INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–2–359–362
http://www.ijab.org

Chemical Composition of Faba Bean Genotypes under Rainfed and Irrigation Conditions

IYAD W. MUSALLAM[1], GHAZI N. AL-KARAKI†, KHALIL I. EREIFEJ AND ABDEL-RAHMAN M. TAWAHA
National Center for Agricultural Research and Technology Transfer, P.O. Box 639, Baqa'a–19381, Jordan
†*Faculty of Agriculture, Jordan University of Science and Technology, P.O. Box 3030, Irbid, Jordan*
[1]Corresponding author's e-mail: Iyadw@yahoo.com

ABSTRACT

Thirteen faba bean genotypes were grown at two locations in northern part of Jordan for seed quality characters under rainfed (Maru) and irrigation (JUST) conditions. The highest protein contents under both irrigation and rainfed conditions were recorded for S82408-1-2-3 and FLIP83-24FB (29.7 & 29.2%, respectively). Over the two locations, Aquadulce and the Local Check contained higher than 2% fat content, while the lowest fat content (1.65%) was found in Reina Blanca. Fiber content ranged from 7.76% (in Aquadulce) under rainfed conditions to 11.04% (in S82408-1-2-3) under irrigation. The highest carbohydrate content (60.5%) was recorded for 80S4387 under rainfed conditions, while the lowest carbohydrate content (52.2%) was found in S82408-1-2-3 under irrigation.

Key Words: Faba bean; Rainfed; Irrigation; *Vicia faba*; Chemical composition

INTRODUCTION

Faba bean is used as a high protein food for humans and as a stock feed mostly in Europe, China, the Middle East and northern Africa (Link *et al.,* 1994; Minyi, 1996). The nutritional value and composition of faba bean is considered very similar in many ways to that of meat (Ali *et al.,* 1982).

There has been recent evidence of genetic variation in composition of the seeds of faba bean (Waly & Abd El-Aal, 1986). The range in protein content of the dry seed ranges from 20 to 40% (Griffiths & Lawes, 1978).

Generally research on seed quality of faba bean has been focused on protein and to some extent on carbohydrate and anti-nutritional factors (Hill-Cottingham, 1983; Tewatia & Virk, 1996). As a result, little is known about the other chemical composition of faba bean seeds. Faba bean seeds reported to have a high level of carbohydrate and crude fiber. Carbohydrate content ranges between 52.3 to 64.4% and crude fiber from 6 to 11% on dry weight basis (Salih & El Hardallou, 1986).

Lipid concentration of faba bean is low, ranging from 0.9 to 4.2% and ash content found to range 3.15 to 8.9% (Tewatia & Virk, 1996). Considerable variability has been reported for starch and soluble sugar contents of faba bean seed (Cerning *et al.,* 1975; Sammour, 1987)

The objective of this study was to compare proximate composition of 13 faba bean genotypes under rainfed and irrigation conditions.

MATERIALS AND METHODS

Field experiments were conducted under rainfed and irrigation conditions during 1997/98 growing season at two locations in northern Jordan to evaluate thirteen faba bean genotypes for their seed quality characters. Names, origin and pedigree of faba bean genotypes used, are listed in Table I.

Table I. Names, pedigree and origin of the faba bean genotypes

Genotype	Pedigree	Country of origin
Aquadulce	I1266	Spain
80S4387	X77TA31 E88159 XΓ 88160	ICARDA† (Syria)
79S4	ILB 1814	Syria
FLIP87-70FB	S 82148 E50088 XΓ 79S79180	ICARDA (Syria)
663-4	BPL 663	Tunisia
FLIP87-26FB	S82148 E50088 XΓ 79S79180	ICARDA (Syria)
FLIP87-140FB	MS 86001‡	ICARDA (Syria)
Reina Blanca	ILB 1270	United Kingdom
L82007-11-3-1	EILB1817 XΓ 76TA56246	ICARDA (Syria)
FLIP87-147	S82112 EReina blanca XΓ 7YTA85	ICARDA (Syria)
S82408-1-2-3	EILB 1814 XΓ BPL 82	ICARDA (Syria)
FLIP83-24FB	Selection 81S36522	ICARDA (Syria)
Local Check	----------	Jordan

‡ MS: male sterile; ICARDA: The International Center for Agricultural Research in the Dry Areas

Site description. Maru Agricultural Experiment Station (34˚40´ N, 32˚36´ E, 590 m.a.s.l) had average annual rainfall of 407 mm for the period of 1993-97 and the total rainfall during the 1997/98 growing season was 505 mm (Table II). The soil texture is silty clay with pH of 7.9, 1.2% total nitrogen (N) and 18 ppm extractable phosphorus (P).

Jordan University of Science and Technology Experimental Station (JUST) (32˚30´ N, 35˚59´ E, 590 m.a.s.l). The average annual rainfall was 227 mm for the period of 1993-97 and the total rainfall and irrigation during the 1997/98 growing season was 292 and 415 mm,

respectively (Table II). The soil texture is fine-loamy with pH of 8.0, 1.0% total N and 4.5 ppm extractable P.

Experimental layout and cultural practices. Seeds of the 13 faba bean genotypes were planted under irrigation at the experimental station of Jordan University of Science and Technology (JUST) and rainfed conditions at Maru Agricultural Experiment Station (Maru). Planting was carried out by hand on November 30th, 1997 at both locations. Irrigation was applied by a trickle irrigation system. At both locations, the plots were laid out in a randomized complete block design (RCBD) with three replications. Plots were 2.5 m long and 2.4 m width. Each plot contained 6 rows, with 0.4 m spacing between rows and 0.1 m between plants within a row. Fertilizer was hand broadcasted prior seeding at a rate of 20 kg ha^{-1} of nitrogen and 40 kg ha^{-1} of P_2O_5. Three weeks after emergence weeds were removed manually.

Proximate analysis. Dry seed samples from each plot were analyzed for chemical composition on dry weight basis. Seed samples were ground to a fine powder using a laboratory mill with 0.5 mm sieve and the flour stored for the proximate analysis. Moisture, protein (N × 6.25), fiber, fat and ash contents were determined according to AOAC (1984). Glucose, sucrose, fructose and raffinose contents were determined according to the method described by Dubois *et al.* (1956). Starch content of seeds was determined according to McCready *et al.* (1950). Carbohydrate contents were calculated by difference.

Statistical analysis. Data from each location were analyzed separately. Combined analysis of variance over locations was also performed using MSTATC statistical software, version 2.10 (Knowledge Dynamics Corporation). Least significant difference (LSD) was calculated to determine the significance of differences between the means.

RESULTS AND DISCUSSION

There were highly significant ($P \leq 0.01$) environmental (location) effects for all traits except for fructose and glucose content (Table III). Genotypes varied significantly over locations for all traits. Genotype × environment interaction was significant for only ash, fat and fructose contents. The chemical composition of the seeds and its variation among location and genotypes is shown in Table IV. Moisture availability significantly affected chemical composition, though differently in the constituents examined. Thus, Ash, protein and fiber were higher under irrigation conditions, whereas the opposite was true for fat and carbohydrate.

Protein content varied significantly and ranged from 25.1% (80S4387) under rainfed conditions to 30.1% (S82408-1-2-3) under irrigation conditions. Kelly (1973) attributed differences in the protein contents of legumes to environmental conditions, genotypes, and agricultural practices.

The fat content also varied significantly within the faba bean genotypes. Over the two locations Aquadulce and the local check contained higher than 2% fat content, while the lowest fat content (1.65%) obtained by Reina Blanca under irrigation conditions. The minor interval variation of the values (1.65 to 2.08% under irrigation & 1.69 to 2.24% under raifed conditions) disagrees with the wide range reported by Karamanos (1994).

Table II. Rainfall, irrigation and air temperature during 1997/1998 growing seasons at experimental sites

Month	Irrigation	Rainfall		Min Temp. (˚C)		Max Temp. (˚C)	
	JUST†	JUST	Maru‡	JUST	Maru	JUST	Maru
September	0	2.9	7	18.02	17.8	29.36	28.5
October	0	26.7	22	16.06	15.3	27.52	26.8
November	35	27.5	35.3	11.90	10.9	20.62	20.6
December	40	60.3	86.9	8.72	7.5	15.44	15.4
January	20	64.9	118.7	6.25	4.8	12.82	17
February	60	31.9	54.9	5.24	5.3	14.18	12.2
March	80	67.5	160.2	6.67	6.6	16.13	14
April	100	4.4	16.5	12.23	11.7	24.40	15.3
May	80	5.6	3.8	14.39	15.1	28.00	23.1
Total	415	291.7	505.3				

† JUST: Jordan University of Science and Technology Experimental Station; ‡ Maru: Maru Agricultural Experiment Station

Table III. Mean squares from analysis of variance for seed proximate composition of faba bean grown under rainfed and irrigation

	DF	Ash	Protein	Fibre	Fat	Carbohydrate	Fructose	Glucose	Sucrose	Raffinose	Starch
Replication	2	0.092 ^{NS}	0.057 ^{NS}	0.409 ^{NS}	0.002 ^{NS}	1.612 ^{NS}	0.006 ^{NS}	0.01^{NS}	0.034 ^{NS}	0.001 ^{NS}	0.500 ^{NS}
Location (L)	1	12.481 **	31.849 **	37.289 **	0.245 **	214.57 **	0.019 *	0.008 ^{NS}	2.484 **	0.116 **	69.16 **
Genotypes (G)	12	0.308 **	9.232 **	1.727 **	0.075 **	15.689 **	0.011*	0.026 **	0.041 **	0.003 **	9.372 **
L × G	12	0.129 *	0.947 ^{NS}	0.379 ^{NS}	0.036 **	1.394 ^{NS}	0.017 **	0.009 ^{NS}	0.021 ^{NS}	0.002 ^{NS}	2.034 ^{NS}
Error	50	0.066	2.074	0.345	0.010	2.686	0.005	0.007	0.013	0.001	2.077

NS = Not significant; *, ** are significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

Table IV. Seed protein, fat, fiber, carbohydrate and Ash content in percent of 13 faba bean genotypes grown under irrigation (I) and rainfed (R) conditions during 1997/98 growing season

Genotype	Protein		Fat		Fiber		Carbohydrate		Ash	
	I	R	I	R	I	R	I	R	I	R
Aquadulce	27.33	26.30	2.08	1.97	9.25	7.76	57.4	60.4	3.92	3.35
80S4387	27.35	25.05	1.73	1.77	9.28	8.88	57.1	60.5	4.55	3.76
79S4	27.47	26.18	1.87	1.89	10.16	7.90	56.2	60.3	4.34	3.73
FLIP87-70FB	27.31	25.17	1.68	1.82	10.62	9.27	55.9	59.8	4.46	3.27
663-4	29.82	28.20	1.87	2.11	10.52	8.57	53.4	57.8	4.42	3.30
FLIP87-26FB	28.21	26.36	1.83	1.83	10.29	9.00	55.1	59.4	4.55	3.42
FLIP87-140FB	27.21	25.97	1.76	1.72	9.85	8.84	56.5	59.8	4.70	3.69
Reina Blanca	29.73	28.08	1.65	2.01	10.91	9.21	53.2	57.1	4.49	3.56
L82007-11-3-1	29.07	27.26	1.79	1.86	10.58	9.50	54.3	57.7	4.26	3.69
FLIP87-147FB	28.01	28.77	1.74	1.94	10.02	8.38	56.4	57.3	3.84	3.59
S82408-1-2-3	30.14	29.28	1.66	1.69	11.04	9.23	52.2	55.9	4.92	3.93
FLIP83-24FB	29.51	28.88	1.78	1.87	10.62	9.80	53.3	55.7	4.75	4.08
Local Check	27.17	26.23	1.82	2.24	10.68	9.51	56.1	58.5	4.27	3.52
Mean	28.33	27.06	1.79	1.90	10.29	8.91	55.2	58.5	4.42	3.62
LSD (0.05)	2.562		0.1779		1.045		2.916		0.457	

Table V. Seed sucrose, fructose, glucose, raffinose and starch content in percent of 13 faba bean genotypes grown under irrigation (I) and rainfed (R) conditions during 1997/98 growing season

Genotype	Sucrose		Fructose		Glucose		Raffinose		Starch	
	I	R	I	R	I	R	I	R	I	R
Aquadulce	1.05	1.40	0.98	0.97	1.75	1.76	0.26	0.41	41.8	43.9
80S4387	0.98	1.18	0.87	1.06	1.66	1.72	0.28	0.35	40.8	44.4
79S4	0.86	1.22	0.80	0.95	1.51	1.59	0.30	0.34	40.7	42.2
FLIP87-70FB	1.01	1.15	1.00	0.96	1.62	1.58	0.33	0.40	40.3	41.1
663-4	0.97	1.30	0.95	0.95	1.61	1.55	0.29	0.37	38.2	41.4
FLIP87-26FB	0.96	1.28	0.99	1.00	1.52	1.60	0.32	0.41	39.7	41.1
FLIP87-140FB	1.03	1.35	0.85	1.01	1.64	1.72	0.32	0.41	40.1	41.1
Reina Blanca	0.93	1.34	0.87	0.93	1.58	1.58	0.23	0.35	37.6	41.0
L82007-11-3-1	0.88	1.37	0.94	0.96	1.60	1.67	0.30	0.36	38.5	41.4
FLIP87-147FB	1.07	1.52	1.01	0.96	1.63	1.73	0.31	0.40	40.3	40.7
S82408-1-2-3	0.82	1.21	0.83	0.94	1.51	1.59	0.29	0.36	37.0	39.9
FLIP83-24FB	0.82	1.41	1.04	0.83	1.69	1.52	0.34	0.40	39.3	39.5
Local Check	0.86	1.15	0.86	0.88	1.58	1.55	0.30	0.33	39.5	40.9
Mean	0.94	1.30	0.92	0.95	1.61	1.63	0.30	0.38	39.5	41.4
LSD (0.05)	0.2028		0.1258		0.1488		0.0562		2.564	

Fiber content values showed significant variation among genotypes at both locations ranging from 7.76% (Aquadulce) under rainfed conditions to 11.04% (S82408-1-2-3) under irrigation conditions. The lower values under rainfed than under irrigated conditions could be attributed to environmental the non-favorable temperature during seed filling stage and other factors. Similar observation was reported by Karamanos *et al.* (1994).

Ash also varied significantly within the investigated faba bean genotypes. The highest value (4.92%) recorded under irrigation condition for S82408-1-2-3, while the lowest value (3.27%) recorded for FLIP87-70FB under rainfed conditions. These results were in agreement with Ereifej and Al-Karaki (1996), who found that under high rainfall ash content in pea (*Pisum sativum* L.) was higher than that under low rainfall conditions.

A significant variation between genotypes at both locations was observed in the carbohydrate content, which ranged from 52.2% under irrigation conditions to 60.5% under rainfed ones. In agreement with the finding of other investigators (Barratt, 1982; Karamanos *et al.*, 1994) carbohydrate content has an inverse relationship with protein content at the two locations. These data on the chemical composition of faba bean seeds in general, correspond with results reported by Farouk *et al.* (1986), Karamanos *et al.* (1994) and Maquardt *et al.* (1975).

The result of present study have shown that glucose was the largest fraction of total sugars found in the seed, followed by sucrose, fructose and raffinose, respectively (Table V). The variation in sucrose and raffinose caused by environmental conditions (locations) was greater than the variation among the genotypes, while the opposite is true for glucose and fructose.

Starch was the largest single fraction found in the seed, it accounted for almost half the total dry weight. A significant variation between genotypes at both locations was observed in the starch content, which ranged from 37.0% (S82408-1-2-3) under irrigation conditions to 44.4% (80S4387) under rainfed conditions.

From the preceding discussion we can conclude that the chemical composition of faba bean seeds has been found to vary according to genotypes and climatic conditions.

However, irrigation significantly improved the protein content. Moreover, it appears that the seeds of faba bean are rich in protein, carbohydrate and fiber but low in fat. Therefore, faba bean can serve as a cheap and alternative protein source to alleviate protein malnutrition among the economically weaker section of population living in developing countries like Jordan.

REFERENCES

Ali, A.E., G.E.E. Ahmed and E.B. El-Handallou, 1982. Faba beans and their role in diets in Sudan. *In*: Hawtin, G. and C. Webb (eds.), *Faba Bean Improvement*, pp: 317–8. Martinus Nijhoff Publishers, The Hague

AOAC (Association of Official Analytical Chemists), 1984. *Official Methods of Analysis*, 14th Ed. Washington, DC, USA

Barratt, D.H.P., 1982. Chemical composition of mature seeds from different cultivars and lines of *Vicia faba* L. *J. Sci. Food and Agri.*, 33: 603–8

Cerning, J., A. Saposnik and A. Guilbot, 1975. Carbohydrate composition of horsbeans (*Vicia faba*) of different origins. *In*: Hebblethwaite, P.D. (ed.), pp: 159–80. *The Faba Bean.* Butterworths, London

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rabers and F. Smith, 1956. Calorimetric method for determination of sugars and related substances. *Ann. Chem.*, 28: 350–6

Ereifej, K.I. and G.N. Al-Karaki, 1996. Physico-Chemical and Cooking Characteristics of Pea Genotypes Grown Under Rainfed Conditions. *Legume Res.*, 19: 143–50

Farouk A.S. and S.B. El Hardallou, 1986. The yield performance and proximate analysis of twelve cultivars of faba beans grown at five sites in the northern region of the Sudan. *FABIS*, 15: 52–9

Griffiths, D.W. and D.A. Lawes, 1978. Variation in crude protein of field beans (*Vicia faba*) in relation to the possible improvement of the protein content of the crop. *Euphytica*, 27: 487–6

Hill-Cottingham, D.G., 1983. Chemical Constituents and Biochemistry. *In*: Hebblethwaite, P.D. (ed.), *The Faba Bean*, pp. 159–80. Butterworths, London

Karamanos, A.J., G. Papadopoulos, C.E. Avgoulas and P. Papastylianou, 1994. Chemical composition of seeds of 11 field grown faba bean cultivars in two cultivation periods. *FABIS*, 34/35: 39-47

Kelly, J.F., 1973. Increasing Protein Quantity and Quality. *In*: Milner, M. (ed.), *Nutritional Improvement of Food Legumes by Breeding*, p. 179. The Protein Advisory Group of the United Nations System, New York, USA

Link, W., W. Ederer, P. Metz, H. Buiel and A.E. Melchinger, 1994. Genotypic and environmental variation for degree of cross-fertilization in faba bean. *Crop Sci.*, 34: 960–4

Marquardt, R.R., J.A. Mckirdy, T.A. Ward and L.D. Campbell, 1975. Amino acid, heamogglutinin and trypsin inhibitor levels and a proximate analysis of faba beans (*Vicia faba*) and faba bean factors. *Canadian J. Anim. Sci.*, 55: 421–9

McCready, R.M., J. Guggolz, V. Silviera and H.S. Owens, 1950. Determination of starch and amylose in vegetables: application to peas. *Ann. Chem.*, 22: 1156–8

Minyi, G.G., 1996. Food legumes in qinghai. *FABIS*, 38/39: 1

Salih, F.A. and S.B. El Hardallou, 1986. The yield performance and proximate analysis of twelve cultivars of faba beans grown at five sites in the northern region of the Sudan. *FABIS*, 15: 52–5

Sammour, R.H., 1987. Chemical constituents and electrophoresis of seed proteins of some species of *Vicia faba*. *FABIS*, 18: 30–2

Tewatia, B.S., and A.S. Virk, 1996. Nutritional potential of faba bean for improved productivity in ruminants/ A Review. *FABIS*, 38/39: 2–11

Waly, E.A. and S.A. Abd El-Aal, 1986. Combining ability for protein and cellulose content in a five-parent diallel of *Vicia faba* L. *FABIS*, 14: 4–6

(Received 20 February 2004; Accepted 28 February 2004)