Variation of Agronomic Traits in a World Collection of Vetch (*Vicia sativa* L.)

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VARIATION OF AGRONOMIC TRAITS IN A WORLD COLLECTION OF VETCH (*VICIA SATIVA* L.)

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Abstract

More than 850 accessions of vetch (*Vicia sativa* L.) representing 16 countries were obtained from the Italian Germplasm Institute and grown in a Southern Italy environment. The five following quantitative characters were analysed: days to harvest, plant dry weight, number of pods per plant, seed yield per plant, and seed yield per pod. The frequencies of various phenotypes were examined for total world collection and for each country in which there was a sufficient number of accessions. Wide phenotypic variability was observed for all characters, and usually within each country. The Shannon–Weaver diversity index (H') was used to examine overall phenotypic diversity on a world and geographic basis. The total world collection showed a high diversity (H'= 0.872) and also the collections of substantial size (Turkey, FAO and Italy) showed a highly significant diversity index (H'= 0.826, 0.762, 0.801). A strong positive correlation was found between biomass and seed yield for total accessions (r = 0,794**) and for the accessions of some countries; these results indicate that simultaneous selection for both traits should be successful.

Keywords: Vetch, germplasm collection, accession, variability, diversity index

Introduction

Common vetch (*Vicia sativa* L.) is an important annual forage legume that is widely grown in many countries for hay and seed production. Gains in productivity were obtained in

the past trough selection in local land races. New and more uniform types have been obtained and widespread replacing the old land races, which became threatened of extinction.

Given the danger of genetic erosion, scientists started to collect the evolved variability in world collections and to preserve it for future generations, because the genetic variation is of interest to germplasm conservationists and plant breeders (Abdalla, 1976).

For these reasons, world collections of different crops have been evaluated by many scientists, in different countries, searching for useful gene combinations (Jain et al., 1975; Porceddu, 1976; Alba et all., 1978; Polignano and Olita, 1981; Polignano and Uggenti, 1984; Aher et al., 1998; Kusmenoglu and Muehlbaner, 1998; Kulakow, 1999). The confidence in this material, as a source of breeding stocks, points to the need of expanding our knowledge of it.

We have very little information about the existing variability in the collected material of *Vicia sativa* and its geographical distribution. This study has been undertaken to ascertain the relationships among five agronomic traits, their frequencies and diversities in various countries and in a world collection of vetch.

Materials and Methods

The analysed material consists of 864 vetch (*Vicia sativa* L.) entries, maintained at the Germplasm Institute, Bari (Italy) and kindly supplied by P. Perrino. 154 entries are classified as FAO collection because they were given to the Germplasm Institute by the FAO at the time of its establishment. Sources of material are listed in Table 1, together with the number of accessions from each country.

The entire collection was grown in Bari, Italy (41° 12' N, 16° 87’ E, 12 m in elevation), with November planting in 1977, in plots consisting of four 10-m rows, spaced 60 cm apart

with 35-40 plants per row. Twenty plants from the two central rows were used for data collection. Data were collected for days to harvest (calculated as the number of days from May 1st to physiological maturity, when 90% of the pods in a plot were golden–brown), plant dry weight, number of pods per plant, seed yield per plant (g) and seed yield per pod (mg).

The nature of inheritance of these characters is not well known in vetch, so that they were considered by phenotypic rather than genotypic categories.

The correlation coefficients and analysis of variance with the countries considered as a source of variation were computed on data in addition to the range of variability and to the frequency of character scores in all the material, as well as in the material from each country. Frequency data were then analysed by the Shannon–Weaver diversity index (H'), as suggested by Jain et al. (1975). This statistics is widely used in ecological literature for evaluating species diversity in communities. Because of its additivity properties, this measure is useful in hierarchical analyses of diversity in a large variety of data such as those encountered in the studies on germplasm resources (Poole, 1974).

Results and Discussion

Table 1 summarizes the phenotypic means for individual characters and countries, together with the range of variability and the diversity index (H').

The differences among the countries were highly significant for all the studied traits. The days to harvest is a very important trait to be considered in the vetch genotypes that are to be grown under the Mediterranean environmental conditions. Actually, in order to escape the drought period that normally starts at mid-June, early types must be selected. In the material considered, the total world collection showed a wide range of variability for this trait (33 days starting from the end of May). Also Turkey, Italy, FAO collection and Portugal showed a wide range of variability and this could be explained with the large variability of

environmental conditions in the places where accessions were collected. As an average, in these countries the mean day of harvest is around mid-June, while in the countries of central and northern Europe the harvesting time occurs in the last week of June, with a range of variability of 15 days.

The plant dry weight varied, among the countries, from 13.7 g (Australia) to 42.1 g (Bulgaria and Hungary). The world total collection showed a mean plant dry weight of 24.5 g with a very large range of variability (from 4 to 60 g). Turkey and Italy showed values not significantly different from the world total ones: 24.5 and 23.5 g, and showed also a variability similar to that of world total (4-60 g and 5-52 g, respectively). In the other countries, the variability was smaller, with a mean plant dry weight lower or similar to that of world total, with the exception of Bulgaria and Hungary in which the mean plant dry weight was higher.

The plant seed yield showed a high variability among the countries, ranging from 1.9 g (Australia) to 9.3 g (Bulgaria) and 8.0 g (Hungary). These results show that this trait is closely related to the plant dry weight. Turkey (4.4 g) and Italy (4.1 g) showed the same plant seed yield as the world collection (4.6 g), with Turkey that has the same large range of variability as the world total (from 0.4 to 19.3 g). In the other countries the variability was smaller.

The number of pods per plant varied from 10.2 to 31.4. In Bulgaria (31.4) and Hungary (31.2) the highest values were observed. These are the countries in which the plant weight was also higher. The mean value of world total collection was 19.2, which is not significantly different from Turkey (21.1) and Russia (20.4). Turkey showed the greatest range of variability (from 9 to 98) that was similar to that of the world collection (from 4 to 98). In the accessions of the other countries, the mean values ranged from 10.2 to 17.3, with even lower variability values.

The highest seed yields per pod were observed, on average, in the accessions of Bulgaria (306 mg) and in the FAO collection (278 mg), while the lowest ones (99 mg) were observed in the countries with few entries. The largest range of variability for this trait was found in the Turkish entries (from 50 to 540 mg) and was similar to the world total one.

The variability, or the entropy, in the accessions from different countries was studied by utilising the Shannon-Weaver diversity index. Estimates of H', individually and pooled over characters and countries, are reported in Table 1. The two highest values of H' are from Turkey (0.826) and Italy (0.801) and are not significantly different from each other ($P>0.1$). The lowest values of H' are from Russia (0.548), Germany (0.580), and Australia (0.587) and are different from those cited above ($P>0.1$). However, the number of available samples of those four countries was small.

Turkey showed the highest H' values for days to harvest (0.878), plant dry weight (0.903), and plant seed yield (0.781), while Italy and FAO collections showed the highest values for the number of pods per plant (0.810) and seed yield per pod (0.874), respectively.

Relationships between characters are shown in Table 2, where the values of simple phenotypic correlation coefficients are reported. The five agronomic traits considered showed significant associations (Table 2). Positive and highly significant phenotypic correlations were found among all the 864 accessions. The correlation between biomass and days to harvest was not always positive. In the accessions collected in Turkey and Italy, the correlation is indeed negative; this can be explained by the natural selection of early types in these environments to escape the drought period of the regions characterised by a Mediterranean climate. This correlation indicates that in these environments breeders must select early genotypes in order to achieve high biomass yield. Moreover, the strong positive correlation between biomass and seed yield indicates that simultaneous selection for both traits should be successful. Large plants, achieved by selection for large vegetative biomass,

may have greater photosynthetic area to produce large quantities of carbohydrates and more pods and seeds per plant.

Unfortunately, this study was carried out in one place and one year only and this fact prevents considering the consequences of any genotype-environment interaction. It is in fact possible that some of the studied characters would show a high degree of variability under different environmental conditions.

In conclusion, our results indicate that a wide phenotypic variability is present in the vetch collection and clear differences seem to exist among entries from different countries, and for all the analysed agronomic traits. The Shannon-Weaver diversity index shows significant differences among traits and countries. The phenotypic correlation among all the studied traits indicates that seed yield can also be improved by selecting for larger vegetative biomass.

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Table 1 - Mean, standard deviation, range, and estimates of H' for various countries and characters, and mean diversity (H') and its standard deviation over all characters.

Character	Country of origin [1]					
	Turkey (482)	Fao Collec. (154)	Italy (82)	Portugal (22)	Bulgaria (21)	France (18)
Days to harvest [2]						
mean ± SD	41,8 ± 5,5	44,8 ± 4,7	45,8 ± 5,3	45,4 ± 3,1	49,7 ± 2,9	51,6 ± 4,6
range	28 - 61	31 -61	28 - 58	37 - 55	43 - 55	40 - 58
H'	.878	.739	.794	.554	.558	.708
Plant dry weight (g)						
mean ± SD	24.5 ± 9.9	17.7 ± 8.3	23.5 ± 8.5	15.1 ± 9.1	42.1 ± 7.8	25.6 ± 9.9
range	4 - 60	4 - 34	5 - 52	6 - 40	20 - 58	5 - 43
H'	.903	.766	.896	.836	.679	.848
Plant seed yield (g)						
mean ± SD	4.4 ± 2.7	3.8 ± 2.1	4.1 ± 2.4	3.5 ± 2.7	9.3 ± 2.2	4.3 ± 2.7
range	0.8 - 19.2	0.6 - 11.3	1.2 - 12.0	0.5 - 10.8	6.4 - 16.1	0.4 - 8.4
H'	.781	.728	.743	.703	.626	.531
Pods no. / plant						
mean ± SD	21.1 ± 13.4	14.7 ± 10.4	16.9 ± 8.0	11.9 ± 6.8	31.4 ± 6.4	17.3 ± 9.3
range	9 - 98	7 - 76	9 - 82	4 - 58	9 - 70	6 - 82
H'	.808	.704	.810	.680	.702	.862
Seed yield / pod (mg)						
mean ± SD	213 ± 82	278 ± 98	239 ± 96	250 ± 41	306 ± 56	232 ± 81
range	50 - 540	46 - 518	60 - 520	51 - 422	123 - 510	65 - 495
H'	.758	.874	.761	.840	.541	.653
$\overline{H}'$ ± SD	.826 ± .05	.762 ± .06	.801 ± .05	.723 ± .11	.621 ± .06	.720 ± .12

	Hungary (15)	Germany (9)	Australia (9)	Russia (7)	Others [3] (15)	World total (834)
Days to harvest						
mean ± SD	53.0 ± 1.6	52.7 ± 3.5	44.1 ± 8.0	50.8 ± 4.1	49.3 ± 2,9	43.2 ± 5.8
range	49 - 58	46 - 58	31 - 55	46 - 58	42 - 57	28 - 61
H'	.383	.553	.661	.520	.480	.906
Plant dry weight (g)						
mean ± SD	42.1 ± 8.4	14.1 ± 7.6	13.7 ± 4.5	29.7 ± 9.8	20.1 ± 9.1	24.5 ± 9.9
range	18 - 60	5 - 30	4 - 13	16 - 48	4 - 31	4 - 60
H'	.729	.553	.531	.497	.506	.947
Plant seed yield (g)						
mean ± SD	8.0 ± 2.6	3.1 ± 2.1	1.9 ± 0.9	4.3 ± 2.1	2.7 ± 1.9	4.6 ± 2.9
range	1.6 - 12.8	0.4 - 6.3	0.5 - 6.7	1.8 - 7.7	0.6 - 4.4	0.4 - 19.3
H'	.775	.407	.528	.571	.626	.822
Pods no. / plant						
mean ± SD	31.2 ± 7.1	12.6 ± 8.8	12.5 ± 5.1	20.4 ± 7.6	10.2 ± 9.2	19.2 ± 11.2
range	8 - 69	5 - 70	10 - 56	20 - 60	5 - 30	4 - 98
H'	.712	.661	.553	.549	.493	.853
Seed yield / pod (mg)						
mean ± SD	249 ± 51	208 ± 93	152 ± 60	206 ± 52	99 ± 47	224 ± 93
range	110 - 513	56 - 386	54 - 243	119 - 416	55 - 205	50 - 540
H'	0.569	0.728	0.661	.605	.541	0.831
$\overline{H}'$ ± SD	.634 ± .14	.580 ± .11	.587 ± .06	.548 ± .04	.529 ± .05	.872 ± .05

[1] Under each country is reported the number of entries

[2] From May 1st

[3] Belgium 6; Israel 3; Sweden and Malta 2; Poland and Czech Republic 1.

Table 2 - Simple phenotypic correlations between five agronomic traits of vetch in the all world collection and in the accessions of different countries.

Character	PDW	PNP	SY	SYP (°)	PDW	PNP	SY	SYP (°)
		World total				Turkey		
Days to harvest (DH)	.151**	.182**	.176**	.173**	-.457**	.252**	.121**	.158**
Plant dry weight (PDW)		.723**	.794**	.192**		.438**	.348**	.173**
Pods no./plant (PNP)			.646**	.628**			.627**	.820**
Seed yield/plant (SY)				.516**				.552**
		FAO Collection				Italy		
Days to harvest (DH)	-.312**	.461**	.423**	.501**	-.474**	.440**	.465**	.400**
Plant dry weight (PDW)		.293**	.262**	.085		.288**	.680**	.034
Pods no./plant (PNP)			.769**	.880**			.851**	.881**
Seed yield/plant (SY)				.608**				.803**
		Portugal				Bulgaria		
Days to harvest (DH)	.034	.722**	.675**	.787**	.089	.050	-.106	-.100
Plant dry weight (PDW)		.156	.347	.118		.416*	.467*	.227
Pods no./plant (PNP)			.947**	.968**			.423*	.769**
Seed yield/plant (SY)				.889**				.382
		France				Hungary		
Days to harvest (DH)	-.068	.422	.131	.325	-.070	-.157	-.143	-.142
Plant dry weight (PDW)		.501*	.521*	.050		.168	.429	.116
Pods no./plant (PNP)			.773**	.726**			.857**	.912**
Seed yield/plant (SY)				.771**				.834**
		Germany				Australia		
Days to harvest (DH)	-.124	.447	.363	.428	-.812**	.313	.274	-.222
Plant dry weight (PDW)		.236	.287	.135		-.314	-.354	.053
Pods no./plant (PNP)			.924**	.920**			.887**	.728*
Seed yield/plant (SY)				.738*				.657

(°) Seed yield/pod.

* ' ** Significant at ($P < 0.05$) and ($P < 0.01$) respectively.