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EVALUATION OF SOME GROWTH CHARACTERS IN COMMON BEAN *(PHASEOLUS VULGARIS L.)*

Agim Canko, Sokrat Jani, Milto Hyso

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INTRODUCTION

In suitable conditions all living organisms may be grown and developed in size, structure and change as well. These processes are important part of the plant life cycle and together with natural systems might contribute to distinguish living and non-living organisms (Hunt 1982). Even for living organisms, it is not easy to give a right definition of “growth”.

The growth and development of common bean are occurring during two main periods, and namely vegetative and reproductive. During the first period a plant grows, whereas during the second, a crop is produced. For each period, common bean requires different environmental conditions (Allavena 1979).

Over the recent years in Albania common bean crop has been low and non-stable due to poor cultural practices, drought and heat stress during the reproductive period (Canko et al. 2004). Knowing the plant growth and development principles, physiological processes in common bean diverse cultivars leaded to the evaluation of growth characters. The plant growth and development processes are very complicated and for a long time many legume researchers are considering them as quantitative traits (Motto et al.1979 and Brinkman et al. 1977).

MATERIAL AND METHODS

The evaluation is carried out during 2006-2008 at the experimental field of ATTC-Lushnja. Three self supporting erect bush type common bean cultivars were used. Two cultivars (Shijak and Cocoblank) are half-restricted types and Kallmet is restricted biological type. The field design was a complete randomized block with three replications. Each cultivar was sown in 5 rows with 4 m long. The plant densities were 30 plants/m2 for the half-restricted type, and 36 plants/ m2 for the restricted type.

The standard cultural practices were used for growing plants in the trial.

Plants were scored in the start and end of flowering, pod growth, bean growth and maturity (every 7-10 days). Five plants were used for each score, excluding the plants from the side rows. From each plant, complete open leaves, growing new leaves, stem and pods were taken separately. Leaf area was measured using weighing and cut discs methods with a known area. After weighing, the plant parts were placed in dryer at 105°C per 24 hrs (Scarascia et al. 1979). Based on leaf area and the dry matter, several growth indexes were calculated, as: leaf area index (LAI), the rate of the growth (CGR), the rate of the accumulation of the dry matter (RGRw), the relative rate of the leaf area growth (RGRL), the relative rate of the net assimilation (NAR) and the coefficient of the re-distribution of the dry matter (α) (Scarascia 1979 and Hunt 1982). Ten plants per each treatment and replications were used at the end of maturity for scoring the yield characters. The data were statistically analysed using the dispersion analysis.

RESULTS AND DISCUSSIONS

Leaf area index (LAI) impacts the extent of the dry matter accumulation and the bean yield. It is controlled by genetic factors, but at the same time is “adjusted” using the leaf number.

Based on our data there are no significant differences among three cultivars for the LAI until 33 days after germination (the growth period) (table 1). During the reproductive stage, differences among cultivars are significant between two biological types. For both biological types, the greatest LAI was obtained 62 days after germination (the pod growth). Until 62 days after germination Shijak and Cocoblank have similar LAI.

Table 1. Leaf area index (LAI) and the number of leaves

Cultivar	LAI m2 /m-2					
	Days after germination					
	33	41	52	62	69	76
Shijak	1.1	2.68	3.50	4.93	2.18	0.4
Cocoblank	0.76	2.31	3.86	4.74	3.09	1.76
Kallmet	0.91	1.46	1.90	2.80	1.11	-
Number of leaves per plant						
Shijak	19.9	30.0	34.4	39.2	22.4	4.2
Cocoblank	12.6	25	36.6	38.8	29.8	14.7
Kallmet	11.6	15.6	18.0	20.2	14.6	-

After 69-76 days of germination Cocoblank has higher LAI than Shijak.

LAI is some 5 m2 m-2 for the half-restricted type and 2.8 m2 m-2 for the restricted type. Since the restricted type has lower compensated capability, the plant density should be higher than 36 plants/ m2. In regard to LAI many researchers have determined an optimal value.

It can be achieved with a certain plant number (Board et. al 1986). Also the contribution of leaf area to the crop yield should be considered, especially towards the end of the reproductive stage. Cocoblank had greater LAI at the end of the reproductive stage. So, this cultivar might have good potential for a high crop production.

The LAI differences are mainly due to different number of leaves per plant. The half-restricted cultivars (Shijak and Cocoblank) have higher LAI because they had more leaves than the restricted type cultivar (Kallmet). During the pod and bean growth, lower leaves change the colour from green into yellow and fall.

In meanwhile the half-restricted type cultivars produced new leaves prolonging the photosynthetic activity. That is very important during the crop productivity stage.

The leaf number of Kallmet (restricted type) doesn't change, because we don't experience neither the fall of old leaves nor coming out of new leaves. This due to the lower leaves; get more light and continue the photosynthetic activity for a longer time than half-restricted cultivars.

The dry matter is synthetised during the photosynthesis. It is obvious that during the reproductive stage the dry matter amount is "multi-folded".

Over this period the accumulation of the dry matter is much higher than during the vegetative stage (table 2).

Table 2. Accumulation of the dry matter during the reproductive period (g/m2)

Cultivar	Days after germination					
	33	41	52	62	69	76
Shijak	50.25	124.13	225.93	484.73	527.14	30.12
Cocoblank	46.93	117.60	202.00	459.53	517.00	220.24
Kallmet	44.64	113.44	192.65	339.28	373.28	-

During the vegetative stage Kallmet accumulates nearly the same amount of the dry matter as Shijak and Cocoblank, but during the reproductive stage accumulates less dry matter, compared with the total dry matter weight.

For a better understanding of the growth characters contribution on the accumulation of the dry matter we extended the number of growth characters during our evaluation (table 3).

Table 3. CGR and RGR in three common bean cultivars

Cultivar	CGR g m2 days-1					
	Days after germination					
	33	33-41	41-52	52-62	62-69	Mean
Shijak	1.52	9.28	12.17	23.69	6.05	10.54
Cocoblank	1.22	8.47	9.83	12.86	9.15	7.73
Kallmet	1.31	8.60	10.50	12.92	4.87	7.64
D-0.01 D-0.05	0.38 0.27	2.70 1.92	4.48 3.18	5.68 4.04	5.61 3.98	
Cultivar	RGR g g-1 days-1					
	Days after germination					
		33-41	41-52	52-62	62-69	69-76
Shijak		0.113	0.075	0.064	0.012	0.002
Cocoblank		0.134	0.077	0.045	0.025	0.011
Kallmet		0.111	0.066	0.048	0.014	-
D-0.01 D-0.05		0.043 0.031	0.026 0.019	0.015 0.011	0.013 0.09	-

Of the analysis of the plant growth rate (CGR), which expresses more or less the photosynthesis rate of "the plant green cover" per area unit, it increases to a higher level in the peak of the LAI formation. Later the accumulation of dry matter is decreased, due to fall of leaves and the reduction of the photosynthesis rate.

There are no significant differences between both types for the relative increase rate of dry matter (RGRw), which measures the new production efficiency of the dry matter, compared with that accumulated previously.

Regarding to the leaf area relative rate (RGRL), Cocoblank shows greatest values till the end of the crop season (table 4). By the end of that RGRL obtains negative values, but even in this case, Cocoblank has greatest values of the relative rate of the leaf growth.

Table 4. RGRL in three common bean cultivars

Cultivar	RGRL m2 m-2 days-1				
	Days after germination				
	41	52	62	69	76
Shijak	0.112	0.039	0.028	-0.118	-0.262
Cocoblank	0.138	0.066	0.027	-0.061	-0.080
Kallmet	0.071	0.019	0.018	-0.108	-

In order to evidence the differences among cultivars for the leaf area efficiency on the accumulation of the dry matter, the net assimilation rate (NAR) was considered. This index expresses the internal factors, which control the production of the plant dry matter. The half-restricted cultivars (Shijak and Cocoblank) have lower NAR then the restricted cultivar (Kallmet). The reduction of the net accumulation during the reproductive stage is due to the leaf physiological ageing (table 5).

Table 5. NAR and index of the re-distribution of the dry matter in three common bean cultivars

Cultivar	NAR gm-2 days-1				
	Days after germination				
	33-41	41-52	52-62	62-69	69-76
Shijak	5.26	4.59	5.21	1.79	0.54
Cocoblank	5.22	3.02	3.76	2.37	1.93
Kallmet	8.14	5.72	3.96	2.99	-
D-0.01 D-0.05	2.95 2.09	3.88 2.75	2.99 2.13	2.62 1.86	
The index of the re-distribution of the dry matter (α)					
Shijak	1.077	2.194	2.674	-0.103	
Cocoblank	0.933	1.453	2.707	-0.406	
Kallmet	1.851	4.681	3.667	-0.134	

Even though the positive values that a cultivar might have for the intensity of the assimilation of the dry matter, final production is depending on dry matter amount. For that reason, the index of the morphogenetic variation (α) is calculated.

It helps for a better understanding on the distribution of the assimilated products between vegetative and reproductive organs of a common bean plant.

This index is important if we compare two cultivars that produce the same amount of the dry matter.

Based on our data, α value are greater than 1 for all three cultivars during the flowering time, pod growth and development. During this period, the assimilated products have been used for the formation of the reserve matter.

The plant itself has been in such equilibrium that the assimilated products have helped for an effective photosynthesis.

Later, 62-69 days after germination, α value is smaller than 1, which means some assimilated products have been used for the formation of the new leaves.

Shijak and Cocoblank have accumulated similar amount of the dry matter, but Shijak has greater α value. This means that Shijak has to produce more yield than Cocoblank.

This is explained further by the analysis of production components (table 6). Common bean is sensitive to short photoperiod and the temperatures mainly during the flowering time and bean growth (Allavena 1979 and Motto et al. 1979).

Initially common bean seedlings grow slowly, but later they grow very fast. As a consequence of that NAR values of common bean crop as a C3 species are lower than other C3 species.

Table 6. Yield characters in three common bean cultivars

Cultivar	Pods		Seeds		Mean seed weight (g/1000 seeds)	Yield (g).	
	Plant	m2	Plant	m2		Plant	m2
Shijak	8.2	246	27.1	813	389	11.07	332.1
Cocoblank	12.1	363	45.5	1365	232	9.66	289.8
Kallmet	7.1	255	18.1	651	438	7.87	283.3

The cultivars having a long active assimilation would possess high yield potential.

Even though Shijak has the same LAI as Cocoblank, it had that for a shorter time, which is explained with the existence of different canopy structure between these two cultivars. The horizontal placement of leaves of Shijak throughout the plant stem shades the lower leaves.

They capture and use more sunlight than leaves on the lower parts of the plant. The common bean as C3 plant species has relatively a low compensation index of the photosynthesis based on the intensity of the solar radiation. For that reason, the upper leaves which are always exposed entirely to the light go quicker onto saturation.

As a consequence, these leaves do not use efficiently the light as long as lower leaves do not capture sufficient light for their photosynthesis. That's why they have to utilise some of their carbohydrates to perform breathing when they do not assimilate any other matters.

During the bean growing and ripening stage Cocoblank has higher values of LAI compared with other cultivars.

As consequence, it has higher yielding ability than others. This happens due to its erect plant type, which prolong the photosynthesis, attributed also to coming out of new leaves.

To common bean, during the vegetative and reproductive stages there are changes on the assimilated product distribution.

Their amount is depending on growth model, which is influenced by genotype and environmental conditions. Although they are insufficient to meet the requirements of pods and beans, the plant itself regulates the assimilated product re-distribution, shifting the nitrogenous matters from leaves into beans.

But, this migration slows down the leaf growth, which will lead to less accumulation as a result of leaf physiological ageing. When the assimilated products are low, leaves can turn into yellow and fall. In these circumstances a self-destruction of leaves is experienced, which is more obvious under the drought conditions.

Since beans have high protein content, coming in the other additional nitrogenous matters from other plant organs during the bean growth stage would lead to physiological destruction of photosynthesis supply. That's why the bean growth stage would be limited due to reduction of assimilated products at disposal.

From our standpoint, since the Cocoblank has higher LAI than other cultivars, it might have a higher yielding ability than other ones. It also continues the photosynthesis activity till the end of the reproductive stage.

But, in our climatic conditions its yielding ability is lower than Shijak and almost the same as Kallmet. This happens due to low rate of net assimilation and the reduced amount of assimilated products which are unevenly distributed more to growing parts rather than to reproductive organs. This can also be explained with the low redistribution index of dry matter, which is lower to Shijak.

The majority of pods do not grow and develop normally and many beans do not grow due to high temperature stress.

CONCLUSIONS

Based on the data analysis and discussion we may conclude as follows:

For some growth characters there are significant differences between and within the common bean biological types.

During the vegetative stage Shijak and Cocoblank have similar leaf area index, but by the end of the reproductive stage Cocoblank has higher LAI due to the production of the new leaves and the plant erect type.

The high efficiency of the solar radiation usage is due to the high leaf area index and the total leaf area. So, Cocoblank has higher LAI by the end of the crop season.

Shijak had higher growth rate than Cocoblank and Kallmet, but it slows down by the end of the reproductive stage. Even during that period, Shijak has still higher growth rate than Cocoblank.

Shijak and Cocoblank accumulate the same amount of the dry matter by the end of the reproductive stage, but Shijak has higher index of the dry matter re-distribution, which leads to higher yielding potential. The growth characters provide a better potential of higher production for Cocoblank, but their efficiency are restricted due to heat stress during the maturity. This cultivar might be grown in the environments with moderate weather conditions.

ABSTRACT

Common bean (white bean) is a major crop in Albania used as a staple for the high protein content. Over last few years the production has significantly declined due to heat and drought stress during the maturity. Since diverse cultivars with various maturities are grown, the effects of stress are differentiated.

A better understanding of basics of plant physiology would be helpful in terms of the explanation of physiological internal mechanisms and different yield potential of diverse common bean cultivars.

Considering that, three cultivars which represent two different biological types have been tested. Based on the accumulation of the plant dry matter and leaf area during the different developmental stages, some physiological indexes of the growth are calculated. Referring to our data, during the plant cycle Shijak and Cocoblank have similar index of leaf area. But, at the end of life cycle Cocoblank has higher leaf area index.

This is due to late growth and erect plant type. Also it has higher yielding ability than Shijak, but the crop yield is lower due to heat stress.

Even though both cultivars accumulate similar dry matter, Shijak has a high rate for the distribution of the dry matter. So, it has higher efficiency of the dry matter utilisation. Cocoblank is not longer suitable for growing in the coastal part of Albania, but it can be grown in other regions which have a temperate climate, especially towards the end of maturity.

REFERENCES

1. ALLAVENA, A., 1979 - Il Fagiolo. Agricola Ricerca. 2:15-17
2. BOARD, J.E. AND SETTIMI, J.R.1986 - Photoperiod Effect before and after Flowering on Branch Development in Determinate Soybean. Agronomy Journal. 6:154-156
3. BRINKMAN, M.A. AND FREY, K.J., 1977 - Growth analysis of isoline-recurrent parent grain yield differences in oats. Crop Science. vol 17: 426-428
4. CANKO, A., SHEHU, R. AND HYSO, M., 2004 - Fasulja: 22-25. Tirane
5. HUNT, R., 1982 - Growth curves. London, 5-46
6. MOTTO, M., SORESSI, G.P., AND SALAMINI, F., 1976 - Growth Analysis in a reduced leaf mutant of common bean (Phaseolus vulgaris). Euphytica 28: 595-598
7. SCARASCIA, M.E. AND LOSAVIO, N., 1979 - Analisi dell' acrescimento e della produzione in due varieta di soia a differente potenzialita produttiva. Rivista di Agronomia 1: 67-77

AUTHOR'S ADDRESS

CANKO AGIM, JANI SOKRAT, HYSO MILTO - Agricultural Technology Transfer Centre (ATTC), Fushë Krujë-Albania, Agricultural Technology Transfer Centre (ATTC), Lushnje-Albania, Independent Expert of Legumes Germoplasm, Tirana-Albania