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Landraces versus Commercial Common Bean Cultivars under Organic Growing Conditions: A Comparative Study Based on Agronomic Performance and Physicochemical Traits

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Summary

This study targeted to assess the yield components and physicochemical traits of eight common bean landraces versus four commercial cultivars widely grown in Greece. The genotypes were cultivated for two growing seasons under organic growing conditions and a preponderance [better agronomic characteristics; number of pods per plant, seed weight, biomass and enhanced physicochemical properties; protein and fat content (%)] of landraces over commercial cultivars was found. It was also observed that organic environment of experimentation allowed for better differentiation of the examined genetic material but displayed a negative impact on the commercial cultivars. These results were obtained by determining the genetic parameters (GCV, H) and orthogonal contrasts between different (landraces versus commercial cultivars) groups according both to growth type and origin. High detectable genetic variation in agronomic performance and physicochemical traits among the examined dry bean cultivars was found. Three high yield landraces of enhanced physicochemical properties (% protein and fat content) were identified as promising material for eventual production of ecotypes endowed with high adaptation to organic cropping system.

Key words. *Phaseolus vulgaris* – local bean cultivars – orthogonal comparisons – organic culture physicochemical parameters

Introduction

Common bean (*Phaseolus vulgaris* L.) is one of the major constituents in human diet, especially in developing countries where it is considered as economic source of protein (Beebe et al. 1995). It is an important crop not only for its adequate nutritive composition but for numerous uses and culinary applications as well (Negri and Tosti 2002). The genetic base of most common bean cultivars within a market class appears to be narrow (Singh 2001). This situation is also attributed to stringent quality requirements imposed by both consumers and processors. To broaden the genetic base and at the same time, to maximize the gains from selection, it is imperative to accumulate favorable genes from other germplasm resources, like wild relatives and landraces. Knowledge, access, and use of diversity available in cultivated bean landraces stand for the essential parameters towards broadening the genetic base of cultivars to sustain improvement (Singh 2001). To maximize and sustain bean production, high yield and quality cultivars with less requirements regarding to water, fertilizer, pesticides and manual labor should be developed (Singh 2001). Thus, the newest cropping approaches of sustainable and organic agriculture renewed the interest in the traditional germplasm, especially for landraces.

The traditional landraces are the product of a continuously evolving process between genotype and natural selection. Sometimes, a non systematic selection was applied by the farmers over the years. As a result these landraces accumulated desirable genes of enhanced environmental adaptation, useful agronomic traits and quality characteristics. The intensive form of agriculture in modern cropping systems, has progressively replaced these landraces with improved commercial cultivars ensuring higher and more stable yield. The landraces in common beans stand for populations since they have been maintained as a mixture of pure lines by farmers through the years (Estribano et al. 1997). Their high adaptability, resistance to biotic and tolerance to abiotic stress and occasionally the presence of specific quality traits enhance the interest for these genetic resources (Mavromatis et al. 2004).

Phaseolus vulgaris as a Leguminosae species, contributes a great amount of nitrogen (N) to the soil which is very important particularly for organic farming (Graham and Ranalli 1997). In general, the economic value of dry beans is strongly related to plant morphology, agronomic performance, seed quality and nutrient value. Seed yield in dry beans can be expressed almost as the product of pods per plant, seeds per pod and seed weight (Nienhuis and Singh 1986). The nutrient value greatly depends on parameters such as protein content, dietary fiber, minerals and trace elements. For all these reasons, the collection, characterization, and utilization of local bean landraces are essential for maintenance of the biological di-

Table 1. Morphological, seed quality and yield traits from eight common bean landraces and 4 commercial cultivars and estimation of coefficient of heritability (H) and genetic coefficient of variation (GCV).

No	Cultivar	C / L	Growth habitus	No. pods per plant	Biomass per plant (g)	Harvest index	Weight of pods per plant (g)	Weight of 100 seeds (g)	Weight of seeds per plant (g)
1	'Rodopi'	L	IV	48.5 ± 8.46	143.6 ± 13.54	0.40 ± 0.030	88.4 ± 9.13	33.37 ± 7.1	59.6 ± 12.8
2	'Xanthi'	L	IV	51.3 ± 3.77	123.2 ± 15.27	0.42 ± 0.056	73.2 ± 8.69	33.87 ± 3.2	51.3 ± 5.4
3	'Kastoria'	L	IV	39.8 ± 7.71	209.7 ± 26.40	0.41 ± 0.084	125.8 ± 13.76	59.82 ± 6.8	86.7 ± 12.2
4	'Byzitsa M/M'	L	IV	21.5 ± 4.35	166.2 ± 12.93	0.48 ± 0.037	104.0 ± 16.62	55.53 ± 5.5	78.8 ± 6.4
5	'Byzitsa A/M'	L	IV	28.7 ± 4.74	185.9 ± 12.07	0.47 ± 0.032	117.2 ± 12.46	55.90 ± 5.8	86.1 ± 8.7
6	'Byzitsa B.'	L	IV	49.5 ± 11.01	184.2 ± 12.84	0.48 ± 0.026	123.8 ± 12.58	28.67 ± 4.5	89.0 ± 10.2
7	'Zargana K.'	C	IV	23.2 ± 3.24	79.1 ± 8.25	0.29 ± 0.023	44.9 ± 8.47	25.20 ± 3.2	24.8 ± 4.8
8	'Stara Zagorski'	C	IV	20.5 ± 2.47	64.3 ± 7.82	0.41 ± 0.032	41.6 ± 9.23	36.50 ± 4.2	26.8 ± 3.6
9	'Velestino'	L	I	23.7 ± 4.13	89.1 ± 12.83	0.36 ± 0.052	54.1 ± 9.43	30.33 ± 6.9	32.0 ± 7.4
10	'Byzitsa K.'	L	I	29.2 ± 8.26	130.7 ± 24.14	0.38 ± 0.015	71.9 ± 12.13	46.87 ± 7.4	48.5 ± 4.5
11	'Magirus'	C	I	20.7 ± 2.13	86.0 ± 8.47	0.29 ± 0.024	40.8 ± 7.42	38.87 ± 1.2	23.4 ± 3.2
12	'Garafal'	C	I	22.3 ± 3.27	87.6 ± 7.54	0.38 ± 0.018	46.4 ± 8.56	32.03 ± 3.1	27.8 ± 3.4
	Mean			31.6 ± 6.45	129.1 ± 12.60	0.40 ± 0.043	77.7 ± 9.90	39.74 ± 4.2	52.9 ± 5.1
	F			**	**	*	**	**	**
	LSD			18.2	36.0	0.13	28.3	21.9	14.5
	Genetic Parameters								
	H			0.73	0.83	0.54	0.73	0.88	0.82
	GCV			8.2	5.8	15.5	7.8	9.4	10.8

Statistical differences among cultivars in studied traits, according to Fisher's test (p: 0.05 (*), 0.01 (**).
L: Landrace; C: Commercial
Growth habitus: I: bushy; IV: climbing

versity through conservation programs and for further improvement of productivity and quality of final product under sustainable or organic growth conditions.

The objectives of this study were: (i) to evaluate the field performance and genetic variation of local bean landraces under organic growing conditions and (ii) to identify landraces with high nutrient value characteristics or specific seed quality traits, competitive with those of commercial cultivars.

Materials and Methods

Eight common bean landraces from two growth types [(I) bushy, (IV) climbing] according to CIAT (1987), were cultivated in Northern and Central Greece, collected and grown in organic farm of University of Thessaly for two growing seasons (2003–04), (Table 1). The experimental field was located in a traditional area for common bean cultivation in Greece (39.23 °N, 22.45 °W), 50 m altitude with mean rainfall 280 mm and temperature 18 to 32 °C.

The agronomic and nutrient value of examined landraces were estimated in comparison to four commercial varieties widely grown in Greece. A three year preculture rotation scheme (*Vicia sativa – Triticum durum – Phaseolus vulgaris*) had been applied in the organic experimental field without any input of agrochemical or fertilizer. The only input referred to, 430 mm of water per, each experimentation period were applied by means of the surface drip method. The stubbles of the previous cereal crop, were mechanically blended prior to sowing. The weeds were manually controlled at regular intervals after the bean's germination. The experimental design was a randomised complete block with three replications and each cultivar was sown in a single row plot with 15 plants. The distance between rows was 50 cm and between plants 30 cm.

Agronomic performance

Agronomic performance in terms of yield was measured with regard to components: number of pods per plant, weight of pods per plant (g), weight of seeds per plant (g), weight of 100 seeds (g), biomass (g plant^{-1}) and harvest index.

Pod traits were recorded in 30 pods per cultivar randomly sampled from 10 plants. Biomass (g plant^{-1}) and harvest index, were also estimated by a random sample of 10 plants.

Statistical analysis. The analysis of variance (ANOVA) carried out according to the random model of STEEL and TORRIE 1981 (Table 2).

According to the model, the total phenotypic variation (σ^2p) = M1/r and genotypic variation (σ^2g) = (M1–M2)/r among landraces and commercial cultivars, were estimated. Furthermore, coefficient of variation (CV %), genotypic coefficient of variation (GCV= $\sqrt{\sigma_g^2}/Mean \times 100$) and the broad sense coefficient of heritability

Table 2. Analysis of variance (ANOVA).

Source of variation	Degrees of freedom	Mean square	Expected mean square
Growing season(s)	s–1		
Reps/growing season	s(r–1)		
Genotypes	g–1	M1	$\sigma^2_e + r*\sigma^2_g$
Error	$s*(g-1)*(r-1)$	M2	σ^2_e
Total	$s*g*r-1$		

g: number of genotypes
r: number of replications

Table 3. Mean squares and significance according to F-test (* p=0.05 , **p=0.01).

Source of variation	df	Mean Squares			
		Yield - seeds per plant	Pods per plant	Biomass per plant	H.I
Cultivars	11	2109.36	3382.09	7048.37	0.0137
F		**	**	**	*

(H=(σ^2g)/(σ^2p)) was found. The comparison of means was made with LSD, and orthogonal comparisons were used between the different groups of landraces and commercial cultivars based on their growth type and origin.

Physicochemical properties and nutritional traits

Physicochemical properties and nutritional traits were measured two months after harvesting when the seeds reached the commercial maturity. In this case, one hundred seed mass was determined by counting 100 seeds using an electronic seed counter and weighing. Seeds (100 g) after weighing, were transferred into a cylinder where 100 ml water, were added. The density of bean seeds was calculated and recorded as g ml^{-1} (Bishnoi and Khetarpaul 1993). Dry beans were monitored for their colour using flex spectrocolorimeter (Hunter miniscan XE-D50, Reston, Virginia, USA). The recorded parameters L* (luminosity), a*(greenness) and b* (yellowness) were determined using a white title as standard and three replications were recorded. Also the Chroma (C) parameter was calculated, according to the formula:

$$C = \left|(a)^2 + (b)^2\right|^{1/2}$$

Finally, the pH was measured using pH-meter model pH526 WTW MultiCal®).

The nutritional quality traits measured, were protein content (measured with the Kjeldhal method; Nx6.25) based on Aoac 981.10 1990. Fat percentage was determined by the petroleum ether extraction method using a Soxhlet extractor Aoac 932.06 1990. All values were expressed as a percentage dry matter of seed weight (% dm). The hardness of seeds was measured using a penetrometer after 15 min of cooking in a sample of fifteen seeds per variety.

Statistical analysis. Data were analysed with ANOVA and regression analyses. The Duncan's multiple range test was used to separate means. Analyses of variance were performed by the usual method (Steel and Torrie 1981), for all the physicochemical traits which studied and significance was accepted at P≤0.05.

Results

A wide genetic variation in many characteristics among the collected common bean landraces was observed. Significant differences were detected among the examined landraces and commercial common bean cultivars in yield components: weight of seeds per plant, number and weight of pods per plant (Table 1). Although the highest values were anticipated to be recorded for commercial cultivars this was not the case. This phenomenon could be due either: (a) to an enhanced genetic potential of local cultivars compared to commercial ones or (b) to the fact that the commercial cultivars of highly demanding inputs, did not perform well under organic conditions. To be more specific some local bean landraces displayed a better performance in terms of number of pods per plant ('Rodopi', 'Xanthi', 'Byzitsa B.') or weight of pods and seeds per plant ('Kastoria' and landraces originated from geographical area of Byzitsa) (Table 1). Furthermore, significant differences in the weight of biomass per plant between landraces and commercial cultivars, were also detected. It was obvious that the specific environment of organic culture maximized the differences especially to the characteristics linked to inputs, like the biomass. The organic environment *of experimentation* allowed for better differentiation of the examined genetic material but displayed a negative impact on the commercial cultivars.

The values of mean squares indicated that populations had significant differences in most of the examined traits providing thus the opportunity for exploitation and breeding of this genetic material (Table 3). The study of genetic parameters, showed that there is a high detectable genetic variation both among and within common bean populations (Table 1). The coefficient of heritability in the broad sense (H) for the components: weight of seeds per plant, weight of pods per plant, number of pods per plant, weight of biomass per plant and weight of 100 seeds, ranged from 0.73 to 0.88, providing an advantage for yield selection (Table 1).

The coefficient of correlation (r) between yield components revealed positive values ranging from 0.34 to 0.92. The correlations between weight of pods and biomass, weight of seeds per plant and biomass, weight of pods and yield of seeds were high, with values 0.92, 0.86 and 0.92, respectively thus giving the possibility for an indirect selection (Table 4).

Genetic differences among cultivars originated from the same geographical area

Differences were revealed in several morphological and yield component traits in accessions from the same region. Among the landraces examined, four populations originating from the area of Byzitsa Magnesias gave the highest yield (Table 1). This could be attributed to the

Table 4. Coefficients of correlation (r) between yield components for all common bean cultivars tested.

	No. pods per plant	H.I	Biomass per plant (g)	Weight pods per plant (g)	Yield - seeds per plant (g)
No. pods per plant	1				
H.I	0.34	1			
Biomass per plant (g)	0.47	0.47	1		
Weight of pods per plant (g)	0.57	0.61	0.92	1	
Yield - seeds per plant (g)	0.39	0.62	0.86	0.92	1

Table 5. Orthogonal contrasts among local bean landraces and commercial cultivars.

	No. pods per plant	Biomass per plant (g)	Yield - seeds per plant (g)
All landraces vs all commercial cultivars	94.9 vs 42.4 *	154.1 vs 80.3 *	66.5 vs 25.5 *
Landraces (gt-IV) vs commercial (gt-IV)	79.1 vs 43.2 *	126.6 vs 74.9 *	56.4 vs 25.8 *
Landraces (gt-I) vs commercial (gt-I)	62.9 vs 41.5	109.9 vs 85.7	40.2 vs 25.2
Landraces from same origin ('Byz. A/M', 'Byz M/M', 'Byz. B.', 'Byz. K.', 'Velestino') vs all other cultivars	94.2 vs 65.4 *	151.2 vs 113.9*	66.8 vs 42.8 *

vs: versus, gt-I : bushy growth type, gt-IV : climbing growth type, Byz.: Byzitsa
Statistical differences: (* P=0.05)

fact that these populations originated from a region quite close to experimentary area of Velestino. However, this observation was not confirmed by the response of homonymous population originating from Velestino which resulted in the lowest yield and gave very low values for traits like, weight of pods per plant, weight of seeds per plant and weight of biomass (Table 1). This is an indication of low potential and genetic buffering of this land race. Furthermore, according to orthogonal contrasts, there were found statistically significant differences between landraces from Magnesia ('Byzitsa A/M', 'Byzitsa M/M', 'Byzitsa B.', 'Byzitsa K.', 'Velestino') and all other cultivars in traits like number of pods per plant, yield and biomass (Table 5).

Although the landraces 'Kastoria' and 'Xanthi' originated from Northern Creece, they displayed very good performance and exhibited high adaptation. The landrace from Kastoria had the highest value for weight of pods and biomass per plant. The landrace from Xanthi having the highest number of pods per plant had an important advantage over the others because it can be also consumed as raw material. It is clearly shown that the above described performance could be due to the genetic buffering of these populations thus rendering them more promising and competitive for extensive use in the future.

Relationships among cultivars based on growth habit and agronomic performance

In this experiment, it was found that the climbing landraces (growth type IV) resulted in higher yield than bushy ones (growth type I) (Table 1). Furthermore, high variability in agronomic components among climbing landraces and bushy ones, was found. Moreover orthogonal contrasts between landraces and commercial cultivars of the same growth type (IV), revealed significant differences (Table 5). At the oppose commercial cultivars 'Magirus' and 'Garafal' (growth type I) used as controls, had very similar agronomic performance with landraces of the same growth type (I) as respect to seed colour and density, harvest index and biomass (Table 1, 6). This observation was also confirmed by the orthogonal contrasts for the number of pods per plant, biomass and yield (Table 5). The weight of 100 seeds was much higher in landraces than commercial cultivars especially for these belonging to growth type IV. In general, the values for this trait was ranged from 30.33 g for landrace 'Velestino' up to 59.82 g for landrace from 'Kastoria' .These values had statistically significant differences from the equivalents of commercial cultivars, being quite close to the mean value (Table 1).

Physicochemical properties and nutritional traits

The landraces proved to be very interesting genetic material from viewpoint of nutrition. As an example, the landrace 'Kastoria' had protein content even higher than commercial cultivars and significantly higher than the average value reported for cultivars of *Phaseolus vulgaris* by Alvarez et al. (1998) and Estribano et al. (1997) (20.48 % and 22.6 %, respectively). For this trait, the commercial cultivars were classified in decreasing order as follows: 'Starazagorski', 'Garafal', 'Magirus' and 'Zargana' (Table 6). The mean value for the fat content (%), amounted to 1.16. However, the landrace 'Byzitsa K.' scored an amazingly highest value (2.39 %) standing for the double of the average whereas 'Velestino' displayed the lowest fat content (0.82 %) (Table 6). It is noteworthy that, apart from 'Byzitsa K.' and 'Velestino', all the other landraces and cultivars were not characterized by considerable differences since their values varied from 0.93 up to 1.36 % with highest values for commercial cultivars (Table 6). Seed density measurements showed the highest value for 'Stara Zagorski' (1.249) and the lowest for

Table 6. Values and coefficient of .variation (%) for physicochemical and nutritional traits of eight common bean landraces and four commercial cultivars. Statistical differences among cultivars based on Fisher's test (p: 0.05 (*), 0.01 (**), 0.001 (***). Classification based on Duncan's test.

No	Cultivar	C / L	Seed colour (parameters) L*/ a*/ b*/ Chroma	Seed density (g ml^{-1})	Hardness (kg F)	Protein content (%)	Fat content (%)	pH
1	'Rodopi'	L	89.79/ −0.87/ 2.5/ 2.7	1.09±0.06 bc	3.03±0.40 b	24.42±0.39 bc	1.15±0.01 b	7.24±0.17 b
2	'Xanthi'	L	90.49/ −0.92/ 2.5/ 2.7	1.14±0.01 b	4.00±0.50 a	25.00±0.92 b	1.02±0.22 bc	7.32±0.08 a
3	'Kastoria'	L	90.02/ −0.77/ 2.7/ 2.9	1.16±0.01 b	4.25±0.68 a	28.58±0.79 a	1.32±0.05 b	7.22±0.05 b
4	'Byzitsa M/M'	L	82.25/ −034/ 2.3/ 2.3	1.10±0.04 bc	2.51±0.52 c	27.04±0.54 a	1.03±0.12 bc	7.20±0.04 b
5	'Byzitsa A/M'	L	83.08/ −0.87/ 3.9/ 4.1	1.12±0.02 b	2.14±0.42 c	25.18±0.40 b	1.12±0.05 b	7.15±0.12 bc
6	'Byzitsa B.'	L	86.24/ 0.31/ 2.9/3.0	0.82±0.03 c	3.69±0.35 b	22.76±0.32 cd	1.15±0.08 b	7.25±0.05 b
7	'Zargana K.'	C	82.07/ 1.27/5.1/ 5.7	0.96±0.04 c	3.91±0.33 b	25.74±0.24 b	1.13±0.12 b	7.08±0.04 c
8	'Stara Zagorski'	C	88.28/ −0.85/ 4.3/ 4.4	1.25±0.02 a	2.95±0.42 c	26.22±0.32 b	1.04±0.08	7.15±0.10 bc
9	'Velestino'	L	89.60/ −0.78/ 2.9/ 3.1	1.05±0.04 c	2.75±0.37 c	24.02±0.24 c	0.82±0.09 c	6.99±0.02 c
10	'Byzitsa K.'	L	89.93/ −0.86/ 2.2/ 2.4	1.13±0.01 b	3.01±0.45 b	23.92±0.35 c	2.39±0.14 a	6.99±0.03 c
11	'Magirus'	C	79.19/ −0.31/ 2.0/ 2.0	1.12±0.02 b	3.38±0.35 b	26.14±0.27 b	1.36±0.04 b	7.02±0.02 c
12	'Garafal'	C	88.28/ −0.85/4.3/ 4.4	1.13±0.01 b	2.97±0.52 c	26.18±0.25 b	0.93±0.12 bc	7. 10±0.03 c
	Mean		86.90/ −0.48/ 2.8/ 3.0	1.08	3.20	25.40	1.20	7.14
	Sx		0.76/ 0.06/ 0.2/ 0.2	0.01	0.26	0.25	0.09	0.15
	F		**	***	***	***	***	*
	CV (%)		3.4	2.5	14.2	2.1	10.7	2.7

L: Landrace; C: Commercia

'Byzitsa B.' (0.82). The average hardness of dry bean cultivars and landraces amounted to 3.2 kg F (Table 6). The highest hardness values were recorded for 'Xanthi', 'Kastoria', 'Zargana' and 'Byzitsa B.' (4.0, 4.25, 3.91 and 3.69) respectively. High hardness is closely related to low water content and thereby prolonged shelf life of dry beans. Therefore, the above mentioned cultivars could with stand longer storage periods compared to the others. The pH of the dry seeds varied among cultivars within a range from 6.99 up to 7.32 (Table 6).The colour parameters did not vary significantly in white seed common bean cultivars. The luminosity (L*) is higher in white cultivars and was ranged from 89.6 ('Velestino') up to 90.5 ('Xanthi') (Table 6). The parameter chroma exhibited considerably greater values for the coloured cultivars. In decreasing order of chroma intensity the examined coloured cultivars were as follows: 'Zargana', 'Starazagorski', 'Garafal' and 'Byzitsa A/M'. On the contrary the white seed cultivars did not show any large variation (range 2.7–2.9) (Table 6).

Discussion

The economic value of a bean cultivar is related to plant morphology, agronomic performance, seed quality and culinary traits (Piergiovanni et al. 2000; Arvanitoyannis and Khah 2003). In the present study, high detectable genetic variation, in growth habit, agronomic performance and physicochemical properties among the examined dry bean cultivars and landraces, was found. Furthermore, the yield potential of common beans determined by growth habit, pod number and distribution, seed characteristics, maturity features was considerably affected by the growing environment, cropping system, agronomic management and inputs applied (Graham and Ranalli 1997). The results of most reported traits in this study indicated that some of the examined landraces are superior to the commercial cultivars in the specific experimental location under organic growing conditions. It is noteworthy that the organic environment of experimentation allowed for better differentiation of the examined genetic material but displayed a negative impact on the commercial cultivars. Furthermore, some of the landraces proved to be very interesting genetic material from the nutritional viewpoint. Two populations in particular ('Kastoria', 'Byzitsa K.') deserve further study since they had better physicochemical characteristics than the commercial varieties. The protein content in landrace 'Kastoria' amounted to 28.58 %. This value is significantly greater than the general mean value (25.25 %) reported in literature (Estribano et al. 1997). Furthermore, the landrace 'Byzitsa K.' scored an amazingly highest value in fat content (2.39 %) standing for the double of the average of all other cultivars.

The correlations between weight of pods and biomass, weight of seeds per plant and biomass, weight of pods and yield of seeds were high, thus giving the possibility for an indirect selection for yield. From agronomic yield components, the number of pods per plant has often been recommended as an indirect selection criterion for increasing the yield (Nienhuis and Singh 1986). In this study, some local bean landraces displayed a better performance in terms number of pods per plant ('Rodopi', 'Xanthi', 'Byzitsa B.') than commercial cultivars. Assessment of determined genetic parameters proved that this behaviour is mainly due to the genetic buffering of these populations thus rendering them more promising and

competitive for extensive use in the future. A simultaneous experimentation in conventional and organic field in two locations is anticipated to provide much more information both for yield performance and general adaptation.

The prospects in short and long term for dry bean, according to GRAHAM and RANALLI (1997) are summarized with greater emphasis on to seed quality, the further development of sustainable or organic agricultural practices and continuous efforts toward enhanced disease and abiotic stress tolerance. The present work shows that there are common bean landraces of equal or superior agronomic performance than usual commercial cultivars when cultivated under organic growing conditions. The sufficient genetic diversity in yield components and physicochemical traits studied is promising for breeding these landraces to produce ecotypes of enhanced adaptation to specific cropping systems or broadening the genetic base of current bean cultivars.

Selection for increased seed yield is difficult in dry beans due to low heritability and large environmental effects on the expression of yield and its components (COYNE 1968; NIENHUIS and SINGH 1986). According to GRAHAM and RANALLI (1997), the horticultural and agronomic traits with lower heritability are likely to be evaluated in a defined environment. Based on our results and the above mentioned researcher's observations, a separate organic breeding program could be proposed for each major market class according to quality seed traits for subsequent optimised utilization of the ideal landrace per occasion. Moreover, the possibility of ensuring marks of origin and quality for the elite landraces ('Kastoria', 'Byzitsa K.') could stand for an important parameter for farmers, processors and consumers.

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