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Full Length Research

Evaluation of some haricot bean (*Phaseolus vulgaris* L.) cultivars for growth characters and dry matter production

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ABSTRACT: Genetic factor is a key factor to realize optimum growth and dry matter production of crops in addition to environmental factors. Haricot beans (*Phaseolus vulgaris* L.) cultivar type is important for good agronomic performance for greater production of dry matter and grain yield. The present study was conducted with objectives to estimate the performance of haricot bean cultivars based on dry biomass and growth traits and to observe the impact of different growth stage on various growth characteristics of haricot bean cultivars. Three haricot bean cultivars were evaluated using RCB design with three replications at Hawassa University Agricultural College, Southern Ethiopia during off season from November 2016 up to January 2017. Collected data were specific leaf area ratio (SLA), leaf area ratio (LAR), net assimilation rate (NAR), relative growth rate (RGR), leaf area and above ground biomass. Dissimilarities have been observed in LAR, SLA, NAR and RGR among cultivars. But there was no significant difference observed among cultivars for total biomass. The LAR and SLA of all cultivars declined as crop development advanced. So, it is fair to say that these haricot bean varieties perform differently across their growing period. The NAR during early development was 41.3 $mg/dm^2/day$ as maximum value. Generally, the current field study elucidates the interdependence of some characters and the existence of difference among haricot bean cultivars for some growth characteristics indicating cultivar difference in morphological characters which may have influence on physiological characters.

Keywords: Cultivars, emergence, growth parameters**,** haricot bean.

INTRODUCTION

Haricot bean (*Phaseolus vulgaris* L.) belongs to order *Rosales*, family *Leguminosae* and genus *Phaseolus* (CIAT, 1986). It is diploid (2n = 2x = 22) and locally known as 'Boleqe'; also known as dry bean, common bean, kidney bean and field bean which is a very important legume crop grown worldwide. It is an erect or twinning, annual and herbaceous plant with various growth habits, morphological traits, and seed and pod characteristics. The bean flower is perfect, possessing both male and female organs on the same flower, and is self fertilizer crop. Pollination coincides with the time when the flower opens (Purseglove, 1968). It is generally accepted that all species of the genus *Phaseolus* originated in tropical America (Mexico, Guatemala, and Peru). The main evidence of their origin is the genetic diversity of the materials that exists in this region. Beans were introduced into Africa probably by the Portuguese and spread into the interior faster than European exploration (Sauer, 1993).

The crop is adapted to an altitude ranging from sea level to nearly 3000 m.a.s.l (CIAT, 1986), but does not grow well below 600 m.a.s.l due to poor pod set caused by high temperature (Acland, 1971; Cobley, 1976). Suitable production areas of haricot bean in Ethiopia have been indicated as areas with an altitude between 1200 to 2200 m.a.s.l, having maximum and minimum temperature mean of less than 30 to 32°C and greater than 10 to 12°C, respectively, and a rainfall of 350 to 500 mm well distributed over 70 to 100 days (Imru, 1985; Amare and Haile, 1989). Similarly, common bean is a warm season food legume crop and cannot grow well under temperature below than 20°C. The optimum mean temperature for common bean is 20 to 25°C. High temperatures interfere with seed setting while low temperature adversely affects its growth (Alghamdi and Ali, 2004). Almost all types of soil with good drainage and reasonably high nutrient content are suitable for haricot bean production (Purseglove, 1968; Acland, 1971).

Haricot bean is an important food crop in eastern and southern Africa. It is known as the second most important source of human dietary protein and the third most important source of calorie of all the agricultural commodities produced in eastern and southern Africa (Leakey, 1970; Kimani, 1999). In Ethiopia haricot bean produced principally under smallholder producers as food crop and source for cash. Early maturity and drought tolerance led the crop vital role for farmers' strategies for risk aversion in low land areas of the country (Abebe, 2009). It is one of the most important pulse crops grown in many lowland areas of Ethiopia as a main crop and protein source.

Evaluation of different common bean cultivars for growth characteristics and dry mater production is imperative, as they have positive correlation with yield and yield components. Thus, agronomic traits play momentous role for indices to select high yielder genotypes. In agreement with this, dry matter production is directly related with agronomic characters of plants (Amanullah and Muhammad, 2011). Also, Awan et al. (2014) reported positive relation between plant height with yield and other yield related traits of common bean. Similarly, Kumar et al. (2009) reported positive associations between pod length and pod height, seeds pod system, weed control, irrigation and fertilizer application.

Genetic factor is a key factor for achieving optimum growth and dry matter production of crops. Different cultivars have different growth parameter performance as well as different biomass production. Therefore, understanding the performance of different haricot bean cultivar is very important in crop production. Hence, the present study was conducted to estimate the performance of haricot bean cultivars based on dry biomass and growth traits and to observe the impact of different growth stage on various growth characteristics of haricot bean cultivars.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Hawassa University College of Agriculture, Southern Ethiopia. Hawassa is a capital city of Southern Nation Nationalities People of Ethiopia. It is located to south 270 km from Addis Ababa. A field trial was conducted during off season from November 2016 up to January 2017 under controlled water supply at experimental field of Hawassa University College of Agriculture. The site is located 6°42' N and 38°29'E of latitude and at an altitude of 1650 m.a.s.l with mean annual rainfall of 900 mm, and mean annual temperature maximum and minimum of 13°C and 27°C respectively.

Experimental materials

The experiment consisted of 3 haricot bean cultivars i.e., Red Wolayta, Ibbado and Omo 95 haricot bean Cultivars.

Experimental design and field operations

The experiment was laid out in RCBD with tree replications at spacing of 40 cm between rows and 10 cm between plants. To ascertain full stand in a plot, two seeds per hill were planted and thinned to appropriate stand 12 days after emergence. A plot of five rows each 2 m long (2 m x 2 m) was used, and 50 kg/ha DAP fertilizer was uniformly applied at the time of planting. Also, other necessary agronomic practices have been done uniformly as per the recommendations. The correct stand count (20 plants per row) was maintained after thinning.

Data collection

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 25 and 43 days after emergence was taken by randomly selecting three plants per plot to measure leaf area, leaf dry weight, stem dry weight and plant height. 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 hours at 70°C and recorded as biomass dry weight during both sampling. Final sampling was taken at 69 day after emergence; sun dried and recorded as total biomass. The remaining data was obtained by calculation as 1st leaf area (LA1), 2nd leaf area (LA2), leaf dry weight (W_{leaf1} and W_{leaf2}), Leaf area ratio (LAR_1 and LAR_2), Specific leaf area (SLA1 and SLA2), Total dry weight (WI and W2), Net assimilation rate (NAR), Relative growth rate (RGR) as:

$$SLA = A/W_{leaf,}$$

$$LAR = A/W$$

$$NAR = (W2-W1)(\ln A2-\ln A1)/(A2-A1)(T2-T1)$$

$$RGR= (\ln W2-\ln W1)/(T2-T1)$$

Where: A=leaf area, W_1 and W_2 = total dry weight of sampling time 1 and 2 respectively.

Data analyses

Analysis of variance (ANOVA) of RCBD was used to see variability using proc mixed procedure of SAS version 9.0 software package (SAS Institute, 2004).

RESULT AND DISCUSSION

Leaf area ratio

The ratio between leaf area and total plant dry weight has been termed the leaf area ratio (LAR). The statistical analysis of leaf area ratios (LAR) is summarized in Table 1. The LAR of all cultivars declined as crop development progressed. A similar decline was reported by Curtis et al. (1969). But the differences in LAR among the cultivars were relatively small. The LAR of Red Wolayta was better than Omo 95 and Ibbado in first sampling date, and greater than Omo 95 in the second sampling. In line with this, Awan et al. (2014) confirmed the existence of variability among some common bean cultivars for growth characteristics. Similarly, Yohannes et al. (2020) reported that the variability among common bean for leaf area and leaf area index. A high LAR has been considered a desirable characteristic because it indicated the plant had a high photosynthetic potential in relation to its respiratory load. Similarly, Wallace and Munger (1965) compared several dry bean cultivars and found the yields were highly and positively correlated with the LAR. However, Buttery (1972a) reported a negative relationship between the grain yields of soybean cultivars and their LAR values.

Specific leaf area

The ratio of leaf area to leaf dry weight has been termed the specific leaf area (SLA). The inverse of SLA has been called the specific leaf weight (SLW). The statistical analysis of specific leaf area (SLA) has been summarized in Table 2. The SLA has been shown to change during the course of crop development. Numerical differences have been observed in SLA among cultivars. Buttery (1972b) compared parents of soybean cultivars with their progeny and found that selection for improved yield had concurrently reduced SLA. They suggested the use of this parameter as a selection criterion. The SLA of all cultivars declined as crop development progressed. But the differences in SLA among the cultivars were relatively small. The SLA of Red Wolayta was better than Omo 95 and Ibbado in both sampling date. These results generally support the suggestion that SLA is directly related to the degree of mutual shading resulting from increasing leaf area index (LAI) (Buttery, 1970). Also, Kassa et al. (2014) and Yohannes et al. (2020) found differences between haricot bean cultivars for leaf parameters and other agronomic characteristics by application of lime at different rate.

Net assimilation rate

The net assimilation rate (NAR) has been defined as the rate of increase of dry weight per unit of leaf area. This parameter has frequently been calculated in field research to estimate the photosynthetic efficiency of crop leaves. The NAR value for a crop was an average value for all leaves. The NAR of *Phaseolus vulgaris* L. during early development, has been near 80 mg/dm^2/day (Wallace and Munger, 1965), in our case 41.3 mg/dm^2/day was maximum value (Table 3). Several studies have revealed a negative correlation between LAR and NAR. The rate of decline in LAR per unit increase in NAR has been used as a measure of the canopy efficiency of crops. Similarly, Watson and Witts (1959) reported that the NAR of improved cultivars showed a slower rate of decline than the older standard ones. They attributed this to improvements of canopy architecture. Also, the present experimental results had shown concurrent relationship, with the finding of Buttery (1972a). They found that SLA had a high heritability and suggested it would be a good characteristic for easy, indirect selection of photosynthetic efficiency. Dornhoff and Shibles (1970) hypothesized that low SLA may be associated with a high cell surface to volume ratio; thus, a lower mesophyll resistance to CO_2 diffusion. The relative NAR of the cultivars depended on the stage of crop development (Table 3). The NAR of Omo 95 was better than Red Wolayta and Ibbado.

Table 1. Mean growth parameters (LAR) of different Haricot bean cultivars.

Cultivar	LAR (cm^2 g^{-1})	
	First Sampling	Second Sampling
Red Wolayta	188.05 ± 8.45	127.66 ± 8.1
Omo 95	166.22 ± 1.75	123.65 ± 3.27
Ibbado	160.6 ± 1.69	128.71 ± 0.93

First and second samples were taken at 25 and 43 days after emergence, respectively.

Table 2. Mean growth parameters (SLA) of different Haricot bean cultivars.

Cultivar	SLA (cm^2 g^{-1})	
	First Sampling	First Sampling
Red Wolayta	237.72 ±18.17	212.29±18.72
Omo 95	232.93 ± 2.73	208.30±2.61
Ibbado	231.35 ± 4.60	188.05±8.45

First and second samples were taken at 25 and 43 days after emergence, respectively.

Table 3. Mean growth parameters (NAR, and RGR) of different Haricot bean cultivars.

Cultivar	NAR (mg dm^{-2} day^{-1})	RGR (mg g^{-1} day^{-1})
Red Wolayta	35.59 ± 6.23	49.89 ± 5.63
Omo 95	41.3 ± 5.62	57.67 ± 7.00
Ibbado	31.96 ± 6.28	45.33 ± 8.76

NNAR = net assimilation rate, RGR = relative growth rate.

Table 4. Analysis of Variance (ANOVA) for total biomass of the three cultivar of haricot bean.

Source of variation	DF	SS	MS	F Value	F tabu	
					5%	1%
Treatment	2	10526.2	5263	1.8^{ns}	6.94	18.0
Block	2	73808.87	36904.4	12.4	6.94	18.0
Error	4	11876.5	2969			
Total	8	96211.5				

DF= Degrees of freedom, SS = sum of squares, MS = Mean of squares, ns = non-significant.

Table 5. Mean biomass of the three haricot bean cultivars.

Treatment	Mean biomass (gm^{-2})
Red Wolyta	164.42
Omo 95	237.6
Ibbado	164.2
Mean	188.74
Cv	19.3
LSD (5%)	123.5

CV = coefficient of variation, LSD = least significant difference.

Relative growth rate (RGR)

Relative growth rate is the rate of increase in plant dry weight relatively to the total dry weight of that plant. The RGR of the cultivars depended on the stage of crop development. The RGR of Omo 95 was better than Red Wolayta and Ibbado numerically. From the present results it is possible to understand NAR has positive correlation with RGR; hence, haricot bean cultivar (Omo 95) with high NAR showed high RGR and vise versa (Table 3).

Biomass

The above ground total biomass showed non-significant for all the three haricot bean cultivars (Tables 4 and 5). Leaf dry weight was the major component of the total dry weight at sample 1, which suggests that leaf growth was favored during early development. Dry matter accumulation in crops has a direct relationship with leaf area ratio. The reason in non-significance of total biomass in this study could be related with leaf area ratio. This result may also be related with genetically potential of the cultivars almost similar production capacity. The current result contrast with the result of Tadesse et al. (2014) who reported significance difference among 11 common bean varieties in total biomass using over two years data.

Conclusions

The optimum growth and dry matter production of crops can be influenced by environment and genetic factors. Evaluating haricot beans (*Phaseolus vulgaris* L.) cultivars for good agronomic performance is important for greater production of dry matter and grain yield. Based on the achieved result of the current experiment, almost all the parameters under study showed significance difference except total biomass. All cultivars show declined performance in LAR and SLA as growth development progressed. The relative NAR and RGR of the cultivars depended on the stage of crop development. The NAR and RGR of Omo 95 were better than Red Wolayta and Ibbado. This indicates that there may be positive correlation between NAR and RGR. The above ground total biomass showed non-significant for all the three haricot bean cultivars, but numerically the maximum yield 237.6 gm/m^2 recorded for Omo 95. Generally, assessment of the performance of haricot bean cultivars in this study revealed the existence of dissimilarity between cultivar and the interdependence of some characters.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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