Pak. J. Bot., 44: 239-243, Special Issue May 2012.

CHANGES IN CONSERVED FIELD CONDITIONS BY GROWING FABA BEAN (*VICIA FABA* L.) DURING TWO VARIED METEOROLOGICAL YEARS

IHSANULLAH DAUR[1*] AND HASAN SEPETOĞLU[2]

[1]*Department of Arid Land Agriculture, Faculty of Meteorology, Environment & Arid Land Agriculture, King Abdulaziz University P.O. Box 80208, Jeddah: 21589, Saudi Arabia,*
[2]*Department of Field Crops, Ege University, 35100 Bornova-İzmir, Turkey*
[*]*Corresponding author's e-mail: ihsanullah.daur@yahoo.com*

Abstract

Growth and development of twelve different faba bean genotypes were studied during two subsequent years (2005-2006 & 2006-2007) in their growing seasons, from October – March, in the research fields of Ege University, Turkey. The study was conducted in a randomized complete block design in an organic field. Various growth parameters of faba beans, including plant height, leaf number, leaf area index (LAI), leaf dry weight, root dry weight, and total plant dry weight were measured. The plant height and leaf number differed significantly (p<0.05) across genotypes and years, and showed genotype x year interactions. Moreover, LAI also statistically varied between genotypes and years, but no genotype x year interaction was observed. The leaf dry weight, root dry weight, and total plant above ground dry weight were found to be significantly different for genotypes, years and their interactions. The variation between years was due to differences in rainfall and soil nitrogen (N) that were high in the first year compared to the second year and these were the factors responsible for changing the conservation status of the field under study. The findings indicated that on an average, a faba bean has 101.90 cm plant height, 49.95 number of leaves plant^{-1}, 3.49 LAI, 354.83 kg leaf dry weights ha^{-1}, 11944 kg total above ground plant dry weight ha^{-1}, and 865 kg root dry weight ha^{1}. These findings are based on number of genotypes and can be used as a reference for growth and development of faba beans. Furthermore, differences in N in the organic fields during the study period shows that it needs to be managed in organic farming even for legume cropping system.

Introduction

Faba bean (*Vicia faba* L.) is one of the important grain legume crops grown in the world especially in the Mediterranean regions. It is an important source of proteins for humans and animals. Due to increasing importance world-wide of faba bean for humans and animals use, it necessitates to study growth and development of the crop in its favorable environment— to generate average data for its growth parameters so that researchers compare its adaptation in their own agro-climatic conditions (Daur *et al.*, 2011).

Research on faba bean growth and development is limited (Jensen *et al*., 2010; Munoz-Romero *et al*., 2010; Tavakkoli *et al*., 2012). Many reports for example, Balaban & Sepetoğlu (1991), Ceter & Sepetoğlu (1995), Lynch (1998) and Fageria (2002), Bulut & Akinci (2010), Daur *et al*., (2010), Khalil *et al*., (2010), Link *et al*., (2010), Buyukkeskin & Akinci (2011), show experiments on different aspects of faba bean like winter hardiness, nutrient composition, planting date, genotypic variation for salinity and drought tolerance, seedlings growth, yield and yield components, fertilizers and soil nutrient uptake. All these studies have shown practical importance.

The present study is different in the way that it was conducted to determine growth and development of 12 different genotypes for two years to find average values for faba bean growth parameters that may be used as a reference. In addition, conservation of the field conditions were evaluated for subsequent growth and development of faba bean in two different meteorological years.

Materials and Methods

A field trial was conducted in 2005-06 and 2006-07 cropping seasons in İzmir, Turkey at the Research Station of the Faculty of Agriculture, Ege University on lupin treated field conserved to support successive organic crop production. Lupine was incorporated at flowering initiation stage in the field for eight years (1996-2004) as green manure.

Each year before sowing of the experimental field area, surface soil (0–30 cm) was sampled for initial soil properties. The samples were oven-dried and crushed to pass through a 2-mm sieve. Sand, silt and clay proportion of the soil were determined using the hydrometer method (Arshad *et al*., 1996). Soil pH was determined in a soil saturation extract as described by Thomas (1996). Organic matter was determined by the Walkley–Black method (Nelson & Sommers, 1996). Nitrogen (N) content was determined with the Khjeldahl method (Bremner, 1996). Phosphorus (P), potassium (K), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) were extracted by the Mehlich 1 extracting solution [0.05 M hydrochloric acid (HCl) + 0.0125 M sulfuric acid (H_2SO_4)]. Phosphorus was determined colorimetrically and K, Cu, Zn, Fe, and Mn by atomic absorption spectroscopy. Calcium (Ca) and magnesium (Mg) were extracted with 1 M potassium chloride (KCl). Soil analysis methods used in this study are described by Ryan *et al*. (2001). The results of selected soil properties are listed in Table 1. The climate of the experimental site was typically Mediterranean, with mild wet winters, and hot dry summers (Table 2).

In the experiments seeds of 12 different genotypes of faba bean were hand planted on 16 October 2005 and 17 October 2006 in six row plots, 6 m long with a spacing of 35-cm between rows using randomized complete block design with three replications. After planting, two light sprinkler irrigations at 5 day intervals were applied to ensure uniform germination. Plots were kept weed-free thereafter by hand weeding. Other cultural practices were consistent with local agronomic practices.

Table 1. Chemical properties of the 0–30 cm clay-loam soil layer of the experimental site.

Soil properties	2005-06	2006-07
pH	7.4	7.6
Organic matter	2.86%	1.44%
Total N	0.106%	0.05%[L]
Quantity (mg kg^{-1})		
P	148	142
K	392	300
Ca	4500	3816
Mg	248	230
Fe	57.4	28.4
Cu	1.77	1.46
Zn	2.72	1.96
Mn	12.1	11.8

In the table value having superscript L indicates Low soil N according to Sillanappa (1982) while other nutrients are enough in soil for a crop growth according to Soltanpur (1985), and Rashid *et al*. (1994).

Procedures for data recording: Ten adjacent plants in the second row of each plot were uprooted using a spade at 150 days after planting in 2005-06, and at 144 days after planting in 2006-07, corresponding to the end of flowering growth stages. The plants were then washed and separated into below ground (root) and above ground (shoot) portions. In the above ground portion various parameters including plant height, number of leaves per plant and leaf area were measured. Plant height was determined on the basis of the average of 10 plants from root separation point to the tip of the plant. Leaf area was determined following the procedure of Daur *et al.*, (2011) by scanning with area measurement software (Fläche) (Sepetoğlu, 2001), and leaf area index (LAI) was calculated as follows:

$$LAI = \frac{LA}{GA}$$

where LA = leaf area of the 10 plants
GA = Ground Area covered by the 10 plants---that was determined from plant count per unit area

Table 2. Monthly rainfall, temperature and relative humidity during growing period in 2005-06 and 2006-07.

Months	Rainfall (mm)		Mean temperature (^{o}C)		Relative humidity (%)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Sept	6.6	167.2	24.1	23.8	61.5	63.5
Oct	22.8	114.5	17.9	19.2	61.1	69.7
Nov	155.9	63.1	12.9	12.4	67.8	68.6
Dec	67.5	9.1	11.3	9.7	67.0	67.5
Jan	77.5	33.1	6.9	10.6	65.6	62.2
Feb	93.4	22.6	9.6	10.6	66.8	66.9
Mar	180.9	28.2	12.1	13.4	68.0	59.8
Apr	29.4	19.3	17.4	16.2	62.7	48.8
May	0.2	44.1	21.1	22.4	61.5	52.2
Jun	10.0	100.2	25.7	28.1	59.3	43.0

The data has been taken from the Government metrological station of Bornova, Turkey

All plant samples were dried in a fan-forced oven at 70^{o}C for two days to determine dry-matter production for various faba bean plant parts including leaf, root and plant dry weight (the plant dry weight here refers to above ground biomass). The values of the samples were converted into ha^{-1} based on average of 10 plants covered area in the experiment.

Statistical analysis: Data were analyzed statistically using MSTATC software for analysis of variance, and means were compared using the least significant differences test (Russell, 1986).

Results and Discussion

Phenological growth parameters: Except LAI, all the other growth parameters including plant height and number of leaves plant^{-1} varied significantly (p<0.05) among genotypes (Table 3). Plant height ranged from 112.2 to 123.6 cm in the first year and from 75.8 to 84.2 in the second year. The average plant height in the first year (121.28 cm) was found to be greater than that in second year (101.90 cm). The mean data of genotypes showed that the maximum plant height was observed for genotype 95-ETA-225 (103.9 cm) and the minimum was observed for genotype SEVİL (94.0 cm). Number of leaves plant^{-1} ranged from 53.98 to 59.53 in the first year and from 42.40 to 47.93 in the second year across genotypes. The overall reduction of leaves plant^{-1} in the second year resulted in low average number of leaves plant^{-1} (44.71) in the second year compared to that in the first year (55.19). The mean data for genotypes indicated that the number of leaves were highest for genotype 98-ETA-329 (53.53 leaves plant^{-1}) and lowest for SEVİL (48.15 leaves plant^{-1}). Genotypes and years interaction indicated that performance of SEVİL was greater in the second year compared to the first year, whereas, performance of FİLİZ-99, ERESEN-87, and KITIKI-2003 was lower in the second year compared to first year. LAI ranged from 3.61 to 4.10 in the first year and from 2.82 to 3.21 in the second year across genotypes, though the differences were non-significant (p<0.05). However, LAI significantly varied between the years – 3.90 was observed in the first year and 3.07 in the second year.

Table 3. Phenological growth parameters including plant height, leaf number plant^{-1}, leaf area index (LAI) of 12 faba bean genotypes during the crop growth period.

Genotype	Plant height (cm)			Leaf number plant^{-1}			Leaf area index		
	2005-06	2006-07	Mean	2005-06	2006-07	Mean	2005-06	2006-07	Mean
FİLİZ – 99	123.0^{a}	82.9^{a}	102.9^{ab}	58.42^{ab}	42.60^{d}	50.51^{bc}	4.03	3.21	3.62
ERESEN – 87	120.8^{ab}	82.7^{a}	101.8^{ab}	55.89^{a-c}	42.60^{d}	49.24^{bc}	3.84	3.20	3.52
KITIKI – 2003	122.6^{ab}	83.8^{a}	103.2^{ab}	54.29^{bc}	42.40d	48.34^{c}	3.91	3.12	3.51
SEVİL	112.2^{c}	75.8^{b}	94.0^{c}	48.38^{d}	47.93^{ab}	48.15^{c}	3.75	2.82	3.29
SAKIZ	118.2^{b}	83.3^{a}	99.7^{b}	55.24^{bc}	45.57^{a-d}	50.40^{bc}	4.06	3.04	3.55
95 ETA 225	123.6^{a}	84.2^{a}	103.9^{a}	53.98^{c}	43.80^{b-d}	48.89^{c}	3.82	3.07	3.44
95 ETA 249	120.7^{ab}	83.4^{a}	102.1^{ab}	54.43^{bc}	45.53^{a-d}	49.98^{bc}	3.98	3.04	3.51
95 ETA 276	123.3^{a}	80.7^{a}	102.9^{ab}	53.67^{c}	43.67^{cd}	48.67^{c}	3.61	3.08	3.34
97 ETA 718	122.8^{ab}	82.9^{a}	102.8^{ab}	56.93^{a-c}	46.93^{a-c}	51.93^{ab}	3.87	2.96	3.41
97 ETA 727	121.9^{ab}	83.1^{a}	102.5^{ab}	55.82^{a-c}	42.27^{d}	49.04^{bc}	3.92	3.14	3.53
98 ETA 296	123.2^{a}	83.7^{a}	103.4^{a}	55.73^{a-c}	45.73^{a-d}	50.73^{a-c}	4.10	3.15	3.61
98 ETA 329	123.3^{a}	83.7^{a}	103.5^{a}	59.53^{a}	47.53^{a-c}	53.53^{a}	4.00	3.04	3.52
Mean	**121.28^{a}**	**82.5^{b}**	**101.90**	**55.19^{a}**	**44.71^{b}**	**49.95**	**3.90^{a}**	**3.07^{b}**	**3.49**
$LSD_{gen.}$	4.816	5.322	3.518	2.923	3.863	2.946	–	–	–
$LSD_{yr.}$		1.436			1.203			0.114	
$LSD_{Int.}$		–			4.166			–	

Values with different superscript letters for genotypes in the same column & between different years in rows differ significantly (*p<0.05*)

The differences in the above mentioned parameters across years are due to varied meteorological and altered field conditions, i.e., low rainfall and decrease in soil N, but the differences in parameters across genotypes are due to the phenotypic expressions of different genotypes. These findings are supported by Ceter & Sepetoğlu (1995), Malik *et al*., (2006), Daur *et al*., (2010), and Liu *et al*., (2012), who have reported differences in these growth characters for different genotypes, water and soil fertility.

Table 4. Biomass growth parameters including leaf dry weight, above ground plant dry weight, root dry weight of 12 faba bean genotypes during the crop growth period.

Genotype	Leaf dry weight (kg ha^{-1})			Root dry weight (kg ha^{-1})			Plant dry weight (kg ha^{-1})		
	2005-06	2006-07	Mean	2005-06	2006-07	Mean	2005-06	2006-07	Mean
FİLİZ – 99	4130^{a}	3360^{ab}	3745^{a}	965^{a}	821	893^{abc}	14452^{a}	11290^{a}	12871^{a}
ERESEN – 87	3899^{ab}	3267^{ab}	3583^{abc}	940^{ab}	798	869^{a-d}	13861^{ab}	10121^{bcd}	11991^{cde}
KITIKI – 2003	3756^{abc}	3297^{ab}	3527^{abc}	905^{ab}	788	847^{a-d}	13331^{bc}	9753^{cd}	11542^{ef}
SEVİL	3356^{c}	2922^{b}	3139^{d}	896^{ab}	783	840^{cd}	12623^{d}	9374^{d}	10999^{f}
SAKIZ	3892^{ab}	3462^{ab}	3677^{ab}	958^{a}	837	898^{ab}	13690^{ab}	10690^{abc}	12190^{bcd}
95 ETA 225	3576^{bc}	3110^{ab}	3343^{bcd}	937^{ab}	821	879^{abc}	13610^{ab}	10172^{bcd}	11891^{cde}
95 ETA 249	3711^{abc}	3245^{ab}	3478^{a-d}	876^{b}	760	818^{d}	13551^{abc}	9906^{cd}	11729de
95 ETA 276	3574^{bc}	3041^{ab}	3308^{cd}	899^{ab}	791	845^{bcd}	13242^{bc}	9636^{d}	11439^{ef}
97 ETA 718	3594^{bc}	3173^{ab}	3374^{bcd}	888^{ab}	790	839^{cd}	13360^{bc}	9897^{cd}	11629^{def}
97 ETA 727	3836^{abc}	3370^{ab}	3603^{abc}	920^{ab}	798	859^{a-d}	13525^{abc}	10360^{a-d}	11943^{cde}
98 ETA 296	4113^{a}	3419^{ab}	3766^{a}	946^{ab}	831	889^{abc}	14123^{ab}	10690^{abc}	12407^{abc}
98 ETA 329	4114^{a}	3542^{a}	3828^{a}	959^{a}	843	901^{a}	14450^{a}	10950^{ab}	12700^{ab}
Mean	3796^{a}	3267^{b}	3532	924^{a}	805b	865	13651^{a}	10237^{b}	11944
$LSD_{gen.}$	506.72	552.27	354.83	774	–	5.486	950.25	992.59	641.84
LSD_{yr}		144.86			22.40			262.03	
$LSD_{Int.}$		–			–				

Values with different superscript letters for genotypes in the same column & between different years in rows differ significantly (*p<0.05*)

Biomass growth parameters: The dry weights of leaf, root, and plant differed significantly ($p<0.05$) between genotypes and years (Table 4), but the genotypes by years interactions were non-significant ($p<0.05$). Leaf dry matter ranged from 3356 to 4114 kg ha^{-1} in the first year while in the second year, it reduced and ranged from 2922 to 3542 kg ha^{-1}. The reduction of overall leaf dry weight resulted in less average dry weight value for the second year (3267 kg ha^{-1}) compared to the first year (3796 kg ha^{-1}). Mean data across genotypes showed that leaf dry weight was highest for genotype 98-ETA-329 (3828 kg ha^{-1}) while lowest for SEVİL (3139 kg ha^{-1}). Root dry weight ranged from 876 to 965 kg ha^{-1} in the first year with significant differences, while in the second year, it reduced and ranged from 760 to 843 kg ha^{-1} with non-significances ($p<0.05$). The average root dry weight in the first year (924 kg ha^{-1}) was significantly higher ($p<0.05$) compared to second year (805 kg ha^{-1}). The mean values for genotypes showed that genotype 98-ETA-329 was found with more root dry weight (901 kg ha^{-1}), whereas, SEVİL had less root dry weight (840 kg ha^{-1}). Plant dry weight for different genotypes ranged from 12623 to 14452 kg ha^{-1} in the first year and from 9374 to 11290 kg ha^{-1} in the second year. That indicated reduced average plant dry weight figure in the second year (10237 kg ha^{-1}) compared to the first year (13651 kg ha^{-1}). The two years data across the genotypes demonstrated that genotype FİLİZ – 99 was found with more plant dry weight (12871 kg ha^{-1}) and SEVİL with less plant dry weight (10999 kg ha^{-1}). The probable reasons for outstanding dry weights of leaf, root, and plant during the first year of our experiments were the favorable weather and soil conditions for the growth of bean in the first year compared to the second year. The findings are in agreement with Ronnenberg *et al*., (2011), Brant *et al*., (2011) and Duzdemir & Ece (2011). Moreover, differences in genotypes during varied meteorological conditions for the above mentioned growth parameters are supported by Rodino *et al*., (2011), and Mohammadi (2012).

Conclusions

The present study on growing faba bean in varied meteorological years indicated that soil conditions especially nitrogen fertility of a field cannot be conserved even through growing a legume crop (faba bean), having an inherent N-fixing ability. Therefore, further research is needed to explore good management practices, to keep the soil conserved for organic crop production.

Acknowledgements

The authors received financial support in the form a PhD scholarship from the Agriculture, Forestry and Food Technologies Research Grant Committee of The Scientific and Technical Research Council of Turkey (TÜBİTAK) under 2215- Fellowship Program.

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(Received for publication 16 April 2012)