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Biomass production of different annual cereal-legume intercrops under Moroccan conditions

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Abstract. Annual cereal-legume forage mixtures are increasingly used in forage production in Morocco. Four forage cereals oat (cv Ghali), barley (cv Tamellalt), triticale (cv Juanillo) and rye (cv Petkus) were evaluated in mixture with three fodder legumes, fodder pea (cv Naima), *Vicia sativa* (cv Nawal) and *Vicia villosa* (cv Ghazza). Two years study was carried out at El Koudia location (N 34°03', O 6°46') to investigate the forage yield and growth rates of legumes-cereals mixtures at seeding ratio 75:25 for legume and cereal, respectively. Results showed significant differences among cereals-legumes intercrops for forage dry matter. The average yields were 8.7 and 6.6 t ha⁻¹ respectively for first year and second year. Intercrops of oat-legumes and triticale-legumes provided higher and more stable yields for two years. Rye-legumes intercrops produced intermediate yields, while production of barley-legumes mixtures was lower for both seasons. Best yields were achieved for oat and triticale mixtures with pea in the first year and of both pea and *Vicia sativa* during the second year. According to the results, yields of cereals intercropped with *Vicia villosa*, were lower than yields of cereals intercropped with *Vicia sativa* or pea, except for barley during the first year. The proportions of pea and *Vicia sativa* in harvested yields were significantly higher than those of *Vicia villosa* for all the tested mixtures, indicating that pea and secondly *Vicia sativa* were more competitive when intercropped with any of the tested cereals.

Keywords. Forage – Cereals – Fodder legumes – Mixture – Oat – Barley – Rye – Triticale – Fodder pea – Vetch.

Production de biomasse de différents annuels cultures associées céréales-légumineuses sous conditions marocaines

Résumé. La culture des mélanges de céréales et de légumineuses fourragères annuelles est une pratique traditionnelle de production fourragère extensive dans les pays méditerranéens. Elle est de plus en plus utilisée dans plusieurs zones au Maroc. Ainsi, quatre céréales fourragères avoine (cv Ghali), orge (cv Tamellalt), triticale (cv Juanillo) et seigle (cv Petkus) ont été évaluées en mélange avec trois légumineuses fourragères, pois fourrager (cv Naima), *Vicia sativa* (cv Nawal) et *Vicia villosa* (cv Ghazza) pendant deux années au site d'El Koudia (N 34°03', O 6°46') pour déterminer les rendements fourragers et établir les meilleures combinaisons au point de vue biomasse et qualité. Les mélanges légumineuses-céréales ont été semés à 75:25 pour les légumineuses et les céréales respectivement. Les résultats ont montré des différences significatives entre les cultures associées pour la matière sèche fourragère. Les rendements moyens ont été de 8,7 et 6,6 t ha⁻¹ respectivement pour la première et la deuxième année. Les cultures intercalaires d'avoine-légumineuses et de triticale-légumineuses ont donné de bons rendements en outre stables pendant les deux années. Les rendements des mélanges seigle-légumineuses ont été intermédiaires, alors que la production des mélanges d'orge-légumineuses s'est révélée plus faible pour les deux saisons. Les meilleurs rendements ont été obtenus par chacune des cultures d'avoine et de triticale mélangées avec le pois et avec *Vicia sativa*. Les résultats ont également montré que les rendements de chaque céréale intercalée avec *Vicia villosa* étaient inférieurs aux rendements des autres mélanges. Les proportions de pois et de *Vicia sativa* dans le fourrage récolté ont été significativement plus élevées que celles de *Vicia villosa*, ce qui montre que le pois et la *Vicia sativa* soient plus compétitifs lorsqu'ils sont mélangés avec chacune des quatre céréales testées.

Mots-clés. Fourrage - Céréales – Légumineuses fourragères – Cultures intercalaires – Mélange – Avoine – Orge – Seigle – Triticale – Pois fourrager – Vesce.

I – Introduction

Annual cereal-legume forage mixtures are considered as a traditional practice for extensive forage production in the Mediterranean countries. These mixtures are increasingly used in forage production areas in Morocco in order to enhance forage productivity and to promote the quality of harvested yields as reported by Gebrehiwot *et al.* (1996). Intercropping cereals with fodder legumes is expected to improve cropping systems, showing agronomic, nutritional and economic advantages compared to sole crops (Bedoussac, 2009). Intercropping is an effective system to promote yield stability and forage nutritive quality according to the crops genotypes and the environmental conditions (Ross *et al.*, 2004, Lithourgidis *et al.*, 2006).

Since the intercropping system is based on the complementarity between the species involved in the mixture, it is quite important to choose adequate partners to ensure the success of the system as whole. Hence, the aim of this study was to evaluate the productivity of forage intercrops based on annual fodder legumes (vetches and pea) and annual small grain cereals (barley, oat, rye and triticale) and to determine their best combinations under Moroccan rainfed conditions.

II – Material and methods

Four cereals species, oat (*Avena sativa* cv Ghali), barley (*Hordeum vulgare* cv Tamellalt), triticale (*Triticosecale* cv Juanillo) and rye (*Secale cereal* cv Petkus) were tested in mixture with three fodder legumes (*Vicia sativa* cv Nawal, *Vicia villosa* cv Ghazza and *Pisum arvens* cv Naima), at a seeding ratio of 75:25 for legume and cereal respectively. The trial was conducted for two years and was located in El Koudia experimental domain (N 34°03', O 6°46') in Morocco, on a sand loamy soil. For both years, sowing was made during the last decade of November in a density of 300 seeds m⁻² based on seed weights. The experimental design was a randomized complete block with 12 treatments (combination of 4 cereals and 3 legumes) replicated three times. Plot size was 2.4 x 6 m. Measurements concerned forage yield, corresponding to 60% of fresh biomass, dry matter yields and species proportions at harvest. Mixtures were harvested around milk stage of cereals (approximately at pod setting of legumes). Statistical ANOVA analysis was performed using SAS software (SAS, 1990). Means comparisons between treatments were estimated according to Least Significant Differences (LSD) test with $\alpha = 0.05$.

III – Results and discussion

The weather conditions during the two growing seasons were quite different in the trial location. In the first year, annual rainfall reached 414 mm and had an irregular pattern with low rainfall at early growth cycle and a wet spring. During the second year, even with similar amount, rainfall pattern was different. The maximum rainfall was received just after sowing and a drought occurred at spring. Rainfall distribution was irregular with a maximum received in two months (December and January), followed by a completely dry period from February to mid-April. This rainfall pattern harmed seed emergence of barley and *Vicia villosa* species.

Seedling emergence occurred two weeks after sowing and averaged 78%. Plant covers were heterogeneous, especially in stands involving barley and *Vicia villosa*, which had weak and slow emergence, especially in the first year.

1. Forage production

Analysis of variance for forage production showed differences ($P > 0.05$) among the tested intercrops in both years. Harvested yields averaged 13 t/ha in both years and intercrops kept similar trends of biomass accumulation except those with triticale, which yielded significantly larger quantity of hay in the second year.

Oat intercropped with each of the three legumes (pea, *Vicia sativa* and *Vicia villosa*) revealed high yield potential at harvest, exceeding the other cereals-legumes mixtures. Furthermore, mixtures of rye and legumes reached higher levels of yield compared to those with barley. Yields from triticale-legumes intercrops were intermediate between the rye-legumes and barley-legumes mixtures (Fig. 1).

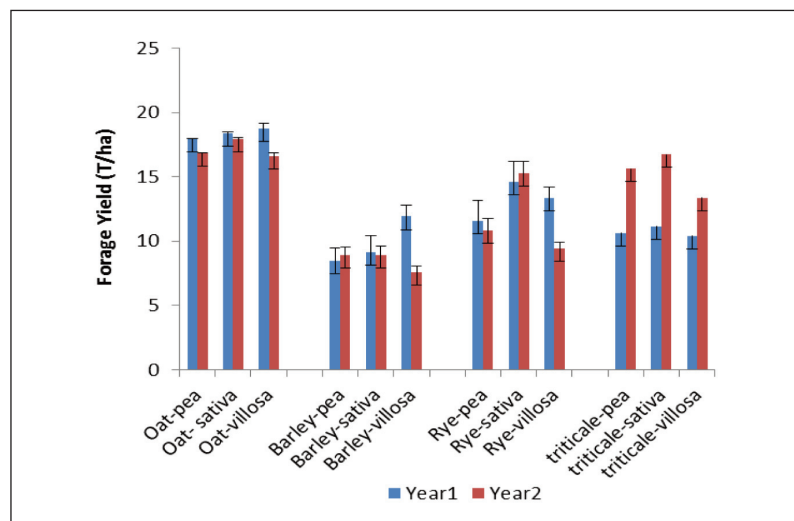


Fig. 1. Two years forage production of oat, barley, rye and triticale intercropped each with *Vicia sativa*, *Vicia villosa* and pea at El Koudia location.

2. Dry matter yields

Significant differences ($P < 0.001$) were recorded among the tested cereals-legumes intercrops for forage dry matter. The year effect was significant for this parameter ($F_{pr} = 0.0021$) and the average yield was significantly higher in the first year (8.7 t ha^{-1}) compared to second year (6.6 t ha^{-1}). The higher yields were achieved by oat and triticale intercropped with pea.

However, intercrops with barley and the three legumes produced lower yields, likely due to an inappropriate variety choice. Besides, intercrops of oat, barley and triticale with pea had higher yields than when intercropped with *Vicia sativa* or *Vicia villosa*. In the second year the trend was confirmed with a net catch-up of the mixtures of the three cereals (oat, triticale and barley) intercropped with *Vicia sativa*.

However, forage yields of cereals mixed with *Vicia villosa*, were lower than those of cereals intercropped with *Vicia sativa* or *Pisum arvens*, except for barley during the first year (Fig. 2).

3. Proportions of fodder legumes at harvest

The proportions of legumes in the harvested forage of intercrops were more or less similar for both years. Fodder legumes accounted for a large share of harvested forage and their contribution in yield was significantly higher in the case of fodder pea-cereals and *Vicia sativa*-cereals (Fig. 3). The proportions went up to the 75:25 initial proportion in the case of barley-pea and triticale-pea mixtures. However, intercropping *Vicia villosa* with cereals resulted in low amounts of this legume within intercrops. Indeed, proportions of *Vicia villosa* in harvested forage ranged between 6 and 20% significantly below of sown proportions.

It seems that the pea and secondly *Vicia sativa* were more competitive than *Vicia villosa* when intercropped with any of the four tested cereals.

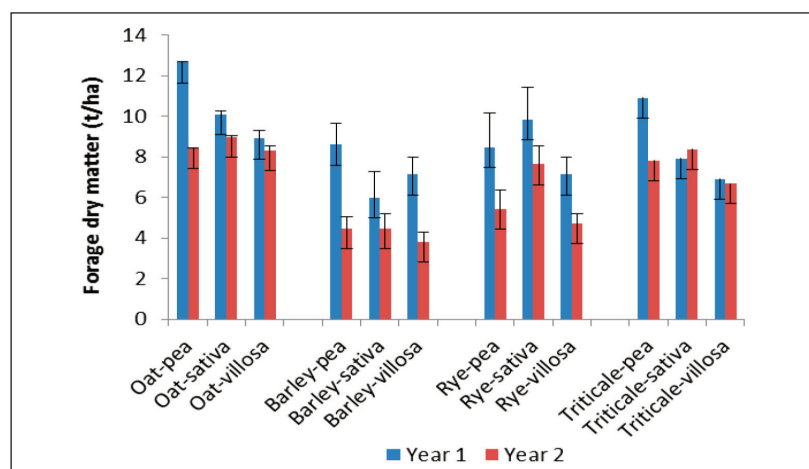


Fig. 2. Forage dry matter of 12 intercrops generated from oat, barley, rye and triticale mixed with *Vicia sativa*, *Vicia villosa* and pea at El Koudia location.

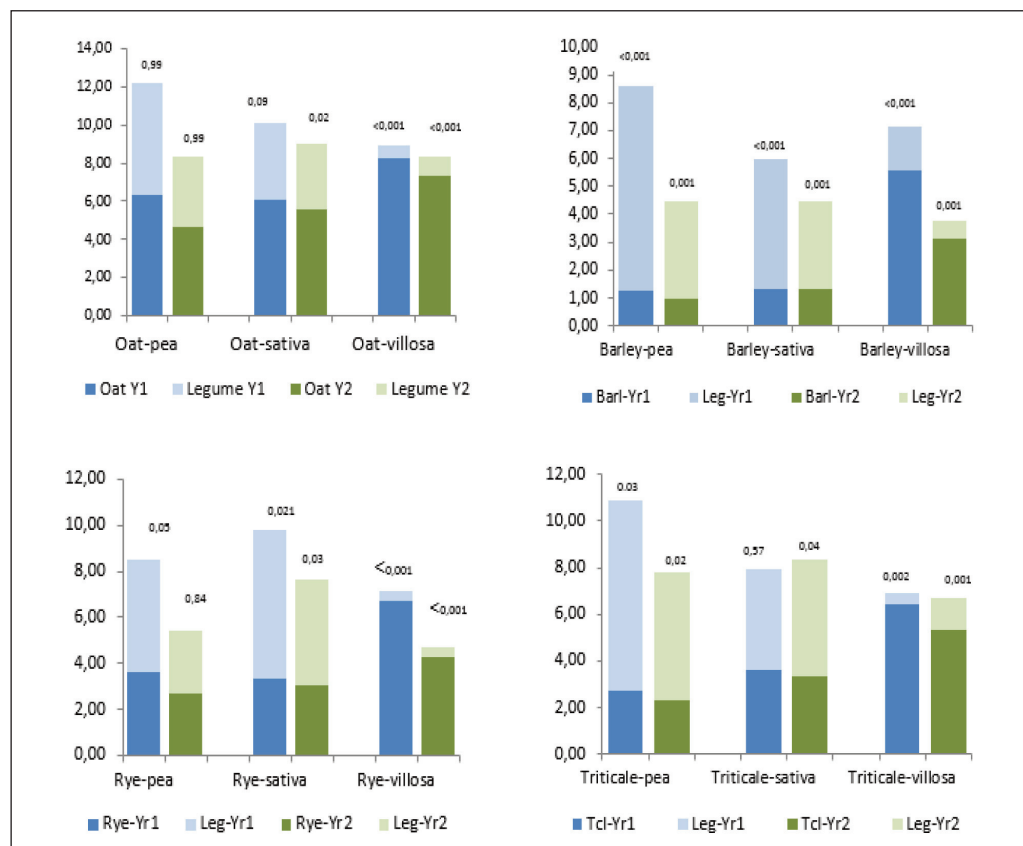


Fig. 3. Shares of cereal and fodder legumes in the forage biomass produced by 12 intercrops generated from oat, barley, rye and triticale mixed with *Vicia sativa*, *Vicia villosa* and *Pisum arvens* at El Koudia location. (The probability of differences significance are indicated on the top of each column).

IV – Conclusion

The present study demonstrates that intercropping of vetches and pea with small grain cereals (oat, barley, rye and triticale) affects forage yields. Intercrops from oat-legumes and triticale-legumes provided high and stable yields. Rye-legumes intercroppings showed intermediate yields and production from barley-legumes mixtures was lower in both seasons. Higher yields were achieved by oat and triticale intercropped with pea and *Vicia sativa*. However, yields of each cereal intercropped with *Vicia villosa*, were lower than those intercropped with *Vicia sativa* or pea. Furthermore, shares of pea and *Vicia sativa* to cereals in harvested yields were higher than those of *Vicia villosa* for all intercroppings, showing that pea and secondly *Vicia sativa* were more competitive when intercropped with any of the four tested cereals.

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