta).

5. Conclusion

For the specific leaf area and leaf area ratio as the plants continue its growing they did not show constant performance. The varieties which show higher value at the first sampling show also increased value at the second sampling and vice versa. So it is fair to say that these Haricot bean varieties perform differently across their growing period. As it is shown on the result, when relative growth rate increase, leaf area ratio and specific leaf area also increases. So we can conclude that both leaf area ratio and specific leaf area affect the Haricot bean growth rate. Regarding to total biomass it is observed that some variety show significant difference while some varieties show no significant difference between them. This indicates that total biomass is not always dependent only on varieties difference rather there is some other factors.

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