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Evaluation of Genotype, Environment, and Management Interactions on Fava Beans under Mediterranean Field Conditions

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Abstract: Faba beans (*Vicia faba* L.), also known as fava beans, like other crops, are influenced by several factors: their genotype, environment, and management, as well as the interaction between these, have an important impact on seed yielding and seed quality traits. This study was conducted at three locations in South Italy between 2017 and 2019 to evaluate the sowing date effect on yield and yield components of three *Vicia faba* L., originating from cool climates. The results showed that seed yield (SY) and yield components declined with sowing delay. The crop's environment (year × site) and management (sowing date) were found to explain 34.01% and 42.95% of the total seed yield variation, respectively. The data showed that the tested genotypes were positively influenced by the environment with sandy loam soil and early winter sowing date, resulting in either a greater number of SY and THS than in the other environment. The three faba bean genotypes showed tolerance to winter frost conditions in the two growing seasons.

Keywords: mediterranean agroecosystems; faba bean; sowing date; genotype adaptation; legumes management

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1. Introduction

The faba bean (*Vicia faba* L.), also known as the fava bean, is an annual herbaceous plant and ancient legume belonging to the Fabaceae family. Originally from Central Asia, these beans are now cultivated all over the world [1]. Like all pulses, the faba bean is an excellent source of fiber, protein, and essential amino acids, and they have high digestibility and low anti-nutritional factor levels [1]. Because of these properties, faba beans can be good source of protein for the human diet [2]. Growing pulses such as the faba bean and innovative crops such as quinoa, amaranth, and buckwheat can represent a sustainable and less resource-intensive alternative diet [3–5]. In 2017, among various grain legume crops grown in Europe, the faba bean ranked third and seventh in area and production, respectively [6,7].

However, the European average faba beans yield varies across countries [6,8]. In 2019, France was the European leader, accounting for 34% of the total European production, followed by Italy, Spain, and Belgium [7]. In Italy, the cultivation of this legume has progressively increased in the last 10 years, from over 46,130 hectares to more than 60,000 hectares [6,9]. In 2020, approximately 1229 thousand quintals of broad beans were produced in Italy on approximately 61,982 hectares, yielding an average of approximately 19.82 quintals per hectare [9].

The cultivation of faba beans represents advantages from an agronomic, environmental, and ecological point of view, reducing the negative impact of agriculture on the environment and reducing the use of non-renewable resources and chemicals [10]. Thanks to the symbiosis with rhizobium, it is able to fix atmospheric nitrogen (N_2), thus determining a lower need for synthetic nitrogen fertilizers. Furthermore, its introduction within the agricultural system determines not only a diversification, but also a nitrogen supply in the soil available for subsequent crops [11], an improvement of the soil structure, and a better control on parasites [12] and weeds that are present in the monoculture systems.

Though the agronomic and economic importance of the faba bean is well demonstrated, its cultivation is still limited due to different factors [13]. Several studies on the genotype × environment interactions with faba bean populations showed that the yield instability is an undesirable trait in this crop [14–16]. Due to high interannual yield variability, the production of faba beans is often viewed as risky by European farmers, who prefer cultivating non-legume species such as cereals, oilseeds, and tubers [17,18]. Yield performance is often limited by the sensitivity of the crop to environmental conditions (especially cold and drought) and the high susceptibility to diseases and pests [13].

Faba beans avoid strong heat and drought but have limited resistance to cold [19]. Late frosts and low temperatures after flowering can cause a noticeable drop in flowers and pods [20]. On the other hand, faba beans grow in cool, deep, well-structured soils that are rich in lime and clay, found in sunny spots [21]. In general, faba beans seem to be rustic and adaptable to different kinds of environments in Italy. The production response is, however, closely linked to the availability of water during the production phases [22]. Therefore, frost tolerance, sowing time, geographical areas (Mediterranean, oceanic, or continental), and cropping years are important factors that determine adaptation strategies, selection environments, yield stability, and parent material for breeding [14,23,24].

A great part of Italian agroecosystems is characterized by the Mediterranean climate and a great part of herbaceous crops today face the problems related to the increase of abiotic stresses. A large part of the cultivation of faba beand in Italy is still linked to local ecotypes characterized by heterogeneity, low production, and difficulties in mechanization; there is not yet a large availability of improved varieties for the Mediterranean area with resistance to increasing abiotic stresses, and this leads to low quantity and quality of productions. With the aim to study the effects of different pedo-climatic and sowing time conditions on qualitative and quantitative productivity parameters of three faba beans cultivars, a biannual field trial was carried out in South Italy.

2. Materials and Methods

Three cultivars of faba beans (Table 1) were evaluated in field study during two growing seasons, 2018 and 2019, at three locations in Italy's Campania region. The site and weather parameters are presented in Tables 2 and 3. The physical and chemical characteristics throughout the upper 0.2 m depth for all soil across sites are reported in Table 4.

In Vitulazio (Naples, Italy), the soil is an alluvial montmorillonite clay loam, defined as Mollic Haplaquept according to the USDA soil classification, with low organic matter (OM) [25]. On the other hand, the soil located in Ponticelli (Naples, Italy) and Acerra (Naples, Italy) is classified as Vitric Andosols [26]; it is representative of deep soils of the Somma-Vesuvius volcanic complex piedmont plain and characterized by high chemical and physical fertility [27,28]. These two sites (Ponticelli and Acerra) have different soil textures. Loamy sand was found in Ponticelli and sandy loam in Acerra (Table 4).

The faba bean cultivars were evaluated in a total of four environments, and each environment consisted of a combination of year × site. The crop management involved two different sowing dates (Early: SD1 and Late: SD2), with the sowing density of the plots being 43 plants m^{-2} [29]. Each field experiment was conducted according to a randomized completely block design (RCBD) with 3 replications. The plot size was 3 m^2, with a distance of 0.50 m between rows and 0.05 m between plants within the row.

Table 1. Description of the faba bean cultivars of studied traits.

Common Name	Cultivar Name	Source	Description
Faba beans	Fuego	NPZ (DE)	Standard and stable cultivar
	Taifun	NPZ (DE)	Low in vicine and convicine
	Tiffany	NPZ (DE)	Low in tannins, white flowers

NPZ (DE) Norddeutsche Pflanzenzucht Hans-Georg Lembke KG (Germany).

Table 2. Description of the environments. Latitude, longitude, elevation, and soil characteristics at the experimental sites.

Environment	Site	Season	Latitude	Longitude	Altitude (m asl)
E1	Vitulazio	2018	41°07′25″ N	14°12′11″ E	23
E2	Ponticelli	2018	40°86′ N	14°33′ E	20
E3	Vitulazio	2019	41°07′25″ N	14°12′11″ E	23
E4	Acerra	2019	40°57′57″ N	14°25′34″ E	26

asl = above sea level.

At maturity, a subplot of 1 m^2 in the middle of each plot was manually harvested and the total yield (SY), the 1000-seed weight (THS), and the above-ground biomass (AGB) were determined. The harvest index (HI) was calculated as the ratio between SY and AGB. The crude protein content was measured using the Kjeldahl method (AOAC 920.152). It was converted into protein using the Jones factor (6.25) [30]. Finally, the protein yield was obtained by multiplying the protein content by the harvested yield (t ha^{-1}).

All the dependent variables were preliminarily evaluated for normal distribution and homogeneity of variance according to the Kolmogorov–Smirnov test and Bartlett test, respectively. If the normality assumption was violated, the data was transformed into normal scores to apply any standard parametric procedure.

Yield, yield components, and seed protein content data were analyzed using a linear model in the mixed-model ANOVA approach to evaluate the significance of the genotype (G), crop management (SD), and environment (a combination of site and year) (E) effects and their interactions based on the variance components' structure using the PROC MIXED procedure of SAS University Edition (Cary, NC, USA). Tukey's post hoc test was used to test the significance of the difference between means.

Principal component analysis (PCA) using the correlation matrix was performed on the yield, yield components, and seed protein content to evaluate the patterns of variation among the factors and select the best-adapted genotypes. The PCA outputs included variable loading for each selected component and treatment component scores. This analysis was carried out using the software package FactoMineR [31] in R studio software [32]. The package is available via the Comprehensive R Archive Network (CRAN, https://cran.r-project.org (accessed on 2 April 2020)).

Table 3. Sowing date, seasonal rainfall, and mean daily maximum, minimum, and mean temperatures, as well as number of frost events at the experimental sites.

Environment		Sowing Date	Harvest Date	Crop Cycle (Days)	Rainfall (mm)	Temperature (°C)			Frost Events
						Max	Min	Mean	
E1	Early	6 December 2017	30 May 2018	175	760.8	16.93	7.68	12.00	8
	Late	30 January 2018	30 May 2018	120	565.0	17.33	8.22	12.49	4
E2	Early	6 December 2017	20 June 2018	196	692.1	19.67	8.44	14.17	9
	Late	12 February 2018	28 June 2018	136	420.6	22.35	10.82	16.79	4
E3	Early	13 November 2018	21 June 2019	220	729.4	18.25	7.49	12.59	13
	Late	18 February 2019	26 June 2019	128	317.8	20.81	8.64	14.46	3
E4	Early	5 December 2018	1 July 2019	208	609.8	18.22	6.99	12.92	18
	Late	28 February 2019	8 July 2019	130	356.6	21.45	9.78	16.06	0

Table 4. Soil properties at 0–0.20 m depth at the three experimental sites.

	Soil Type	Soil Texture	Clay (%)	Silt (%)	Sand (%)	Bulk Density (g/cm^3)	pH_{H20}	EC (µS/cm)	$CaCO_3$ (%)	Organic Carbon (%)	Total N (g/kg)
Vitulazio	Mollic Haplaquept	Caly loam	38.9	38.5	22.6	1.3	8.03	210	0.16	0.91	0.18
Acerra	Vitric Andosols	Sandy loam	15.5	26	58.5	1	7.37	289	-	2.54	1.82
Ponticelli		Loamy sand	8	12	80	1.17	7.9	409	-	1.47	1.81

3. Results

3.1. Weather Conditions

The weather regime for the four environments considered in this study is shown in Table 3 in terms of the minimum, maximum, and average air temperature, rainfall, and number of frost events. In both the growing seasons, the total rainfall across sites markedly differed from year to year. Total precipitation during the early sowing date (SD1) in the four environments was higher than that of the late sowing date (SD2). Rainfall in all the environments was above 300 mm, which is the minimum requirement for rainfed faba beans in Mediterranean environments [33]. The average temperature was higher for both the sowing dates at Ponticelli (E2), compared with the other sites. The number of frost events was greater for the early sowing date than the late sowing date for all environments.

3.2. Seed Yield Response Factor

Table 5 reports the analysis of variance results for seed yield (SY) and yield components (AGB, HI, and THS), protein content, azote, and protein yield for three genotypes evaluated under four environments (a combination of site and year) and two sowing dates. According to the analysis of variance, the faba bean seed yield showed a trend towards significance (p = 0.08) under different environments. The management (SD) and G × E × SD effects were significant for SY. The largest proportion of variance in SY was explained by the crop management with 42.95% of the total phenotypic variance (data not shown). In general, the E4 environment produced a higher yield than the other environments (Figures 1a and 2). The lowest yielding environment was E3 (2.81 t ha^{-1}), followed by E2 at 3.53 t ha^{-1}. SY was 57.64% less in the late sowing date (Sd2) treatment compared to the early sowing treatment (Sd1) (Table 5). The variation of yield under G × E × SD effects showed that "Fuego" and "Tiffany," which had the early sowing date under E4, were the most productive, and their average yield values ranged from 10.88 to 11.11 t ha^{-1} (Figure 2).

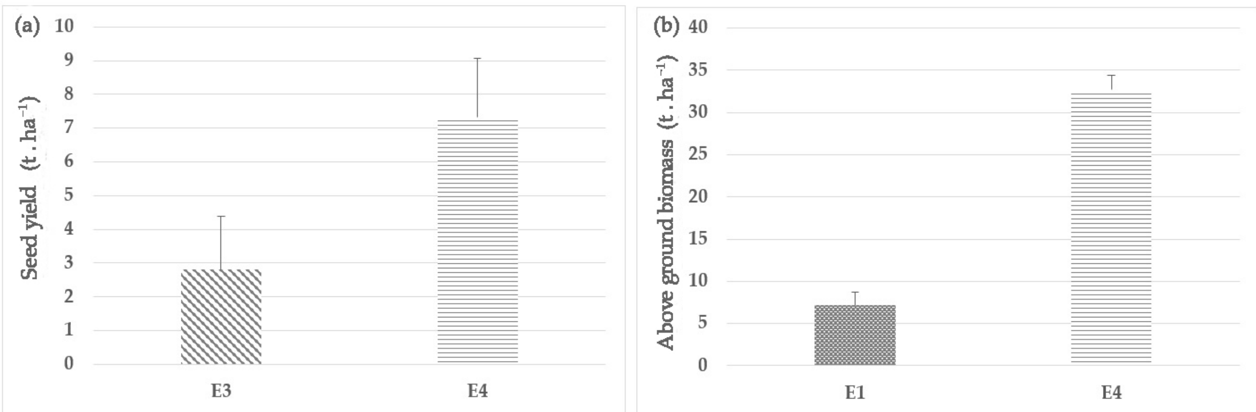

Figure 1. Seed yield (**a**) and above ground biomass (**b**) of most contrasting environment. E1, E3, and E4 represent the different environments (see Table 2 for more details). Values (means ± SE, n = 3).

Table 5. Faba bean seed yield, above-ground biomass, HI, weight of 1000 seeds (THS), protein content, azote, and protein yield as affected by environment, sowing date, and genotype.

Source of Variation	Seed Yield (t ha^{-1})	AGB (t ha^{-1})	HI	THS ^{z} (g)	Protein Content ^{z} (%)	N ^{z} (%)	Protein Yield ^{z} (t ha^{-1})	Pod Size (cm)
Environment (E)	ns	*	*	ns	ns	ns	*	ns
E1	6.12 ± 1.69	7.15 ± 1.20 d	86.73 ± 22.71 a	-	-	-	-	7.14 ± 0.74
E2	3.53 ± 2.48	7.66 ± 3.98 c	42.71 ± 10.67 b	433.52 ± 115.74	25.81 ± 1.85	4.13 ± 0.30	0.91 ± 0.64 b	7.07 ± 1.21
E3	2.81 ± 2.72	16.23 ± 10.44 b	12.19 ± 9.29 d	357.50 ± 95.81	25.29 ± 2.13	4.05 ± 0.34	0.70 ± 0.68 c	7.96 ± 1.27
E4	7.31 ± 3.03	32.71 ± 9.13 a	21.62 ± 3.76 c	451.61 ± 51.13	25.27 ± 1.67	4.04 ± 0.27	1.84 ± 0.76 a	7.67 ± 0.68
Sowing date (SD)	*	*	*	ns	ns	ns	*	ns
SD_1	6.94 ± 2.53 a	21.24 ± 14.04 a	48.10 ± 33.95 a	485.38 ± 60.31	25.34 ± 1.67	4.06 ± 0.27	1.73 ± 0.71 a	8.00 ± 1.07
SD_2	2.94 ± 2.19 b	10.64 ± 8.17 b	33.52 ± 28.10 b	343.04 ± 75.93	25.57 ± 2.08	4.09 ± 0.33	0.57 ± 0.50 b	6.92 ± 0.72
Genotype (G)	ns	ns	ns	ns	*	*	ns	ns
Fuego	5.46 ± 3.32	16.99 ± 13.12	42.83 ± 35.12	426.75 ± 114.43	24.68 ± 1.96 b	3.95 ± 0.31 b	1.28 ± 0.97	7.33 ± 0.83
Tiffany	4.96 ± 3.51	15.51 ± 13.15	40.22 ± 32.25	421.25 ± 100.33	25.13 ± 1.87 ab	4.02 ± 0.30 ab	1.07 ± 0.87	7.64 ± 1.26
Taifun	4.41 ± 2.38	15.31 ± 11.94	39.39 ± 29.02	394.62 ± 81.76	26.56 ± 1.26 a	4.25 ± 0.20 a	1.10 ± 0.71	7.41 ± 1.06
E × G	ns	**	ns	ns	ns	ns	ns	ns
E × SD	ns	***	ns	ns	ns	ns	ns	ns
G × SD	ns	ns	ns	ns	ns	ns	*	ns
E × G × SD	****	ns	****	ns	ns	ns	ns	*

AGB, HI, THS, and N represent, dry above-ground biomass, harvest index, weight of 1000 seeds, and azote content, respectively. *, **, ***, **** indicate differences at $p \leq 0.05$, $p \leq 0.01$, $p \leq 0.001$ and $p \leq 0.0001$, respectively. ^{z} data analysis only for the sandy soil in 2018 and clay and sandy soil in 2019 due to missing data on clay soil in 2018. Means followed by different letter in each column are significantly different according to the Tukey's post hoc test (p = 0.05). Values (means ± SD, n = 3).

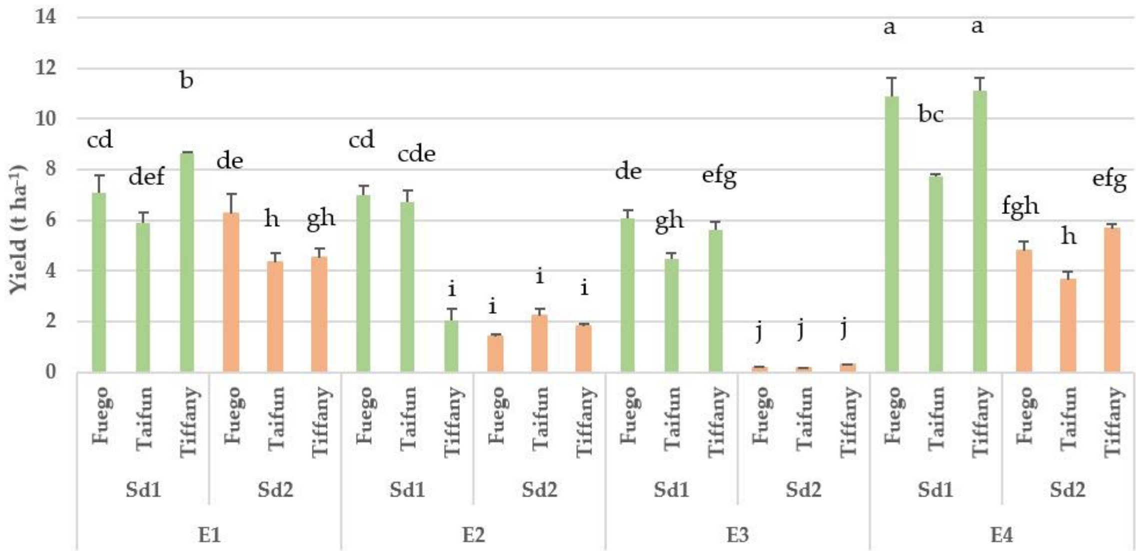

Figure 2. Interaction between faba bean cultivars with different sowing dates under different environments for seed yield. SD1: early sowing date and SD2: late sowing date. E1, E2, E3, and E4 represent the different environments (see Table 2 for more details). Values (means ± SE, *n* = 3). Means followed by different letter in each bar plot are significantly different according to the Tukey's post hoc test (*p* = 0.05).

3.3. Above Ground Biomass, HI, Pod Size, and Weight of 1000 Seeds

As seen in Table 5, the environment and sowing date effects were significant for AGB and HI. The THS only showed a trend towards significance (P = 0.08) under E × SD interaction effects. The pod size showed a trend towards significance (P = 0.07) under a different sowing date. The interaction effects E × G and E × SD were highly significant for AGB, while the G × E × SD effect was significant for HI and pod size. The highest value of pod size with respect to sowing date was recorded in SD1 (8 cm).

The AGB and HI variation range across environments and crop management was broad. The highest value of AGB with respect to environment was recorded in E4 (32.71 t ha^{-1}) and the lowest in E1 (7.15 t ha^{-1}) (Figure 1b), while the highest value with respect to management was recorded for the early sowing date (21.24 t ha^{-1}). HI across different environments and management effects ranged from 12.19 to 86.73 and from 48.10 to 33.52, respectively, as shown in Table 5.

3.4. Protein Content, N, and Protein Yield

According to the analysis of variance (Table 5), the genotype effect was significant only for protein content and N. Protein content varied across the three faba bean cultivars, with the lowest value of 24.68% being generated for Fuego cv. and the highest value of 26.56% for "Taifun". The protein yield differed markedly from environment to environment (Table 5), with the highest values of protein yield recorded in E4 and the lowest values in E3. The effect of the sowing date on the protein yield was also evident, with the highest value of protein yield recorded in early sowing date (1.73 t ha^{-1}).

To obtain a comprehensive overview of the SY and yield components (AGB, HI, and THS), protein content (PT), azote (N), and protein yield (PY) of faba beans in response to the cultivars, environments, and sowing dates, the whole data set, including the climatic parameters during the two consecutive growing seasons, was subjected to PCA. The first two principal components (PCs) corresponded to eigenvalues higher than one and explained 80.54% of the cumulative variance for yield and yield components (AGB, HI, and THS), protein content, azote, and protein yield. PC1 (first component) accounted for

45.59%, while PC2 (second component) accounted for 34.95% of the cumulative variance for the faba bean traits (Table 6, Figure 3).

Table 6. Eigenvalues, relative, and cumulative percentage of total variance, and correlation coefficients for faba bean traits with respect to the two principal components (PC1 and PC2).

Principal Components	PC1	PC2
Eigenvalue	3.191	2.447
Relative variance (%)	45.59	34.95
Cumulative variance (%)	45.59	80.54
Eigenvectors		
SY	**0.956**	−0.213
AGB	0.451	**−0.651**
HI	**0.618**	0.578
THS	**0.864**	0.302
PT	−0.001	**0.877**
N	−0.001	**0.877**
PY	**0.972**	−0.123
Ancillary variables		
Tmin	**−0.620**	0.128
Tmax	**−0.736**	−0.150
Tavg	**−0.635**	−0.101
Rain	**0.724**	0.106
nFrost	**0.570**	−0.305

Eigenvectors: seed yield (SY), dry biomass (AGB), harvest index (HI), 1000-seed weight (THS), protein content (PT), azote (N), and protein yield (PY).

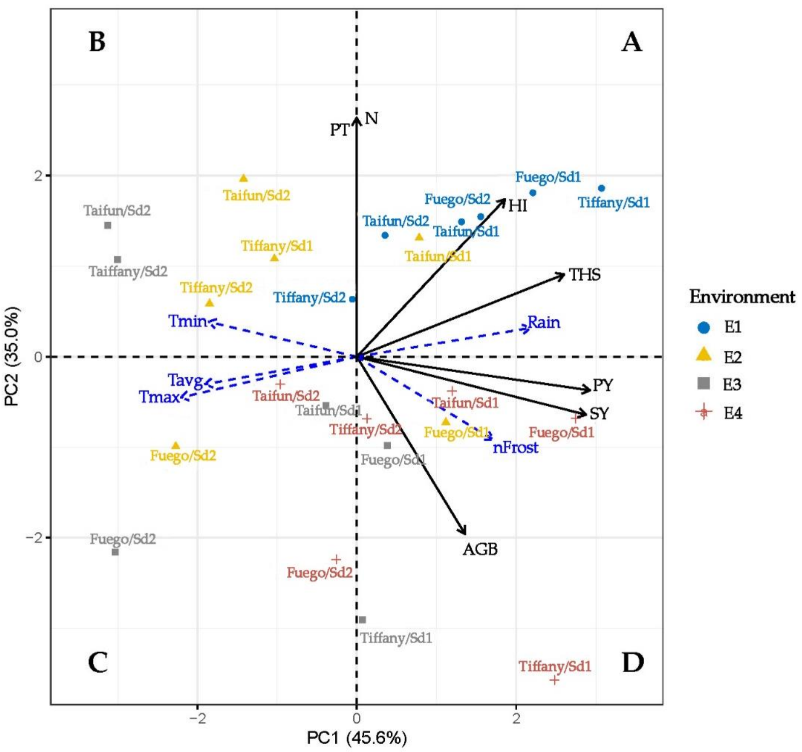

Figure 3. Principal component loading plots and scores of the first and second principal components after the PCA analysis on dry biomass (AGB), seed yield (SY), HI, 1000-seed weight (THS), protein content (PT), azote (N), and protein yield (PY) in faba beans as a function of the environment, cultivars, and sowing dates. The square indicates a Pearson correlation coefficient of 1. The black arrows represent principal variables. Dotted blue arrows represent supplementary variables (weather parameters). Tavg, average temperature; Tmax, maximum temperature; Tmin, minimum temperature; Rain, rainfall; nFrost, the number of days per month where the minimum temperature dropped below 0 °C in winter. A, B, C, and D indicate upper-right, lower-right, upper-left, and lower-left quadrant, respectively.

For faba beans, PC1 was positively and strongly correlated (>0.6) with increased SY, PY, THS, HI, rain, and the number of days per month the minimum temperature dropped below 0 °C. PC1 was negatively correlated with the minimum, maximum, and average temperatures, whereas PC2 was positively correlated with an increased PT and N and negatively correlated with AGB (Table 6, Figure 3).

Figure 3 illustrates the relationships among variables were two vectors with an angle <90° are positively correlated and two vectors with an angle >90° are not correlated. For instance, the variation of SY was most closely aligned to PY and the variation of THS was more strongly correlated to HI rather than SY and PY. Similarly, AGB was more strongly correlated to SY than PY, whereas PT and N were not correlated to SY (angle >90°).

In the current study, the positive side of PC1 (Figure 3), particularly the upper-right quadrant (A) and bottom-right quadrant (D), included the most treatments of the early sowing date (SD1) coming from E1 and E4, where "Fuego" and "Tiffany" with the early sowing date under E4 and "Tiffany" with the early sowing date under E1 were the most productive cultivars.

Both quadrants (A) and (D) were characterized by high rainfall, number of frost events, SY, PY, HI, and THS. The treatments from the upper-right quadrant (A) were also characterized by high protein content and azote, and treatments from the bottom-right quadrant (D) were characterized by high AGB.

4. Discussion

The genotype (G), environment (season × site) (E), and management (M) interactions analysis can help translate results from field experimental trials into simple messages for farmers and breeders. These interactions reflect complex phenotypic responses of crops to different combinations of G, M, and E factors, and their impact on the demand and supply of resources for growth, the timing, and the intensity of crop stresses [34–36]. In this article, an analysis is proposed to evaluate adaptability in terms of the yield components and seed quality of different faba bean genotypes, in response to autumn or early winter and late winter sowing dates in two different pedoclimatic environments of South Italy.

The results showed that the tested genotype was significantly affected by interactions of G × E × M in terms of seed yield, HI, and pod size. Yield and protein content were not affected by a simple effect of different environments even if the growth of above-ground biomass changed significantly; this confirms that the faba beans can be cultivated in a wide variety of geographic locations [37].

The highest SY and pod size were found for early sowing, which might be because in early sowing, plants get more rainfall during a longer growing period and the plants are exposed to lower temperature compared to late sowing plants. According to Corokalo et al. [38], the growth of pods greatly depends on temperature, since high temperatures accelerate pod growth of green beans. Similar findings were reported by several authors in many species [39,40]. According to the PCA results, dynamic variation—determined by the changing meteorological conditions, especially variation in rainfall—can account for 80% of the variability of the yield, and it remains to be attributed to the soil variability. The soil properties influencing the crop development are the texture and the organic matter. Texture and organic matter decisively influence a large part of the chemical–physical properties of the soil (porosity, hydrological constants, structure, etc.) and the availability of nutrients for crops [41].

The effect of different environments on the protein yield values was evident; particularly, the protein yield was significantly higher in environments characterized by sandy loam soils and pH values around 7 (E4), compared to clayey soils and a pH above 8 (E3).

The soil type is the main determinant of plant growth, nutrient dynamics of the rhizosphere, and microbial community structure [6]. Through mutualistic symbiosis, faba beans receive ammonia fixed from atmospheric N_2 by rhizobium in the root nodule to supplement their nitrogen (N) requirements [42]. According to several authors [43,44], the effectiveness of biological nitrogen fixation (BNF) of the faba bean is affected by agro-ecological factors such as the use of N fertilizer, cropping systems, and soil management systems. For instance, poor nodulation and poor plant vigor in beans grown in soil with low extractable P led to a poor BNF [45]. While N_2 fixation is an enzymatic process, the extreme temperatures affect N_2 fixation adversely. Mínguez and Rubiales [12] report that a common feature of legume N_2 fixation is that it is depressed by an increase in soil mineral N content (NO_3^- and NH_4^+).

The biological cycle of the *Vicia faba* L. may vary depending on the sowing date and growing conditions, especially water availability and solar radiation. The duration of this phase is not always a guarantee of high productivity. In fact, the duration of the crop cycle is imposed by the need to avoid limiting factors, such as drought, rather than by a minimum duration of the vegetative or reproductive phase [29]. The most significant result of the experiment is related to the effect of the sowing date: all yield components (yield, AGB, HI, THS, and protein yield) were negatively influenced by the delay in the sowing date. The effect of sowing date has also been confirmed by other authors [46,47] who reported that, under rainfed conditions, it is better to sow faba beans early, as late-sown crops are not able to develop enough biomass and grain yield. Seed yield reduction in late-sown plants may be due to poor growth, shorter grain filling duration and maturity period, smaller number of fruiting nodes, and pods plant^{-1} and minimum grains pod^{-1} [48]. Sowing time determines the amount of rainfall and temperature to which the crop is exposed at different growth stages. The longer the growing season, the higher the amount of intercepted solar radiation, as well as dry matter production and crop yield, assuming constant harvest index [49–51]. It seems that a good seed production is obtainable in environments in which the average daily seed productivity during the reproductive phase is higher than 50 kg ha^{-1} day^{-1} [52].

The three tested genotypes (Taifun, Tiffany, and Fuego), originating from cool climates, recorded seed yield values in agreement with the data from the literature (average values of 5 t ha^{-1}) [16]. The tannin-free variety Taifun showed an average protein content (over 26%) higher than that of the tannin varieties Tiffany and Fuego.

5. Conclusions

Today, some of the main challenges for agriculture include attaining nutritional security, decreasing animal protein consumption, and encouraging the consumption of more sustainable protein sources such as those of plant origin. In this perspective, the research that leads to the improvement of the content and availability of underutilized staple foods from protein plants, such as faba beans, is becoming a priority. The development of faba bean varieties improved from agronomic and nutritional point of view, representing a new opportunity to increase the production and use of a crop that has not been globally exploited to its full potential [53]. The environmental impact of specific crops in specific environments is an increasingly important topic of discussion. Due to its ability to fix atmospheric nitrogen and make it available to the other crops in rotation, the cultivation of faba beans can lead to undisputed environmental, ecological, and economic advantages. The research carried out on the qualitative characteristics and response to the agronomic practices of different developed varieties allows for an improvement in yields and protein production for specific environmental characteristics.

In the present study, three *Vicia faba* L. originating from cool climates were evaluated for four different environmental conditions and two sowing dates under Mediterranean field conditions. Seed yield and yield components were impacted by the sowing date. The results show that the proportion of variance explained by the sowing date factor was much more important than other factors, at least in the cases of SY and THS, whereas the effect of environment (year $\times$sSite) was more significant in the AGB and HI. In most environments, sowing later in winter under Mediterranean field conditions resulted in losses of yield and yield components, especially if heat and drought conditions were prevalent during growing seasons. Higher losses can be expected in these conditions if faba beans grow on sandy loam soils.

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