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ASSESSMENT OF THE FALL DORMANCY OF LUCERNE (*Medicago sativa* L.) IN THE MEDITERRANEAN AREA

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Introduction

The difficulties in assessing the distinctness characters in lucerne plants have recently led to reject the registration to the EU database of plant varieties for several new varieties with valuable agronomic characteristics [1]. The tendency of lucerne plants to grow during winter and their fall dormancy (FD) could be an efficient tool for discriminating varieties during registration tests and an interesting agronomic characteristic to evaluate cultivar suitability to different climatic conditions [2]. The information about the dormancy of lucerne are limited and the dormancy class of many Italian varieties is still unknown.

Figure 1. Visual assessment of different Fall Dormancy Class

Aim of the Research

The aim of our study was to validate under Mediterranean climate the method proposed by the International Union for the Protection of New Varieties of Plants (UPOV) for the assessment of the dormancy class and to classify an adequate number of Italian cultivars to be used as control varieties in future registration tests.

Materials & Methods

The experiment was carried out at the experimental farm of CREA-DC located in Palermo, Italy (38.08° N, 13.42° E; 34 m a.s.l), during three consecutive Distinctness, Uniformity and Stability (DUS) trials (18 months each; 2016-2019).

Seven varieties, representing the fall dormancy classes (FDC) 2, 4, 5, 6, 7, and 9, were used as control varieties, while other twenty-one varieties under DUS testing were evaluated to assess their dormancy class. Natural plant heights (NPHs) was measured during the different DUS trials according to UPOV guidelines in five growth stages: 2 weeks after the first autumn equinox following sowing (NPH_2); 6 weeks after the first autumn equinox following sowing (NPH_3); about 1 month after the beginning of growing the year after sowing (NPH_4); 2 weeks after the second autumn equinox following sowing (NPH_{14}); 6 weeks after the second autumn equinox following sowing (NPH_{15}). A cut was made 2 weeks before and 2 weeks after each autumn equinox.

The NPH values measured for control varieties were used to evaluate the FDC by applying the models proposed by Montegano [3] and Teuber [4]. The first method uses regression analysis to fit a linear equation to the PC1 values obtained from a Principal Component Analysis (PCA) performed on NPHs. Thus, a PCA was performed for each DUS trial, investigating the correlation among the varieties and the natural plant height at different growth stages. The input matrix for the analysis comprised the NPH values of the control varieties. Regression analyses were then performed to fit a linear equation to the data of PC1 from the PCA of each DUS trial [3]. Moreover, regression analyses were also performed to fit a linear equation to the data of each NPH [4]. The linear regression models obtained from the single NPH measurements over the three DUS trials were compared to find the equation with the highest correlation. The equations obtained were then used to estimate the dormancy rating of the varieties under DUS testing that was compared to the dormancy assessed visually by using the control varieties as references.

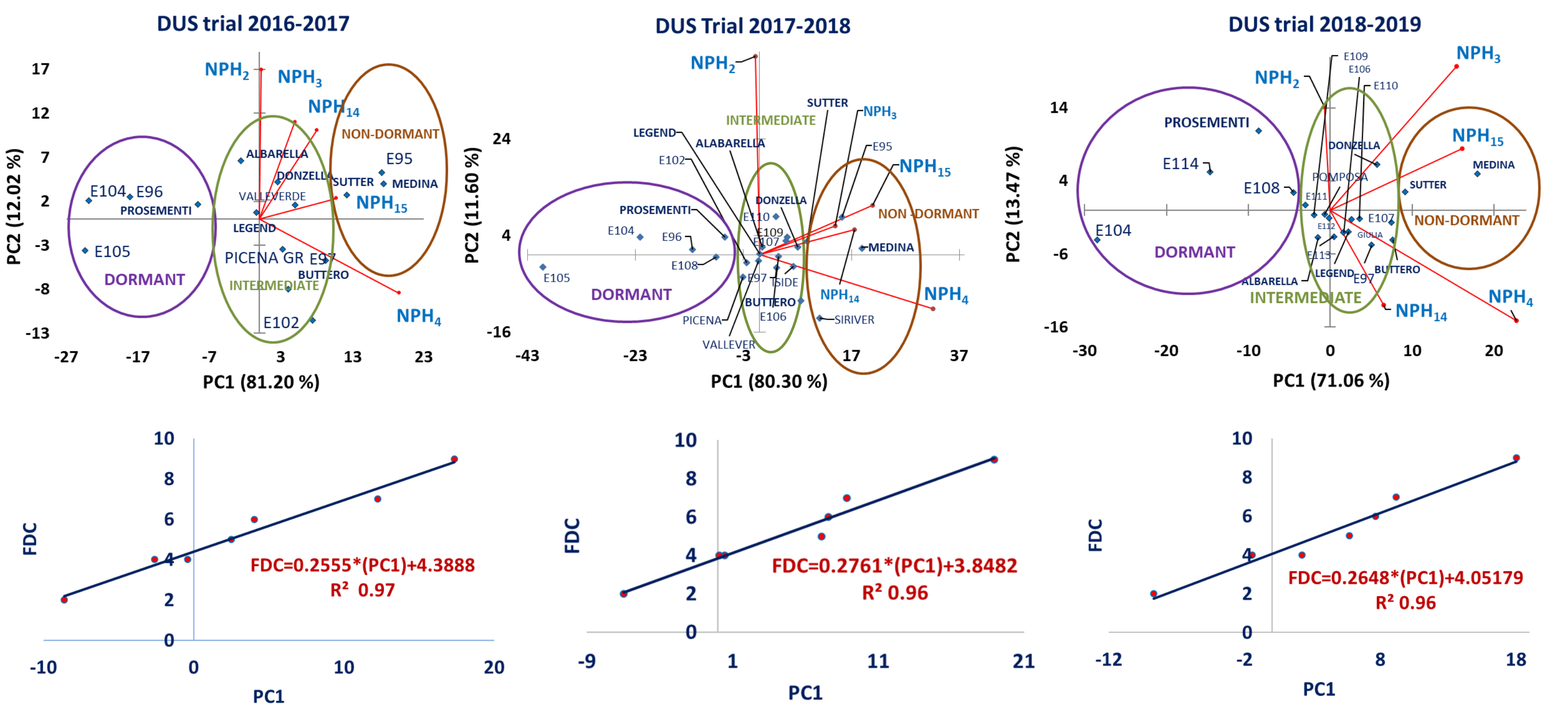

Figure 2. Principal component analysis and linear regression models of the three DUS trials

Results

The biplots obtained from the PCA related to each DUS trial showed that NPH_4 and NPH_{15} were positively correlated with PC1, while NPH_2 was mainly correlated with PC2.

In each DUS trial, three main groups could be distinguished based on the fall dormancy class of the control varieties: Dormant (FDC 1-3), Intermediate (FDC 4-6) and Non-Dormant (FDC>6) (Figure 2).

The PC1 and the fall dormancy class had a significant linear relationship in all the years of the trial (Figure 2). These models showed R^2 values of 0.97 in the first DUS trial and 0.96 in the second and third trial. As regards the models obtained from the regression analyses between the FDC of control varieties and each NPH a high and significant correlation with FDC (R^2 values higher than 0.72) was found using NPH_4 and NPH_{15} (Table 1).

Table 2 shows the estimated FDC classes of the control varieties calculated from the models with PC1, NPH_4 and NPH_{15}. The linear regression models obtained using PC1 fitted better, showing lower differences between estimated classes and official FDC of the control varieties (Table 2).

This model (FDC=a*PC1+b) was then used to estimate the FDC of the 21 varieties under DUS testing and the results are presented in Table 3.

Table 1. Linear regression models obtained using NPH values

DUS Trial	NPH_n	Model	r	R^2	Pr > F
2016 - 2017	NPH_2	FDC=1.4616*NPH_2-6.2439	0.16	0.02	0.738
	NPH_3	FDC=5.968*NPH_3-37.606	0.46	0.22	0.295
	NPH_4	FDC=3.1414*NPH_4-11.053	0.99	**0.99**	**< 0.0001**
	NPH_{14}	FDC=6.3167*NPH_{14}-45.849	0.63	0.40	0.128
	NPH_{15}	FDC= 6.1215*NPH_{15}-34.403	0.85	**0.72**	**0.015**
2017 - 2018	NPH_2	FDC=-1.3607*NPH_2+15.168	-0.21	0.05	0.644
	NPH_3	FDC=7.7577*NPH_3-45.271	0.85	0.72	0.016
	NPH_4	FDC=4.0021*NPH_4-20.389	0.94	**0.88**	**0.002**
	NPH_{14}	FDC=12.364*NPH_{14}-85.999	0.73	0.53	0.064
	NPH_{15}	FDC=7.0959*NPH_{15}-38.689	0.97	**0.94**	**0.000**
2018 - 2019	NPH_2	FDC=-0.3903*NPH_2+8.3198	-0.06	0.00	0.905
	NPH_3	FDC=5.2886*NPH_3-32.3865	0.74	0.54	0.059
	NPH_4	FDC=2.9213*NPH_4-9.6057	0.90	**0.82**	**0.005**
	NPH_{14}	FDC=4.3468*NPH_{14}-31.763	0.48	0.23	0.273
	NPH_{15}	FDC=7.2351*NPH_{15}-47.19	0.91	**0.83**	**0.004**

Table 2. Estimated FDC classes of the control varieties using the models with PC1, NPH_4 and NPH_{15}

Control Varieties	Official FDC	DUS trial 2016 - 2017 Estimated FDC			DUS trial 2017 - 2018 Estimated FDC			DUS trial 2018 - 2019 Estimated FDC		
		PC1	(NPH_4)	(NPH_{15})	PC1	(NPH_4)	(NPH_{15})	PC1	(NPH_4)	(NPH_{15})
PROSEMENTI	2	2.2	1.9	2.5	2.1	2.5	2.9	1.7	1.1	3.5
ALBARELLA	4	3.7	3.6	3.5	4.0	3.9	4.5	3.7	5.1	2.9
LEGEND	4	4.3	4.4	5.0	3.9	4.0	3.2	4.6	5.3	4.8
DONZELLA	5	5.0	5.1	4.5	5.8	6.4	4.4	5.6	5.3	5.2
BUTTERO	6	5.4	6.1	7.1	5.9	5.5	5.8	6.1	6.2	5.1
SUTTER	7	7.5	7.2	7.7	6.3	5.8	7.1	6.5	6.2	6.5
MEDINA	9	8.8	8.7	6.7	9.1	9.1	9.1	8.8	7.9	9.2

Table 3. Estimated FDC classes of the varieties under DUS testing

Varieties	FDC	Group	Varieties	FDC	Group
E104	1	Dormant	E109	5	Intermediate
E105	1	Dormant	E106	5	Intermediate
E114	1	Dormant	VALLEVERDE	5	Intermediate
E96	2	Dormant	GIULIA	5	Intermediate
E108	2	Dormant	E110	5	Intermediate
E111	4	Intermediate	E97	5	Intermediate
POMPOSA	4	Intermediate	E107	6	Intermediate
E112	4	Intermediate	ISIDE	6	Intermediate
PICENA GR	4	Intermediate	SIRIVER MK II	7	Non-dormant
E102	4	Intermediate	EM95	9	Non-dormant
E113	5	Intermediate			

Conclusions

The results of this study allowed: (I) the validation of the method proposed by UPOV guidelines to our environmental conditions; II) the selection of a fair number of control varieties to be used in future official DUS tests.

Our study confirmed that the dormancy rating obtained through the NPHs is an important characteristic for the discrimination of lucerne varieties. The models obtained from PC1, NPH_4 and NPH_{15} explained a high proportion of variability. In our climatic conditions, high temperatures occurring in early autumn don't allow discrimination among the varieties by using NPH_2. Therefore, the NPH2 measure could be avoided, reducing the costs of DUS tests of lucerne.

In conclusion, the results of this work could help to simplify the assessment of variety dormancy ratings.

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