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Abstract. Greater use of annual cereal-legume mixtures in grains is one solution to improve goat farms sustainability and protein self-sufficiency. Still few references are available about its use in dairy goat systems, despite its interests (low-input culture, resistance to bio-aggressors, crude protein yield). For 3 years (2016 to 2018), 113annual cereal-legume mixtures have been studied, both in commercial farms (REDCap: 101 samples) and in experimental unit (Inra Patuchev: 12 samples). Every sample represents an annual cereal-legume mixture produced by a breeder on his farm (plots of 8.8 ha +/-5.3), and given to goats. For each sample, we collect information on the sown mix, sowing rate, soil type, weather and technical route. We measure the yield, the proportion of each species and the quality of the harvested mix. Production costs are also estimated. They are often composed of triticale, peas, oats, faba beans, vetch and/or barley. 48% of annual cereal-legume mixtures are made of 3 or 4 species, with about 300 seeds/m² sown (+/– 72). On average, 3.5 t /ha (+/– 0.9) are harvested. It produces an interesting feed for animals, with 88.2% (+/– 0.04) of digestibility of organic matter,1 UFL (+/-0.04) and 15.7% (+/-2.8) of crude proteins. Annual cereal-legume mixtures represent 10% of goat requirements and 17% of protein requirements. An analysis of the database shows that i/mixtures with about 10% of fabaceae, ii/presence of faba bean (10-15 grain/m²) and iii/about 3-4 species secure yield and feeding value. These references will help goat farmers to develop the use of annual cereal-legume mixtures in dairy goat systems.

Keywords. Goat – Annual cereal-legume mixture – Protein self-sufficiency – Grain.

Développement de mélanges céréales-protéagineux (méteils) dans les élevages de chèvres laitières du sud-ouest de la France, pour améliorer l'autonomie protéique et les coûts d'alimentation

Résumé. *une plus grande utilisation des mélanges céréales-protéagineux (méteils) récoltés en grain est une solution pour améliorer la durabilité et l'autonomie alimentaire des élevages de chèvres. A l'heure actuelle, peu de références existent sur son utilisation dans les systèmes d'élevage caprin, malgré ses nombreux intérêts (culture bas-intrant, résistance aux bio-agresseurs, rendement protéique). Pendant 3 ans, de 2016 à 2018, 113 méteils ont été étudiés, à la fois dans des élevages (REDCAP) et sur le dispositif expérimental Patuchev (Inra). Chaque échantillon correspond à un mélange produit par un éleveur dans sa ferme (les parcelles mesurent en moyenne 8,8 ha +/-5,3), et distribué aux chèvres. Pour chaque échantillon, nous avons récolté des informations sur la composition du mélange semé, la densité de semis, le type de sol, les conditions météorologiques et l'itinéraire technique. Nous avons mesuré le rendement, la proportion de chaque espèce récoltée, et la valeur alimentaire du mélange. Le coût de production a également été estimé. Ces mélanges sont souvent constitués de triticale, pois, avoine, féverole, orge et/ou vesce. 48% des méteils sont composés de 3 ou 4 espèces, semé à une densité de 300 graines/m² (+/-72). En moyenne, 35 qx sont récoltés par hectare. Un aliment intéressant pour les chèvres est produit, avec 88,2% de digestibilité, 1 UFL et 15,7 % de MAT (protéines). Cette récolte représente dans les élevages 10% des besoins massiques des animaux et 17% des besoins en protéines. Une analyse de la base de données montre que les mélanges avec 10 % de protéagineux semés, la présence de la féverole et des mélanges avec 3-4 espèces sécurisent le rendement et la valeur alimentaire. Ces références vont aider les éleveurs de chèvres laitieres de développer cette culture de méteil.*

Mots-clés. *Mélanges céréales-protéagineux – Méteil – Grain – Chèvres – Autonomie protéique.*

I – Introduction

Increasing feed self-sufficiency and grassland use leads to reduce feeding costs and negative environmental impacts of goat farms. In the south-west of France, a research and development scheme for high performance and sustainable goat farming has been created: REDCap and Patuchev (Caillat and Jost, 2015). It gives a wide place to i/ experiments in experimental units (Patuchev) and on farms (REDCap), ii/ exchanges between scientists, advisors and breeders to support the emergence of innovations and iii/ spread new knowledge on these topics. The network REDCap and the experimental plateform Patuchev of Inra work on these topics, using the Agroecology principles (Altieri, 2002): i) designing farming systems based on biological regulations and interactions between the components of the farm, ii) increasing local feed resources and inputs self-sufficiency, iii) working with local actors.

In western France goat farms, only 25% of concentrates are produced in farm and the level of protein self-sufficiency is 38%, which is quite low (Brocard *et al*., 2016). Greater use of home-made concentrate, as for example annual cereal-legume mixtures harvested in grains and given to goat as a concentrate, is one solution to improve goat farms sustainability and protein self-sufficiency.

Some farmers are using this opportunity. However, still few references are available about its use in dairy goat systems, despite its interests (low-input culture, resistance to bio-aggressors, crude protein yield).

II – Material and methods

During 3 years (2016 to 2018), 113 annual cereal-legume mixtures have been studied, both in commercial farms (REDCap: 101 samples) and in experimental unit (Inra Patuchev: 12 samples). Every sample represents an annual cereal-legume mixture produced by a breeder on his farm (plots of 8.8 ha +/-5.3), and given to goats in grain. The studied area concern two Region: Nouvelle-Aquitaine and Pays de la Loire. For each sample, we collect information on the sown mix, sowing rate, soil type, weather and technical route. Yield, proportion of each species and quality of the harvested mix are measured.

Finally, production costs (Perel method[1]) and impact on self-sufficiency are also estimated (Idele method: Contribution to goat requirements and protein requirements, Bossis *et al.*, 2015).For biochemical analyses, all samples are analyzed by the reference methods at LABCO of Surgères. Feeding values are calculated by tables Inra 2007.

III – Results and discussion

1. Description of annual cereal-legume mixtures used in dairy goat farms in Western France

Mixtures are on average composed of 4 species (+/-1.3). However, their composition is variabble: 30% of mixtures are composed of 2 species, 22% of 3 species, 25% of 4 species and 23% of more than 5 species. The more complex one count 9 species.

There is also diversity in terms of species used. 6 different cereals and 5 legumes are used by farmers. Table 1 presents the frequency of presence of each specie. Presence of triticale, pea, oat and faba beans can be noticed in more than half of mixtures. Other species are often used in complex

1. Perel method : http://www.perel.autonomie-fourragere-des-elevages.fr/couts-des-fourrages/

mixtures. Lupine is few used by farmers, because of the variability of its yield and the necessary to have a specific soil.

Table 1. Frequency of presence of each specie in mixtures

Triticale	Forage pea	Oat	Faba bean	Spelled	Vetch	Pea	Barley	Corn	Lupin	Rye
85%	75%	56%	50%	23%	21%	17%	22%	7%	6%	4%

Sown density is 297 seed/m² (+/-72), which is quite high (recommendation is 260 seeds of triticale/m² according to arvalis, 2019). Mixtures are composed of 10% of legumes seeds, in terms of seed sown. On average, 3.5 t (+/– 0.9) are harvested during summer.

54% of mixtures are produced with an organic agriculture label. Farmers often say “annual cereal-legume mixtures only need to be sown and harvested”. Indeed 92% of mixtures have no phytosanitary treatment, 88% no weeding and 85% no mineral nitrogen added.

2. Interest of annual cereal-legume mixtures for goat diet

These mixtures are an interesting feed for goats, with 88.2% (+/– 0.04) of digestibility, 1 UFL1 (+/-0.04) and 15.7% (+/– 2.8) of crude proteins. There are few variations on digestibility and energy values. Variations are more important on crude protein.

Table 2 present the diversity of yield and nutritive values, according to criteria: yield and crude protein value. 4 groups were made to show the diversity of success of this culture.

Table 2. Productivity of annual cereal-legume mixtures (source: REDCap)

	No. of samples	Yield (t/ha)	Crude Protein (as fed %)	Protein yield (kg of CP/ha)	Contribution to goat requirements	Contribution to goat protein requirements
Average	113	3.5	15.7%	595	10%	17%
High yield – High protein value	36	3.9	17.9%	698	13%	21%
High yield – Low protein value	24	2.2	18.6%	409	12%	19%
Low yield – High protein value	43	4.2	12.8%	538	14%	16%
Low yield – Low protein value	8	1.9	12.2%	231	8%	9%

[2]UFL = Unité Fourragère Lait; Net energy for lactation in MJ = UFL × 6.7 for grass (all types) and UFL × 6.8 for maize silage.

3. Interests of annual cereal-legume mixtures to improve protein self-sufficiency andreduce feeding costs

In terms of productivity, one hectare of mixture produce 595 kg of crude protein. There is a large variability (+/-213).

In the followed up farms, annual cereal-legume mixtures represent 10% of goat requirements and 17% of protein requirements. “Best mixtures” (high yield and protein value) produce 21% of protein requirements of goats.

Production costs were also estimated in 2016. This culture costs 385 €/ha (+/-60): 158 € of seeds, 125 € of mechanic works and inputs and 103 € of harvest. It represents 144 €/t or 8.5 €/% of CP.

IV – Conclusion

Cereal-legume mixtures are an opportunity for goat farmers, to improve their protein self-sufficiency, and in the mean-time to reduce input use and feeding costs. However, there is quite an important diversity of mixtures, and of successful. Next step will be to better understand the evolution of mixture, in terms of productivity and nutritional values. The goal is to propose recommendations to farmers. A fast analysis of the database shows that i/mixtures with about 10% of fabaceae, ii/presence of oats (10-15 grain/m²) and iii/about 3-4 species secure yield and feeding value. These references will help goat farmers to develop the use of annual cereal-legume mixtures in dairy goat systems.

With the development of goat organic farming, the promotion of protein self-sufficiency and the goal to decrease inputs in cultures, annual cereal-legume mixtures is an interesting culture for goat farmers in South-West France.

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