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NUTRIENT REMOVAL, PERFORMANCE OF GROWTH AND YIELD OF FABA BEAN (*VICIA FABA* L.)

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Abstract

A study on 12 faba bean genotypes was conducted for 2 years to evaluate its growth, nutrient removal, yield and yield components. The genotypes were KITIKI-2003, ERESEN-87, FİLİZ-99, SEVİL, SAKIZ, 95 ETA 225, 95 ETA 249, 95 ETA 276, 97 ETA 718, 97 ETA 727, 98 ETA 296 and 98 ETA 329. In each year mostly significant differences were observed among genotypes for growth, nutrients removal, yield and yield components. In the study on the average of two years across the 12 faba bean genotypes 301 kg ha^{-1} nitrogen, 30.0 kg ha^{-1} phosphorus, 206.9 kg ha^{-1} potassium, 138.5 kg ha^{-1} calcium and 23.9 kg ha^{-1} magnesium were uptaken in response to 11944 kg ha^{-1} plant dry matter production. In addition to the nutrient study on the average 101.9 cm plant height, 3.49 LAI, 864.4 kg ha^{-1} root dry matter and 11944 kg ha^{-1} plant dry matter were observed in the experiment. Furthermore, 7.84 pods $plant^{-1}$, 2.35 grains pod^{-1}, 1557.1 1000-grain weight and 4585 kg ha^{-1} grain yield were recorded. These findings can be used for fertilizer management of faba bean, sustainable faba bean production and as a reference.

Introduction

Faba bean (*Vicia faba* L.) is an annual grain legume, which is mainly grown for its high protein content (on average 30%). It is an important source of proteins for humans and animals. Faba bean popularity has increased recently as its high yield makes it attractive to producers while its high protein content and low-priced makes it attractive to consumers (Pala *et al*., 2000).

Experimental work on the nutrient removal of faba bean is limited. Literature on faba bean or other crops have generated idea for the present study is reviewed. Salih (1986) reported that phosphorus play important role in increasing yield of faba bean. Balaban & Sepetoğlu (1991) observed variability in faba bean genotypes for nutrients uptake and their response. Babiker (1995) reported increases in the root and shoot dry weights, number of pods per plant, as well as yield and yield components of faba bean with the application of fertilizers. Similarly many workers (Sarafi, 1978; Dantuma & Hulze, 1979; Labuda, 1986; Bochniarz *et al*., 1987; Bergareche *et al*., 1988; El-Fouly *et al*., 1989; Shrivastava *et al*., 1989; Ricciardi, 1989; Stuelpnagel, 1993; Ceter & Sepetoğlu, 1995; Lynch, 1998; Fageria, 2002) have revealed beneficiary effect of fertilizer or variation of genotypes in response to fertilizer.

All of the work cited above has shown its own importance in practical life but its use for planning fertilization program or sustainable production is not appropriate. Likewise due to increasing environmental problem strong efforts are directed to optimum fertilizers application because excess of fertilizers effect the environment while shortage leads to low yield. Furthermore, optimum fertilizers application is economical because surplus fertilizers increase just cost of production without increasing crop yield (Sepetoğlu, 2002).

Keeping this in view the present study was conducted to determine uptake of some important plant nutrients for planning a fertilization program. Similarly some growth parameters, yield and yield components were investigated because less or no literature is available to compare results while making selection in faba bean for increased yield. While planning the experiment we hypothesized that (i) the experimental site has sufficient nutrient required for the crop, (ii) the different genotypes would have differential regarding growth, nutrients uptake and yield.

Materials and Methods

A field trial was conducted in 2005-06 and 2006-07 cropping season in İzmir, Turkey on nutrients rich and productive field in the Research Station of the Faculty of Agriculture, Ege University.

Soil of the experimental field area at 0–30 cm depth was sampled to test initial soil properties. The samples were oven-dried, 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 in soil saturation extract as described by Thomas (1996), organic matter by the Walkley–Black method (Nelson & Sommers, 1996), total nitrogen (N) content was determined with 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 in a “Soil and Plant Analysis Laboratory Manual” written by Ryan *et al*., (2001). The results of selected soil properties are listed in Table 1. The climate of the experimental site was typical mediterranean, with mild and rainy winters and hot and dry summers (Fig. 1).

Data regarding nutrients (N, P, K, Ca and Mg) uptake, growth and yield of 12 faba bean genotypes was collected. The genotypes used included KITIKI-2003, ERESEN-87, FİLİZ-99, SEVİL, SAKIZ, 95 ETA 225, 95 ETA 249, 95 ETA 276, 97 ETA 718, 97 ETA 727, 98 ETA 296 and 98 ETA 329. Seeds 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. Each year after planting, two light sprinkler irrigations at 5 days 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 and were carried out uniformly as per requirement.

Plant samples were taken each year at 147 and 167 days after sowing that were related to end of flowering and grain filling stages, respectively. In all these samples each time 10 adjacent plants in the second row of each plot were uprooted. Samples at the end of flowering were used for LAI determination, following the principle of Sepetoğlu (2002). He has shown that LAI in faba bean has maximum value at the end of flowering while plant height, root dry matter and plant dry matter has maximum value at grain filling stage. Leaf area for the sampled plants was determined on simple scanning procedure with area measurement software (Fläche) (Sepetoğlu, 2001). For this, leaves were detached, categorized and counted as small leaves (SL), medium leaves (ML) and large leaves (LL). Average leaf area for each category was determined according to Fläche Computer Software with 20 representative leaves by using flatbed scanner. The average leaf area for different categories: small, medium and large was referred to as LAs, LAm, LAl respectively. Finaly leaf area for the 10 sampled plants was determined as [Leaf area = (SL x LAs) + (ML x LAm) + (LL x LAl)], then leaf area index (LAI) was calculated.

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

Soil properties	2005
pH	7.4
	Unit (%)
Organic matter	2.86
N	0.106
	Unit (mg kg^{-1})
P	148
K	392
Ca	4500
Mg	248
Fe	57.4
Cu	1.77
Zn	2.72
Mn	12.1

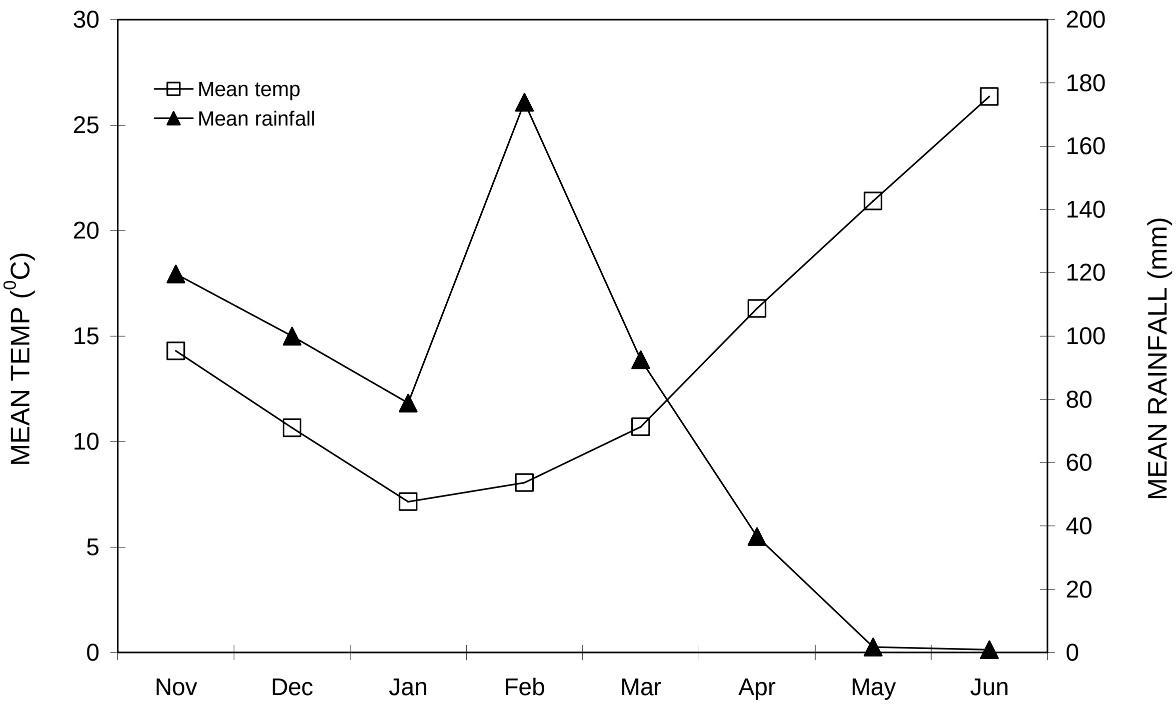

Fig. 1. Mean temp (^{0}C) and rainfall for the two consecutive experimental seasons.

Plant height was determined at grain filling stage by measuring tap for the sampled plants, after that all plant samples were dried in an air-forced oven at 105^{o}C to determine root dry matter, plant dry matter and nutrient analysis. Total above ground dry matter (biomass) was the sum of all plant parts. Dried plant material was ground and digested with a 2:1 mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$). The total N content was determined with Khjeldahl method. Phosphorus was determined colorimetrically, K was determined by flame photometer, Ca and Mg were determined by atomic absorption spectroscopy. Plant analysis methods used in this study are described in a "Soil and Plant Analysis Laboratory Manual" (Ryan *et al*., 2001). The crop was harvested at 14 % moisture content and was used to determine pods $plant^{-1}$ on randomly selected samples of 10 plants in each plot, 1000-grain weight was determined from seed lot of each plot while seed yield (kg ha^{-1}) was calculated based on harvested crop area, middle two rows of each plot.

Table 2. Mean data of two years for total nutrients (N, P, K, Ca and Mg) accumulated by twelve faba bean genotypes during 2005-07.

Genotype	Nitrogen ($kg\ ha^{-1}$)	Phosphorus ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Calcium ($kg\ ha^{-1}$)	Magnesium ($kg\ ha^{-1}$)
FİLİZ-99	325a	34.17^{a}	222.3^{a}	151.5^{ab}	26.91^{a}
ERESEN-87	315ab	29.63^{bc}	207.6^{bc}	139.2^{b-e}	24.15^{a-d}
KITIKI-2003	286cd	28.92^{bc}	200.0^{c}	128.7^{ef}	22.39^{cd}
SEVİL	280cd	27.72^{c}	188.1^{d}	123.6^{f}	21.72^{d}
SAKIZ	307abc	30.92^{bc}	212.5^{ab}	136.6^{cde}	24.20^{a-d}
95 ETA 225	302bcd	29.02^{bc}	205.9^{bc}	140.7^{a-e}	23.73^{a-d}
95 ETA 249	290cd	29.33^{bc}	204.4^{bc}	141.5^{a-d}	23.54^{cd}
95 ETA 276	283d	29.68^{bc}	198.1^{cd}	133.2^{c-f}	22.38^{cd}
97 ETA 718	290cd	28.35^{c}	200.4^{c}	132.3^{def}	22.77^{cd}
97 ETA 727	297bcd	30.78^{bc}	205.8^{bc}	136.1^{c-f}	23.58^{bcd}
98 ETA 296	314ab	30.88^{bc}	215.8^{ab}	145.3^{abc}	25.19^{abc}
98 ETA 329	328a	31.68^{ab}	222.1^{a}	153.0^{a}	26.76^{ab}
$LSD_{Ggenotype\ (0.05)}$	21.98	3.27	11.38	12.83	3.22
Mean	**301**	**30.0**	**206.9**	**138.5**	**23.9**

Values with different letters in superscript indicate significant difference. Also abcd = a-d

Data for observed traits were statistically analyzed and means were calculated according to standard analysis of variance technique for RCB design using MSTATC computer software and means were separated using Fisher's protected least significance difference (LSD) test at 95 % level of probability (Steel & Torrie, 1980).

Results and Discussion

In the present experiment nutrients (N, P, K, Ca and Mg) removal significantly varied among genotypes (Table 2). The nutrients removal ($kg\ ha^{-1}$) across the genotypes ranged from 280-328 for N; 27.72-34.17 for P; 188.1-222.3 for K, 123.6-153.0 for Ca and 22.39-26.76 for Mg. Our objective in the experiment was to achieve mean values for different nutrients removal on the bases of 12 genotypes growth in two years. The mean values were recorded as 301, 30.0, 206.9, 138.5 and 23.9 $kg\ ha^{-1}$ for N, P, K, Ca and Mg respectively. The nutrients removals in our experiment showed similarity with findings of Balaban & Sepetoğlu, (1991); Ceter & Sepetoğlu, (1995). If we compare the nutrients removal of faba bean with chickpea that is important grain legume crop; it reveals that faba bean N and Ca removal was very high compared to N and Ca removal in chickpea while removal of P, K and Mg were almost similar in both the crops (Sepetoğlu *et al.*, 2008). The probable reason for the differences in nutrient removal with chickpea was considered the genetic difference of the two crops.

Results related to plant height, LAI, root dry matter and plant dry matter are presented in Table 3. Except LAI all the growth parameters significantly varied among genotypes. Plant height ranged from 94.0 to 103.9 cm. The variation in plant height among genotypes may be corresponded with phenotypic difference as result of different genotypes as supported by Nasib, 1984.

Table 3. Mean data of two years for 12 faba bean genotypes plant height, leaf area index (LAI), root dry matter and plant dry matter during 2005-07.

Genotype	Plant height (cm)	Leaf area index (LAI)	Root DM (kg ha^{-1})	Plant DM (kg ha^{-1})
FİLİZ-99	102.9^{ab}	3.62	892.9^{abc}	12871^{a}
ERESEN-87	101.8^{ab}	3.52	868.9$^{a\text{-}d}$	11991^{cde}
KITIKI-2003	103.2^{ab}	3.51	846.2$^{a\text{-}d}$	11544^{ef}
SEVİL	94.0^{c}	3.29	839.5^{cd}	10997^{f}
SAKIZ	99.7^{b}	3.55	897.7^{ab}	12191^{bcd}
95 ETA 225	103.9^{a}	3.44	878.9^{abc}	11891^{cde}
95 ETA 249	102.1^{ab}	3.51	818.0^{d}	11729de
95 ETA 276	102.9^{ab}	3.34	842.9^{bcd}	11438^{ef}
97 ETA 718	102.8^{ab}	3.41	839.2^{cd}	11629^{def}
97 ETA 727	102.5^{ab}	3.53	859.0$^{a\text{-}d}$	11940^{cde}
98 ETA 296	103.4^{a}	3.61	888.5^{abc}	12406^{abc}
98 ETA 329	103.5^{a}	3.52	901.0^{a}	12700^{ab}
LSD$_{\mathbf{Ggenotype\ (0.05)}}$	3.518	–	54.86	641.84
Mean	**101.9**	**3.49**	**864.4**	**11944**

Values with different letters in superscript indicate significant difference. Also abcd = a-d

Table 4. Mean data of two years for 12 faba bean genotypes pods plant^{-1}, 1000-grain weight and grain yield during 2005-07.

Genotype	Pods plant^{-1}	Grains pod^{-1}	1000-grain weight	Grain yield (kg ha^{-1})
FİLİZ-99	8.98^{a}	2.37	1417^{g}	4715^{a}
ERESEN-87	8.63^{ab}	2.37	1597^{ab}	4620^{a}
KITIKI -2003	7.53$^{b\text{-}e}$	2.37	1483^{ef}	4574^{ab}
SEVİL	6.78^{e}	2.34	1517de	4357^{c}
SAKIZ	8.51^{abc}	2.37	1440^{fg}	4624^{a}
95 ETA 225	7.16^{de}	2.33	1498^{def}	4560^{ab}
95 ETA 249	7.30^{cde}	2.36	1690^{a}	4586^{a}
95 ETA 276	7.61$^{b\text{-}e}$	2.32	1625^{b}	4572^{ab}
97 ETA 718	7.60$^{b\text{-}e}$	2.33	1548^{cd}	4595^{a}
97 ETA 727	7.58$^{b\text{-}e}$	2.34	1629^{b}	4566^{ab}
98 ETA 296	8.10$^{a\text{-}d}$	2.34	1623^{b}	4601^{a}
98 ETA 329	8.25$^{a\text{-}d}$	2.37	1619^{b}	4653^{a}
LSD$_{\mathbf{Ggenotype\ (0.05)}}$	1.262	–	59.448	226.6
Mean	**7.84**	**2.35**	**1557.1**	**4585**

Values with different letters in superscript indicate significant difference. Also abcd = a-d, bcde = b-e

LAI ranged from 3.29 to 3.62 across genotypes, though the differences were non-significant. Root dry matter ranged from 818.0 to 901.0 kg ha^{-1} while plant dry matter ranged from 10997 to 12871 kg ha^{-1} for different genotypes. The variation in root and plant dry matter among genotypes is in agreement with Pandey (1981), Thompson (1983), Ceter & Sepetoğlu (1995). Mean values for the growth parameters like plant height was 101.9 cm, mean LAI was 3.49, root and plant dry matter were 864.4 and 11944 kg ha^{-1} respectively. The purpose of measurement of growth parameters was to get their mean values so that to generate knowledge that may use as reference in different improvement programs of faba bean especially in potential genotype selection.

During the present study yield and yield components record for 12 faba bean genotypes on the bases of 2 year study and their means are presented in Table 4. Pods plant^{-1} were significantly differente among various genotypes. In genotypes pods plant^{-1} ranged from 6.78 to 8.98 and mean pods plant^{-1} was 7.84. Grain pod^{-1} was not significantly different among different genotypes and its mean value was recorded as 2.35. 1000-grain weight significantly varied from 1417 to 1690 g across the genotypes. Mean 1000-grain weight was 1557.1 g. Grain yield ranged from 4357 kg ha^{-1} to 4715 kg ha^{-1} that showed significant difference among genotypes; average grain yield was 4585 kg ha^{-1}.

The grain yield was at par with findings of Ishag (1973), Salih (1986), Malik *et al*., (1983), Bergareche *et al*., (1988), Shrivastava *et al*., (1989), Dhingra *et al*., (1990) Pekşen and Gülümser (2007). Similarly our findings for yield components are supported by El-Beltagy & Hall (1975), Farah (1981), Lawes *et al*., (1983), Pekşen *et al*., (2006).

Conclusions

Faba bean genotypes differed significantly in growth, nutrients removal, yield and yield components and these differences may be related to difference in genotypes. Nutrient removal was significantly increased with increase in dry matter production. However, responses varied from genotypes to genotypes. On the bases of mean values and dry matter production we can make fertilizer recommendation for sustainable faba bean production. Also these findings can be used as a reference in literature and improvement program of faba bean.

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