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Research Article

Evaluation of Some Faba Bean (*Vicia faba* L.) Genotypes with Low Tannin Content for Agronomical Characteristics

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Abstract

Although seeds of pulses contain high level of protein for human nutrition and animal feeding, they consist of some antinutritional substances. Among these substances, tannins, making difficult to digest by binding to consumed plant proteins, are known as important antinutritional factors in legumes including faba bean (*Vicia faba* L.). This study was aimed to determine the agronomical characteristics of faba beans genotypes with low tannin content and compared with a local control (SAKIZ) with tannin content. The local population had the highest grain yield since SAKIZ had the adapted genes in the region and buffering ability to biotic and abiotic stresses. Some genotypes with low tannin content were found to be compete with the local population in terms of grain yield and earliness, and these genotypes were considered as an alternative protein source for human nutrition and animal feeding to get rid of tannins in faba bean.

Keywords: *Vicia faba; Faba Beans; Tannin; Yield*

Introduction

Pulses are important plant protein sources for human nutrition and animal feeding [1-12]. Although pulses are one of the major protein sources derived from plants for human nutrition and animal feeding, seeds of legumes have some components, which have positive or negative effects on nutritive values. High protein, fat content, vitamins, minerals and dietary fibers have positive effects on nutrition and health, however, some anti-nutritional elements like enzyme inhibitors, lectins, gas-producing factors, polyphenols, tannins, phytic acid and saponins have negative effects [5,13].

Faba bean (*Vicia faba* L.) among the pulses is one of the oldest domesticated plants. It has been cultivated in the Mediterranean and South-Eastern Asian countries since ancient times. The origin of faba bean is pointed out between Afghanistan and the Eastern Mediterranean, and the wild form of the faba bean is not known exactly [1,4,14]. In the present day, faba bean is grown in an area that spreads from northern Europe to Ethiopia. They are grown at the highest rates in the Asia Continent. It is cultivated in all countries located in the Mediterranean coastline. China, Egypt, Morocco, France, Italy and Spain are among the countries where faba beans are cultivated at higher rates [15]. In Turkey, it is grown at maximum amounts in Aegean, Marmara, Central, Northern, Black Sea, the Mediterranean and Middle Eastern regions, respectively. The cities that have the highest growing rates are Çanakkale, Balıkesir, Kütahya, Bursa, Manisa, and Antalya [16]. Faba bean has an important place in human nutrition and consumed in different ways [17] such as fresh pods, fresh seeds, canned fresh pods, seeds and dried seeds due to their rich protein contents [10]. In seeds of faba bean, there are some toxic substances and compounds that make digestion difficult [17-19]. Tannins are one of the most important antinutritional factors in faba beans [20]. Tannins exist intensely especially in the coat of the seeds. Particularly, the tannin amount in the seed coat of faba beans, peas and cowpeas may be 7 - 10 times more than the whole seed. There is a close relation between the color of the flower and the seed coat and the tannin level. The

tannin level is more in dark colored seeds, producing brownish white, purple and red flowers. The presence of tannins in seed coat of faba beans has been shown by a great number of studies. It is hypothesized that the high tannin content, which is associated with the ability to inhibit pathogenic fungi, is an evolutionary advantage. The faba bean cultivars that do not contain tannins are characterized with pale green and whitish cream seed coats, white hilum and white flowers [5,20]. Favism is a disease that is characterized with hemolytic anemia and shows its effect when some people consume faba beans. It is mostly seen in people who live in Mediterranean countries. Canavanine, which is a non-protein amino acid in legumes, leads to favism. Such free amino acids are found especially in *Lathyrus* and *Vicia* [21]. Meanwhile, the faba bean having low tannin content is more preferred as protein source for monogastric animals and poultry animals compared to the normal faba bean having tannins [22-25]. In Europe, faba bean with zero tannin content are examined in breeding studies [25].

Purpose of the Study

The purpose of the present study was to determine the suitable faba bean genotypes with low tannin content and high adaptability to the west Mediterranean region of Turkey and compare them with local cultivar.

Materials and Methods

A total of 28 faba bean genotypes including 27 genotypes having low tannin content improved by the International Center for Agricultural Research in the Dry Areas (ICARDA), and one local control faba bean population (SAKIZ) having tannin content were used in the present study. The study was conducted at fields (K 36^0 53.910' D 030^0 38.554') of the Department of Field Crops, Faculty Agriculture, Akdeniz University, Antalya, Turkey.

The experiment was established in the Complete Randomized Block Design (CRBD) with 2 replications with 50 cm row spacing, 20 cm plant spacing in a row, and 2 rows per plot, and each row was 4 m in length. The planting was made by hand on November 19th 2015. Diammonium Phosphate (DAP) fertilizer was applied as 2 kg/da pure nitrogen fertilization. The measured characteristics were below [26]: days to first flowering (day), days to 50% flowering (day),days to maturity (day),plant height (cm),number of main branches per plant, first pod height (cm), number of pods per cluster, number of pods per plant, length of pods (mm), width of pods (mm), number of seeds per pod, biological yield (g/plot), seed yield (g/plot), 100-seed weight (g) and harvest index (%). Weeds were controlled by hand.

The data obtained were analyzed in the MINITAB 16.1 Package Program [27].

Results and Discussions

Among means of the faba bean genotypes, significant differences were detected in terms of the number of days to first flowering, number of days to 50% flowering, plant height and 100-seed weight at $P< 0.01$. Significant differences were found at $P< 0.05$ level for the first pod height, the number of main branch per plants, number of pods in the plant, the length of the pods, the width of the pods, the number of seeds in the pods, the biological yield, seed yield and harvest index. Similar results were reported by some researchers [6,26,28-30]. The first number of days flowering, 50% flowering days, plant height, first pod height, number of main branches and number of pods per plants are given in table 2.

Registry Number	Name	Pedigree	Origin
1	FLIP 12-094FB	HBP/S0G/2008/2498-1/2009	ICARDA
2	FLIP 12-074FB	HBP/S0G/2008/2439-1/2009	ICARDA
3	FLIP 12-090FB	HBP/S0G/2008/2491-8/2009	ICARDA
4	FLIP 12-098FB	HBP/S0G/2008/2512-3/2009	ICARDA
5	FLIP 12-099FB	HBP/S0G/2008/2513-1/2009	ICARDA
6	FLIP 12-100FB	HBP/S0G/2008/2515-2/2009	ICARDA
7	FLIP 12-101FB	HBP/S0G/2008/2518-7/2009	ICARDA
8	FLIP 12-102FB	HBP/S0G/2008/2521-6/2009	ICARDA

9	FLIP 12-103FB	HBP/S0A/2007/2524-1/2009	ICARDA
10	FLIP 12-104FB	HBP/S0A/2007/2524-3/2009	ICARDA
11	FLIP 12-106FB	HBP/S0A/2007/2524-5/2009	ICARDA
12	FLIP 12-107FB	HBP/S0A/2007/2526-5/2009	ICARDA
13	FLIP 12-108FB	HBP/S0A/2007/2527-1/2009	ICARDA
14	FLIP 12-109FB	HBP/S0A/2007/2528-1/2009	ICARDA
15	FLIP 12-110FB	HBP/S0A/2007/2528-2/2009	ICARDA
16	FLIP 12-111FB	HBP/S0A/2007/2529-1/2009	ICARDA
17	FLIP 12-112FB	HBP/S0A/2007/2529-4/2009	ICARDA
18	FLIP 12-113FB	HBP/S0A/2007/2532-5/2009	ICARDA
19	FLIP 12-114FB	HBP/S0A/2007/2533-8/2009	ICARDA
20	FLIP 12-115FB	HBP/S0A/2007/2534-1/2009	ICARDA
21	FLIP 12-116FB	HBP/S0A/2007/2534-6/2009	ICARDA
22	FLIP 12-118FB	HBP/S0A/2007/2534-8/2009	ICARDA
23	FLIP 12-120FB	HBP/S0A/2007/2536-6/2009	ICARDA
24	FLIP 12-069FB	HBP/DS0/2000/2436-7/2009	ICARDA
25	FLIP 12-091FB	HBP/S0G/2008/2492-6/2009	ICARDA
26	ELISAR	FLIP85-98 FB	Lebanon
27	ICAWHITE	HBP/S0C/2003-Fan54B	ICARDA
28	SAKIZ	Local Variety	

Table 1: *Descriptive data on the genetic materials used in the study.*

Months	**Maximum Temperature (^{0}C)**	**Minimum Temperature (^{0}C)**	**Average Temperature (^{0}C)**	**Average Humidity (%)**	**Total Precipitation (Kg/m^2)**	**Daily Total Open Surface Evaporation (mm)**
November	20.8	13.6	16.8	65.8	9.7	2.2
December	18.1	9.6	13.2	50.0	0.0	2.0
January	14.3	7.3	10.5	57.0	2.5	2.5
February	18.5	11.3	14.5	66.2	2.3	2.3
March	19.3	11.5	15.2	60.4	1.8	3.1
April	22.7	15.7	19.0	67.4	0.4	3.9
May	22.0	16.1	19.0	72.4	1.0	3.6

Table 2: *Monthly meteorological data of the years 2015- 2016.*

The average number of first flowering days of the genotypes ranged between 81 and 98 days. ICAWHITE was the earliest flowering genotype with 81 days, and the latest flowering genotype was FLIP 12-112FB with 98 days. In the faba bean genotypes, days flowering 50% was 87 days (ICAWHITE), and 102 days (FLIP 12-101FB and FLIP 12-110FB). Similar findings were also reported by Toker., *et al* [29]. The average first pod height genotypes varied between 57 cm (FLIP 12-115FB) and 84 cm (FLIP 12-091FB). In a study conducted by Inci and Toker [6], the plant heights were measured between 48 cm and 65 cm in faba bean genotypes. The first pod height of the genotypes varied between 15 cm (FLIP 12-103FB, FLIP 12-118FB and ICAWHITE) and 25 cm (FLIP 12-114FB).

In a study conducted by Bozoğlu [30], the plant heights were measured between 65.0 cm and 82.5 cm in faba bean genotypes. In a study conducted by Karadavut., *et al.* [31], the average height of the plant in the faba beans was reported as between 95.20 and 103.07 cm, and the first pod heights were determined as 12.87 cm to 17.87 cm. The average number of main branches in faba beans was recorded as 2 to 5 number per plant. While FLIP 12-074FB was the least branching genotype, FLIP 12-108FB and SAKIZ were the most branched genotypes. The average number of pods per plant was 6 number/plant (FLIP 12-109FB and FLIP 12-113FB) and 16 number/plant (FLIP 12-108FB and FLIP 12-091FB). The pod length of the genotypes (cm), pod width (cm), number of seeds in pod, parcel biological yield (g) parcel seeds yield (g), 100-seeds weight (g), and harvest index (%) values are given in table 3.

Genotypes	Number of days to first flowering (day)		Number of days to 50% flowering (day)		Plant height (cm)		Height of First Pod (cm)		Number of Main branches per plant		Number of pods per plant	
FLIP 12-094FB	91	± 1,5	93	± 2,5	74	± 0,75	24	± 3,00	3	± 0,50	9	± 2,75
FLIP 12-074FB	82	± 1,5	89	± 2,5	69	± 6,75	19	± 1,75	2	± 0,00	8	± 0,87
FLIP 12-090FB	85	± 3,0	92	± 4,0	78	± 6,13	23	± 2,62	3	± 1,00	7	± 2,88
FLIP 12-098FB	97	± 2,0	101	± 0,0	70	± 7,25	24	± 2,50	4	± 0,50	11	± 4,50
FLIP 12-099FB	94	± 3,5	100	± 0,0	73	± 0,37	23	± 6,37	3	± 1,00	8	± 3,38
FLIP 12-100FB	89	± 5,0	95	± 5,5	79	± 0,75	20	± 1,50	4	± 0,12	12	± 2,75
FLIP 12-101FB	91	± 1,0	102	± 0,0	80	± 1,37	21	± 2,00	4	± 0,25	12	± 2,75
FLIP 12-102FB	90	± 2,0	96	± 1,0	64	± 7,38	19	± 0,87	3	± 1,75	11	± 6,13
FLIP 12-103FB	88	± 2,5	94	± 5,0	60	± 4,87	15	± 1,00	3	± 0,37	9	± 3,62
FLIP 12-104FB	86	± 1,0	93	± 0,5	71	± 5,38	21	± 0,87	4	± 0,12	12	± 1,50
FLIP 12-106FB	89	± 1,5	96	± 1,5	69	± 5,38	19	± 3,25	4	± 0,50	10	± 0,12
FLIP 12-107FB	90	± 0,5	97	± 0,5	71	± 3,13	22	± 0,75	4	± 0,25	10	± 1,37
FLIP 12-108FB	89	± 0,0	94	± 0,5	73	± 0,00	16	± 1,50	5	± 0,50	16	± 2,38
FLIP 12-109FB	90	± 1,5	101	± 1,5	73	± 5,38	22	± 4,75	3	± 0,62	6	± 1,13
FLIP 12-110FB	91	± 1,0	102	± 0,5	73	± 3,38	17	± 0,25	3	± 0,75	12	± 2,88
FLIP 12-111FB	91	± 1,5	97	± 0,0	67	± 1,62	18	± 3,50	3	± 0,25	9	± 1,75
FLIP 12-112FB	98	± 0,0	101	± 0,0	63	± 1,00	20	± 1,00	3	± 0,37	10	± 0,37
FLIP 12-113FB	90	± 0,5	95	± 1,5	61	± 6,25	20	± 0,62	4	± 1,13	6	± 1,75
FLIP 12-114FB	87	± 2,5	92	± 1,0	72	± 4,38	25	± 2,62	3	± 0,12	9	± 1,75
FLIP 12-115FB	86	± 1,0	92	± 0,5	57	± 4,50	19	± 0,12	3	± 0,62	7	± 2,38
FLIP 12-116FB	89	± 1,0	94	± 1,5	66	± 1,25	19	± 1,62	4	± 0,75	11	± 2,25
FLIP 12-118FB	88	± 1,0	94	± 2,5	59	± 3,62	15	± 2,25	4	± 1,13	9	± 1,88
FLIP 12-120FB	85	± 2,5	90	± 2,0	64	± 0,87	16	± 2,38	3	± 0,12	10	± 0,37
FLIP 12-069FB	84	± 1,5	90	± 0,0	67	± 8,50	19	± 0,25	3	± 0,87	12	± 1,75
FLIP 12-091FB	90	± 0,5	100	± 1,5	84	± 6,13	20	± 5,50	4	± 0,75	16	± 3,00
ELISAR	88	± 5,0	91	± 0,5	72	± 3,00	17	± 2,38	4	± 0,00	10	± 1,37
ICAWHITE	81	± 0,5	87	± 1,0	71	± 1,00	15	± 1,13	3	± 0,25	14	± 2,75
SAKIZ	82	± 1,0	88	± 0,5	71	± 2,00	16	± 0,25	5	± 1,00	8	± 0,75

Table 3: *Number of days to first flowering (day), number of days to 50% flowering (days), height of plant (cm), height of first pod (cm), number of main branches in plants, and number of pods in plant, and standard error values (±).*

FLIP 12-098FB was recorded as the faba bean genotype with the shortest length of 6 cm, and the SAKIZ local cultivar was determined to be the longest genotype with 10.6 cm. Similar findings were reported by Karadavut., *et al* [31]. The widths of the pods of the genotypes were measured to be between 1.4 cm and 2.0 cm. The average number of seeds per pod was 2 (FLIP 12-090FB, FLIP 12-098FB, FLIP 12-101FB, FLIP 12-108FB and FLIP 12-113FB); and 4 seeds per pod in ICAWHITE. Similar results were reported by Inci and Toker [6].

Toker., *et al.* [29] conducted a study on different faba bean genotypes and reported the number of pods per plant as 18 to 32. The FLIP 12-100FB genotype had the highest biological yield average with 2050 g/plot. The lowest plot biological yield was weighed as 615 g in the FLIP 12-115FB genotype. While the lowest plot seed yield in the faba bean genotypes was obtained from FLIP 12-090FB with 115g, the local variety SAKIZ had the highest seed yield (580g). In genotypes, the averages of 100-seeds weight were determined between 63g (FLIP 12-074FB) and 129g (SAKIZ). The harvest index values in faba bean genotypes were calculated between 13% (FLIP 12-090FB) and 46% (ICAWHITE). It is considered that the foreign-origin genotypes that may compete with SAKIZ, which is the local variety in terms of earliness and seed yield, may be preferred for both growers and consumers due to their low tannin content, and may be used in the development of new varieties.

Genotypes	Pods Length (cm)		Pods Width (cm)		Number of Seeds per pod		Biological Yield (g/ plot)		Seed Yield (g/plot)		100-Seeds Weight (g)		Harvest Index (%)	
FLIP 12-094FB	7,375	± 0,12	1,525	± 0,02	3	± 0,25	1340	± 230	220	± 10	75	± 2,56	17	± 3,67
FLIP 12-074FB	7,325	± 1,17	1,500	± 0,25	3	± 1,00	840	± 10	235	± 5	63	± 3,86	28	± 0,26
FLIP 12-090FB	7,750	± 0,25	1,575	± 0,75	2	± 0,00	885	± 295	115	± 45	69	± 0,80	13	± 0,84
FLIP 12-098FB	6,000	± 0,25	1,850	± 0,10	2	± 0,50	1445	± 385	225	± 145	73	± 8,99	14	± 6,34
FLIP 12-099FB	8,675	± 1,42	1,750	± 0,30	3	± 0,50	1375	± 235	210	± 120	70	± 2,19	14	± 6,30
FLIP 12-100FB	8,000	± -	2,100	± 0,00	3	± 0,00	2050	± -	330	± 250	101	± 3,96	28	± 0,00
FLIP 12-101FB	6,625	± 0,37	1,425	± 0,22	2	± 0,25	1970	± 150	410	± 30	83	± 4,77	21	± 3,13
FLIP 12-102FB	7,325	± 0,82	1,450	± 0,30	3	± 0,25	1210	± 730	395	± 265	86	± 11,30	31	± 3,47
FLIP 12-103FB	9,250	± 0,25	1,800	± 0,15	3	± 0,00	1175	± 215	305	± 155	73	± 7,89	24	± 8,73
FLIP 12-104FB	8,250	± 0,50	1,500	± 0,00	3	± 0,25	1365	± 75	475	± 55	93	± 2,51	35	± 2,12
FLIP 12-106FB	9,425	± 0,17	1,725	± 0,02	3	± 0,25	1340	± 390	440	± 130	78	± 3,33	33	± 0,15
FLIP 12-107FB	8,500	± 0,50	1,550	± 0,05	3	± 0,00	1335	± 165	350	± 70	80	± 0,57	26	± 2,03
FLIP 12-108FB	8,250	± -	1,750	± 0,00	2	± 0,00	1580	± -	465	± 85	87	± 5,79	35	± 0,00
FLIP 12-109FB	7,750	± 0,75	1,750	± 0,00	3	± 0,25	1230	± 110	290	± 50	95	± 1,63	23	± 1,97
FLIP 12-110FB	8,750	± 0,75	1,725	± 0,17	3	± 0,25	1700	± 160	510	± 10	93	± 3,13	30	± 3,44
FLIP 12-111FB	7,625	± 0,37	1,525	± 0,03	3	± 0,50	1265	± 25	335	± 55	70	± 1,15	27	± 4,87
FLIP 12-112FB	7,750	± 0,25	1,475	± 0,31	3	± 0,50	985	± 5	215	± 35	67	± 4,61	22	± 3,66
FLIP 12-113FB	9,250	± 0,75	1,775	± 0,03	2	± 0,25	1040	± 580	355	± 185	84	± 8,15	35	± 1,81
FLIP 12-114FB	9,250	± 1,25	1,900	± 0,14	3	± 0,75	1380	± 190	415	± 55	96	± 8,57	30	± 0,15
FLIP 12-115FB	9,125	± 0,37	1,525	± 0,31	3	± 0,00	615	± 235	210	± 110	68	± 6,82	32	± 5,67
FLIP 12-116FB	8,000	± 0,50	1,550	± 0,28	3	± 0,50	775	± 45	305	± 25	79	± 2,95	39	± 0,94
FLIP 12-118FB	9,250	± 0,75	1,650	± 0,21	3	± 0,50	790	± 140	270	± 30	77	± 0,79	35	± 2,33
FLIP 12-120FB	8,500	± 0,00	1,675	± 0,46	3	± 0,00	1390	± 190	225	± 185	107	± 10,70	18	± 15,80
FLIP 12-069FB	7,750	± 0,75	1,625	± 0,03	3	± 0,25	1260	± 300	465	± 85	74	± 5,06	37	± 2,16
FLIP 12-091FB	7,350	± 1,35	1,725	± 0,38	3	± 0,25	1680	± 740	490	± 280	74	± 8,36	27	± 4,74
ELISAR	8,975	± 0,22	2,050	± 0,28	3	± 0,25	1535	± 195	470	± 210	105	± 1,58	29	± 9,95
ICAWHITE	10,000	± -	1,450	± 0,00	4	± 0,00	1410	± -	510	± 140	78	± 0,06	46	± 0,00
SAKIZ	10,625	± 1,13	2,000	± 0,00	3	± 0,50	1805	± 185	580	± 90	129	± 6,08	33	± 8,37

Table 4: *Descriptive statistics of the characteristics of the genotypes: Pods length (cm), pods width (cm), number of seeds per pod, biological yield per plot (g), seed yield per plot (g), 100-seeds weight (g) and harvest index (%), and standard error values (±).*

Conclusion

In conclusion, some faba bean genotypes with low tannin content were found to be compete with the local population in terms of grain yield and earliness, and these genotypes were considered as an alternative source of protein for human nutrition and animal feeding to get rid of tannins in faba bean.

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