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Forage production of a collection of sainfoin over a three year period

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Abstract. The agronomic characteristics of a collection of 23 sainfoin accessions (*Onobrychis viciifolia* Scop.) were assessed over a three year period. Flowering intensity, yield and its repartition, growth habit and mortality were followed in a small plot trial in Zaragoza, Spain. A wide range of variation was encountered for all traits. Variety, cut and year effects affected significantly forage parameters in most of the cases: total forage yield ranged from 1041 g DM/plant for 'Cotswold common' to 1776 g DM/plant for 'Polonia' when mortality ranged from 50% ('Yubileyna', 'Polonia') to 78% ('Somborne', 'Ambra'). Principal component analysis allowed us to integrate these data according to flowering intensity and mortality and from there, to preselect the varieties presenting the best agronomic properties.

Keywords. Flowering intensity – Persistency – Germplasm – *Onobrychis viciifolia* Scop.

Production fourragère d'une collection de sainfoin (*Onobrychis viciifolia* Scop.) au cours de trois années

Résumé. Les caractéristiques agronomiques d'une collection de 23 variétés de sainfoin (*Onobrychis viciifolia* Scop.) ont été suivies sur une période de trois ans. L'intensité de floraison, le niveau de production et la répartition au cours de l'année, le port de la plante et la mortalité furent étudiés dans un essai en champ à petite échelle à Saragosse, Espagne. Une ample gamme de variation fut observée sur tous les critères. La variété, la coupe et l'année eurent des effets significatifs sur ces paramètres dans la plupart des cas : la production totale de fourrage varia de 1041 gMS/plante pour 'Cotswold Common' à 1776 gMS/plante pour 'Polonia', quand la mortalité oscilla entre 50% pour 'Yubileyna' ou 'Polonia' à 78% pour 'Ambra' ou 'Somborne'. L'analyse en composantes principales nous a permis d'intégrer ces données selon l'intensité de floraison et la mortalité et de là à sélectionner éventuellement les variétés présentant les meilleures caractéristiques agronomiques.

Mots-clés. Intensité de floraison – Persistance – Germoplasme – *Onobrychis viciifolia* Scop.

I – Introduction

Sainfoin (*Onobrychis viciifolia* Scop.) is a forage legume much appreciated by farmers due to high palatability, high nutritional value and non bloating properties (Delgado *et al.*, 2002). In the Mediterranean area, the plant prefers highlands above 600 m; it thrives on poor soils particularly well-drained and alkaline (Buendía Lázaro and García Salmerón, 1965). It contains tannins which enhance the utilisation of proteins by ruminants and protect livestock against parasites (Min *et al.*, 2003). Producing high level of home-grown protein of optimal use, this promising fodder may lead to more efficient, animal- and environmental friendly farming system.

However, a high level of variability among sainfoin accessions were encountered at agronomic level by Michelana and Hycka (1988) and Delgado *et al.* (2008). The exploitation of the full genetic potential of sainfoin requires knowledge of the existing diversity of sainfoin. Thus, the objective of this work is to assess the agronomic characteristics of a sainfoin collection.

II – Materials and methods

Twenty-three lines of sainfoin were selected for this study, among them 12 European commercial entries: Yubileyna (Bulgaria); Visnovsky (Czech Republic); Sepial and Fakir (France); Ambra and Inconornata (Italy); Esparcette and Polonia (Poland); Ucraina (Ukraine); Costwold common and Somborne (United Kingdom) and Korunga (Turkey), representing the commercial material available. Nine landrace were collected from seed production growers in the North-Eastern Spain, Graus; Lagueruela; Loarre; Mezquita de Jarque; Reznos; Tartareu; Torrecilla de Cameros; Villahermosa del Río and Villahoz. Two breeding lines from the CITA, Selección 7.1 and Teruel 9.2, selected respectively for persistency or production were added.

They were sown in a silty-loamy soil (0.41CE; 1.5 dδ/m) under irrigation in Zaragoza (41°3'N; 0°47'W). The climate of the area corresponds to a sub-humid Mediterranean type with mean temperatures of 6.0°C min and 23.2°C max and total precipitations of 381 mm. Thirty six plants of each of the 23 varieties were sown in three randomised block with 12 plants per block at 0.4 m x 1 m. Irrigation was provided by monthly flooding during the summer months. In 2008 and 2009, the plants were cut every time they reached the phenological stage of 'full flowering stage' defined as the stage in which 50% of stems have 50% of the flower blooming. In November, the non-flowering autumn regrowth was also cut. In total, five cut were performed in 2008 and 2009.

The flowering intensity was defined as the percentage of flowering plant in the sowing year and was recorded in 2007. In each cut, plants were cut individually, weighted and dried in a ventilated stove at 60°C for the determination of dry matter (DM) yield. Growth habit was considered as the ratio between the plant height and diameter, the height being measured from ground level on the three highest stems and the diameter as the measurements of the two widths of the plant. Mortality proportion is presented as the percentage of dead plants at each cut.

The flowering intensity and mortality percentages were arcsine-transformed prior to statistical analysis. All data were analysed by ANOVA. For yield, growth habit and mortality proportion variables, variety, year, number of cut and their interactions were regarded as fixed effects; number of cut was considered as repeated measurements. For flowering intensity, variety was regarded as fixed effect. Analysis of variance were undertaken using the proc mixed procedure of the SAS statistical package (SAS, 2004) and principal component analysis which was realised using in the Minitab software package (Minitab Inc., 2003).

III – Results and discussion

Flowering intensity differed significantly between varieties ($P < 0.001$), it ranged from 14.2% of flowering plant for 'Costwold common' to 91.4% for 'Reznos', being 74.4% in average. In spite of the numerous references to sainfoin plant being of one-cut or two-cut type (Michelana and Hycka, 1988), in our collection, few the varieties may be allocated clearly to one type or the other, 'Sepial' and 'Reznos' for two-cut and 'Costwold common' and 'Graus' for one-cut varieties.

DM yield, growth habit and mortality are given in Table 1. Total forage yield of the two year ranged from 1041 g DM/plant for 'Costwold common' to 1776 g DM/plant for 'Polonia' (average 1395 g DM/plant). DM yield was affected significantly by variety, cut and year (Table 2). DM yield of sainfoin declined from first (C1) to last cut (C5), the proportion being 43, 31, 12, 9 and 5% for 2008 and 51, 19, 11, 14 and 6% for 2009. This repartition is similar to results obtained by De Falco *et al.* (2000). The difference observed in yield repartition between 2008 and 2009 may be due to the shortest time between the first and second cut in 2009, which did not allow plants to regrowth as much as in 2008. DM yield was lower in 2009 than in 2008 (572 g DM/plant against 822 g DM/plant) (Table 1). Some varieties had a divergent pattern though cuts and

years, 'Korunga', 'Yubineyna', 'Polonia', 'Reznos' and 'Visnovsky' had a higher proportion of C1 and C2 in the annual yield, these varieties gave significantly higher DM total yield.

Table 1. Dry matter (DM) yield, growth habit and mortality of a collection of sainfoin through the cut

Cut	DM yield (g DM/plant)				Growth habit				Mortality			
	2008		2009		2008		2009		2008		2009	
	Mean	SD†	Mean	SD†	Mean	SD†	Mean	SD†	Mean	SD†	Mean	SD†
1st	365	161	295	155	1.13	0.39	1.13	0.39	0.00	0.06	2.17	2.47
2nd	252	111	111	67	1.32	0.21	1.32	0.21	0.85	1.76	10.10	9.53
3rd	94	54	60	42	1.23	0.40	1.58	0.41	8.08	7.21	7.40	6.26
4th	70	43	81	56	1.48	0.42	1.64	0.51	15.24	9.51	10.15	6.32
5th	43	30	33	20	1.60	0.40	1.60	0.40	3.26	4.22	2.88	2.61

†SD: standard deviation.

Table 2. Effect of fixed effects on flowering intensity, growth habit, DM yield and mortality of a collection of sainfoin

Effect	Variety	Year	Cut	Year x variety	Cut x variety	Cut x year	Cut x year x variety
Flowering intensity	***	/	/	/	/	/	/
Growth habit	***	***	***	NS	***	***	NS
DM yield	***	***	***	***	***	***	***
Mortality	NS	**	***	NS	*	**	NS

*P<0.05, **P<0.01, ***P<0.001, NS: non significant.

As yields in C3, C4 and C5 were low and similar for all varieties, differences observed in DM yield are mainly due to differences in C1 and C2. On the other hand, some varieties had fewer variations between cuts ('Lagueruela', 'Torrecilla de Cameros', 'Sel 7.1', 'Fakir').

The measure of growth habit as ratio between plant height and diameter revealed to be easy and less time costly than visual appreciation, apart to be less subjective, nevertheless it reflected well the range of growth habit found, from prostrate (1.0) to erect (1.6). The average sainfoin was semi-erect (1.40); 'Costwold common' and 'Korunga' were the most prostrate varieties (1.17); 'Esparcette' and 'Ambra' the most erect (1.57). Plants were more erect from C1 to C2 to C3, probably because plants being smaller in the latest cuts, the bunch of stems did not opened under the weight, that may be an explanation especially for semi-erect plants. In C4, growth habit decreased notably, as plants, although in full flowering stage, were oldest that in C1, C2 or C3 being C3-C4 the longest period (68 and 72 days). The interval being shorter between C4 and C5, and the plant even smaller, the growth habit increased in C5. In the same way, plants were more erect in 2009 than in 2008, probably because they were smaller.

Mortality ranged from 50% ('Yubileyna', 'Polonia') to 78% ('Somborne', 'Ambra'). Mortality was not influenced by the variety effect and presented no significant correlation with DM yield, growth habit or flowering intensity. Mortality occurred during summer, in C3 and C4 in 2008, and C2, C3 and C4 in 2009. The reduction of plant reserves due to the intensive cutting regime and to high temperatures in summer may explain this seasonality of mortality.

To synthesise all data, a principal component analysis was performed on the following plant

traits: flowering intensity in 2007, growth habit, DM yield and mortality in 2008 and 2009. The two first component of the PCA explained 85% of the variability observed. The first axis was formed by flowering intensity, growth habit and DM yield with preponderant weigh of flowering intensity. The second axis was associated with mortality. Varieties scattered on these axes (Fig. 1), the upper right quarter correspond to interesting varieties ('Polonia', 'Yubileyna', 'Sepial', 'Sel. 7.1', 'Visnovsky' and 'Torrecilla de C.'), presenting high yield and low mortality.

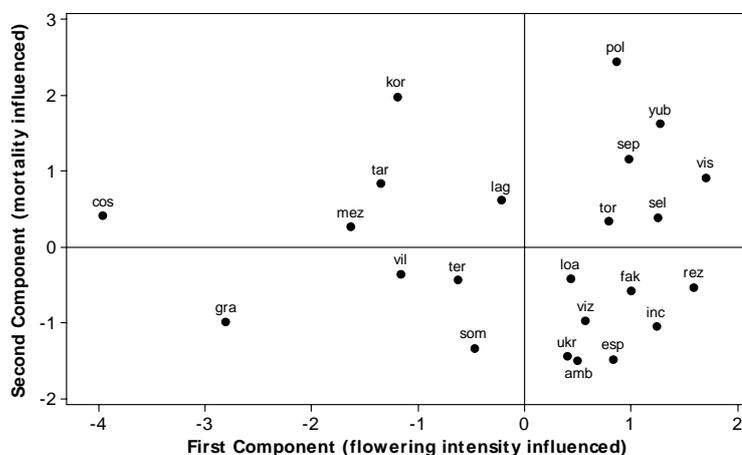


Fig. 1. PCA on flowering intensity, persistency, growth habit and DM yield of a collection of sainfoin.

IV – Conclusions

The three year assessment of the agronomic characteristics of sainfoin collection confronted us to a wide range of variation in all observed traits. Varieties, year and cut effects influenced the flowering intensity, growth habit, DM production and mortality. DM production of sainfoin occurred principally in the first cut. Principal component analysis helped to integrate all data and eventually to select several varieties of interest, both commercial accessions and landraces, on agronomic criteria.

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