RESEARCH ARTICLE Legume Research- An International Journal, Volume 49 Issue 1: 103-108 (January 2026)

Effect of Mixtures of Grass Pea (*Lathyrus sativus* L.) and Different Forage Grasses on Yield and Quality

Ceyda YILDIZTEKİN[1], Tahir POLAT[2]

10.18805/LRF-877

ABSTRACT

Background: Grass pea (*Lathyrus sativus* L.) is a valuable forage legume due to its adaptability and nutritional quality. However, optimizing its yield and quality often requires mixed planting with compatible cereals. This study aimed to identify the best mixture ratio of grass pea with awnless barley (*Hordeum vulgare*), triticale (*Triticosecale wittmack*) and oat *(Avena sativa*) to achieve high-yield, high-quality forage. The goal was to balance grass pea's high protein content with the structural and yield-enhancing benefits of cereals, improving digestibility while reducing fiber content.

Methods: The experiment was conducted over two winter seasons using a randomized block design with three replications. Grass pea was intercropped with awnless barley, triticale and oat at different ratios. Parameters such as forage yields, crude protein content, acid detergent fiber (ADF), neutral detergent fiber (NDF), digestibility and relative feed value (RFV) were measured. The data were collected annually and two-year averages were used. Statistical analysis assessed the effects of mixture ratios on yield and forage quality.

Result: The study showed that increasing cereal ratios enhanced green forage and dry matter yields and crude protein content but also raised ADF and NDF levels, reducing digestibility. In contrast, higher grass pea ratios improved crude protein content and forage quality. Across both years, pure grass pea and the 60% grass pea + 40% awnless barley mixture had the highest crude protein contents, while pure cereals and the 20% grass pea + 80% barley mixture produced more dry matter. Overall, the 60% grass pea + 40% awnless barley mixture provided the best balance of yield and nutritional value for ruminant feed.

Key words: Fodder plants, Grass pea, Quality, Yield.

INTRODUCTION

Turkiye has suitable ecological conditions for the cultivation of many forage crops. In order to develop forage crop based agriculture, alternative forage crops suitable for our country's ecological conditions are needed in addition to alfalfa, maize and vetch, which are in the first three plants. One of the annual legume forage crops that can be grown in the arid areas of our country is damsel berry (*Lathyrus sativus* L.). A total 77 grass pea species have been identified in the Turkish flora and 25 of them are endemic (Arslan *et al.*, 2018). The common grass pea is tolerant to drought, cold and moderate salinity and can grow in a wide variety of climates and soil types (Tripathi *et al.,* 2022).

However, mullein has a weak stem and causes lodging during the rainy spring period and feed loss occurs due to the decay that occurs as a result. For this reason, it is a common practice to plant common mullein with a grass forage plant with an upright habit. For this purpose, barley, oat, triticale and wheat are the most preferred plants for mixed forage planting (Gennatos and Lazaridou, 2021; Özdemir *et al.*, 2020; Papanaoum *et al.*, 2020; Oruç and Avcı, 2024a, 2024b). Instead of planting these plants alone in production, plants consisting of mixtures make better use of the current conditions and provide higher yields. The poaceae are benefited from the nitrogen that legumes fix in the soil. Roughages obtained from mixtures are more balanced in terms of carbohydrates and proteins and contain more nutrients and for this reason, plant mixture planting systems are widely used in Mediterranean countries (Sayar, 2014). In this study, the effects of awnless barley (*Hordeum vulgare* L.), triticale (*Triticosecale Wittmack*) and oat (*Avena sativa* L.) intercropped with grass pea were investigated on yield and quality traits. It has been demonstrated that optimizing the complex mechanisms and management practices involving legumes in cropping systems is of vital importance for sustainable agriculture (Sharma *et al.*, 2025).

[1]GAP Agricultural Research Institute, Şanlıurfa, Turkiye.
[2]Faculty of Agriculture, Harran University, Şanlıurfa, Turkiye.

Corresponding Author: Ceyda YILDIZTEKİN, GAP Agricultural Research Institute, Şanlıurfa, Turkiye.
Email: ceydayildiztekin3363@hotmail.com
ORCID: 0009000011021331,0000000157549684

How to cite this article: YILDIZTEKİN, C. and POLAT, T. (2026). Effect of Mixtures of Grass Pea (*Lathyrus sativus* L.) and Different Forage Grasses on Yield and Quality. *Legume Research*. **49(1):** 103-108. doi: 10.18805/LRF-877.

Submitted: 09-05-2025 **Accepted:** 15-08-2025 **Online:** 18-09-2025

MATERIALS AND METHODS

The experiments were conducted during the 2022-2023 and 2023-2024 winter growing seasons using a randomized complete block design with three replications at the Koruklu Research Station of GAP Agricultural Research Institute. The materials used in the project

included grass pea (*Lathyrus sativus* L.) Gürbüz 2001 variety, awnless barley (*Hordeum vulgare* L.) Ruha, triticale (*Triticosecale* Wittmack.) Egeyıldızı and oat (*Avena sativa* L.) Manas variety. The forage crops evaluated for performance in the study were sown both in pure form and in binary mixtures. In the research, row spacing was maintained at 20 cm and each plot consisted of 6 rows, each 5 m long. The sowings for the 2022-2023 and 2023-2024 season took place in the second week of November.The cereal crops used in the study included awnless barley, triticale and oat as cereals and grass pea as a legume. The plots were arranged as follows: 100% grass pea (*Lathyrus sativus* L.), 100% awnless barley (*Hordeum vulgare* L.), 100% oat (*Avena sativa* L.), 100% triticale (*Triticosecale* Wittmack), 80% cereal + 20% legume, 60% cereal + 40% legume and 40% cereal + 60% legume. In pure sowings, the sowing rates were 18 kg/da for awnless barley and oat plots, 25 kg/da for triticale plots and 14 kg/da for grass pea plots. For mixed sowings, the seed amounts were calculated based on the mixture ratio, using the pure sowing seed rates for each crop. Plot sizes were 5 m × 1.2 m = 6 m^2, with a row spacing of 20 cm, a plot spacing of 0.5 m and a block spacing of 2 m. After excluding the border effect rows on the right and left sides of each plot, the remaining area (5 m × 0.8 m = 4 m^2) was designated as the harvest area, where observations and measurements were made. During the growing period, irrigation, hoeing and all necessary maintenance practices were carried out uniformly in all the plots. Based on soil analysis results, 10 kg/da of nitrogen and 5 kg/da of phosphorus were applied with sowing in the establishment year using urea and triple superphosphate fertilizers. Half of the nitrogen was applied in the fall with sowing and the other half was applied during the stem elongation stage of the cereals. Weed control was conducted as needed. Harvesting was performed during the full flowering stage of the grass pea. In the experiment; green forage yield (kg/da), dry matter yield (kg/da), crude protein content (%), ADF (%), NDF (%), digestible dry matter content and relative feed value (RFV) were determined according to the principles reported by Anonymous, (2019). To determine the general soil texture of the area to be sown, soil samples were taken and analyzed in the laboratory for their organic matter content, pH values, lime and salinity levels and certain plant nutrients (Table 1). The climate data for the years in which the experiment was conducted are presented (Fig 1) General Directorate of Meteorology [MGM] (2024). The data obtained from field measurements and laboratory analyses were evaluated using the LSD multiple comparison test.

RESULTS AND DISCUSSION

Green forage yields

The lowest green forage yield was determined in the pure grass pea application, while statistically significant differences were found among the green forage yield values obtained from the other applications. The average green forage yield in the first year of the study was found to be 3997 kg/da, while it was 4098 kg/da in the second year (Fig 2). Based on the two-year average yields, the lowest green forage yield was 3188 kg/da from pure grass pea and the highest green forage yield was 4584 kg/da obtained from the mixture of 20% grass pea and 80% awnless barley. Seydoşoğlu *et al.* (2015) reported the lowest green forage yield in pure sowing as 1379.50 kg/da and the highest green forage yield as 3154.17 kg/da, Büyükkılıç and Polat, (2022) found that, based on the two-year average green forage yields, the green forage yield values in pure and mixed applications ranged between 3520 kg/da and 4390 kg/da in their studies on legume and cereal mixtures.

Table 1: Chemical properties of experimental soil.

Texture	pH	$CaCO_3$ (%)	P_2O_5 (kg da^{-1})	Organic mat. (%)	Water saturation (%)
Clay	7. 63	28.1	1.56	2.02	74

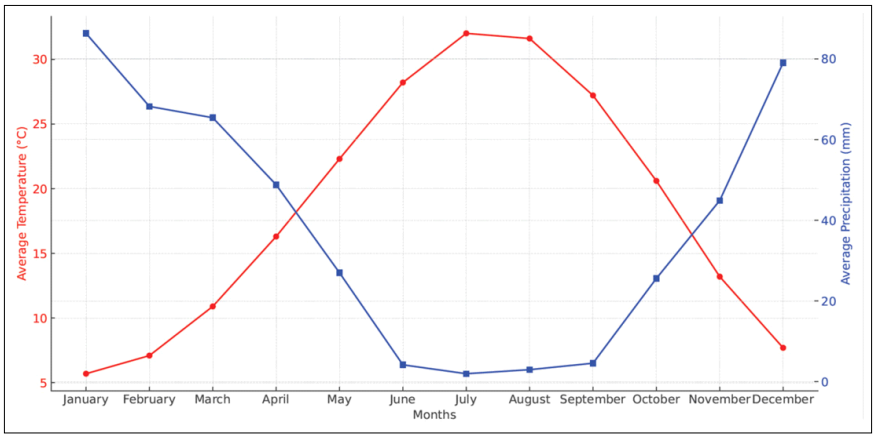


Fig 1: Sanliurfa province 1929-2024 long-term monthly average temperature and precipitation.

Dry matter yields (kg/da)

The lowest yield of 904 kg/da was obtained from pure grass pea, while the highest yield of 1338 kg/da was obtained from awnless barley (Fig 3). According to Gündüz, (2010), this is due to cereals accumulating more dry matter and having higher carbohydrate content than legumes, resulting in stronger growth. Droushiotis, (1989) stated that as the proportion of legumes in mixtures increases, dry forage yield decreases. Indeed, the lowest dry forage yield was obtained from grass pea and as the proportion of grass pea in the mixtures increased, the dry forage yield decreased. Total forage dry matter yield from intercrop treatments from 100% corn, 75:25 corn-soybean and 50:50 corn-soybean were not significantly different but further increase in soybean components progressively reduced total forage yield (Baghdadi *et al.*, 2016). The mixed cropping treatment of barley (47.5 kg ha^{-1}) and alfalfa (47.5 kg ha^{-1}) at 1:1 seed rate ratio under 75% ET0 was found to be the best mixed cropping treatment and irrigation application for high dry matter yield (Al-Menaie *et al.*, 2024).

Crude protein (%)

The lowest content was found in pure awnless barley at 15.05% and the highest content was found in pure grass pea at 23.27% (Fig 4). Based on the two-year averages, the lowest crude protein content in mixtures was 17.82% in 20% grass pea + 80% oat and the highest was 21.94% in 60% grass pea + 40% awnless barley. An increase in the proportion of grass pea in cereal mixtures resulted in an increase in protein content. Çınar, (2012) reported a crude protein content of 20.6% in his study, which aligns with our findings. Kır *et al.* (2021) found the lowest crude protein content of 10.7% in pure oat and the highest crude

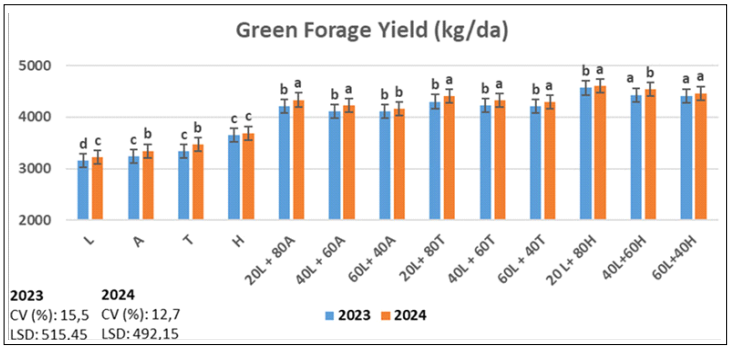


Fig 2: Effect of mixtures of grass pea and different forage grasses on green forage yield.

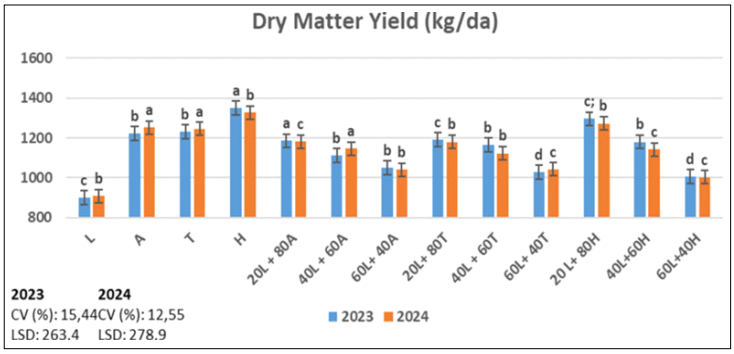


Fig 3: Effect of mixtures of grass pea and different forage grasses on dry matter yield.

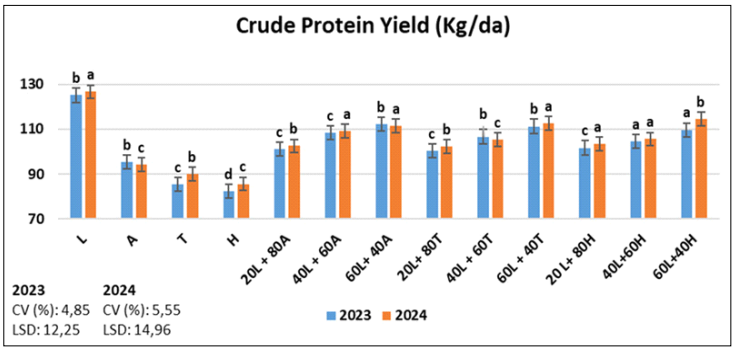


Fig 4: Effect of mixtures of grass pea and different forage grasses on crude protein yield.

protein content of 20.0% in pure grass pea, consistent with our findings that the crude protein content increased as the proportion of grass pea in the mixtures increased. The physical and textural properties of ready-to-eat cereals are influenced by the incorporation of legumes. This effect may vary depending on the protein quality and quantity, the supplementation ratio and the type of legume used in product development (Yadav and Bhatnagar, 2017).

Neutral detergent fiber (NDF, %)

According to the two-year averages, the lowest NDF ratio of 41.21% was obtained from pure grass pea, while the highest ratio of 50.43% was obtained from pure awnless barley among thirteen different applications of grass pea, awnless barley, triticale and oat sown in pure and mixed stands (Fig 5). Kır *et al.* (2021) also found the lowest NDF ratio of 39.7% from pure grass pea and the highest ratio of 53.8% from pure oat in their study. The higher proportion of cell wall components in cereals compared to legumes results in higher levels of ADF and NDF. Indeed Kavut *et al.* (2014) stated that the NDF content decreases as the proportion of grass pea increases. Özyazıcı and Açıkbaþ (2023) found that the ADF ratio ranged between 28.92% and 33.44%, the NDF ratio between 35.13% and 40.47%, RFV between 146.75 and 176.80, ratios varied between 3.14-3.48 and 0.720-0.918, respectively.

Acid detergent fiber (ADF, %)

According to the two-year averages, the highest ADF ratio of 38.91% was obtained from pure awnless barley, while the lowest ratio of 30.27% was obtained from pure grass pea among thirteen different applications of grass pea, awnless barley, triticale and oat sown in pure and mixed stands (Fig 6). Kır *et al.* (2021) found the lowest ADF ratio of 34.4% from pure grass pea and the highest ratio of 38.5% from pure oat in their grass pea mixture study. In mixtures, as the proportion of grass pea increased, the ADF ratio decreased, while the ADF ratio increased as the proportion of cereals increased. Lithourgidis *et al.* (2006) stated that the ADF ratio decreases as the proportion of legumes in mixtures increases.

Relative feed value (RFV)

In the first year of pure and mixed applications, the average RFV was 112.97, while it was 112.85 in pure oats in the second year (Fig 7). According to the two-year average RFV values in pure and mixed applications, the highest value was found in pure grass pea at 122.60 and the lowest value was found in pure oat at 104.07. Türk *et al.* (2022) reported that the relative feed value ranged between 316.7 and 668.3 in their study. Büyükkılıç and Polat, (2022) found that the highest RFV was 127.41 and the lowest was 103.53 in their study.

Digestible dry matter content (DDMC)

In the first year of pure and mixed applications, the average DDMC was 57.90, while it was 56.85 in the second year. According to the two-year average DDMC values in pure and mixed applications, the highest value was found in pure grass pea at 62.64 and the lowest value was found in

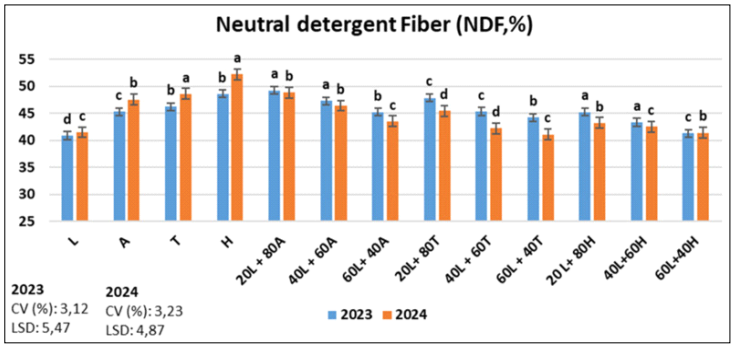


Fig 5: Effect of mixtures of grass pea and different forage grasses on neutral detergent fibre.

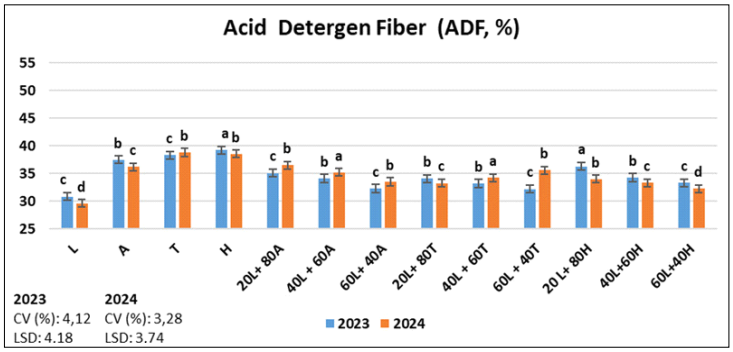


Fig 6: Effect of mixtures of grass pea and different forage grasses on acid detergent fibre content.

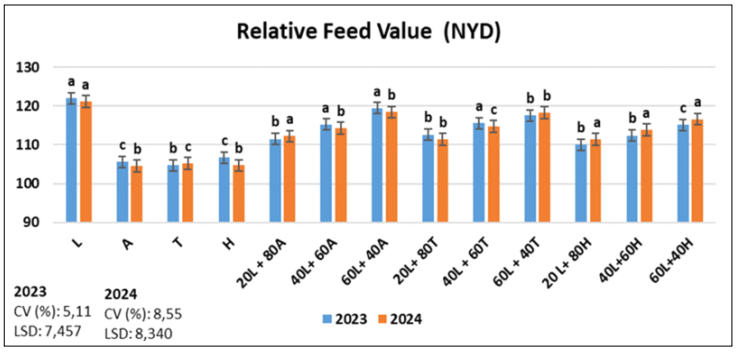


Fig 7: Effect of mixtures of grass pea and different forage grasses on relative feed value.

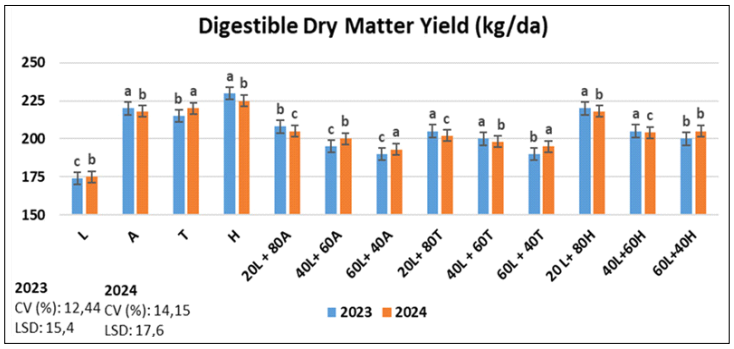


Fig 8: Effect of mixtures of grass pea and different forage grasses on digestible dry matter yield.

pure awnless barley at 53.19 (Fig 8). In the two-year average mixtures, the lowest value was 54.93 in 20% grass pea + 80% awnless barley and the highest was 59.90 in 60% grass pea + 40% oat. Büyükkılıç and Polat, (2022) found the highest value of 61.75 in pure alfalfa and the lowest value of 69.39 in pure cane hay in their study. These values are consistent with our study. Seydoşoğlu, (2020) found that the DDMC values were 59.91% in the first year of the study and 59.48% in the second year, with no significant statistical difference. The mixture ratios were statistically significant. Additionally, in vetch mixtures, increasing the proportion of legumes in the mixture resulted in a decrease in the ADF ratio, thereby increasing the DDMC values. This result is expected because legumes have higher crude protein and lower ADF and NDF content compared to cereals. ADF, due to its cellulose and lignin content, is closely related to digestibility (Kodes *et al.,* 2015, Rocateli and Zhang, 2017).

CONCLUSION

In conclusion, this study demonstrated significant differences in yield and nutritional values among different forage crops in pure and mixed sowings. These findings provide valuable insights for forage crop producers and researchers in selecting sowing strategies and crop types by following these conclusions, forage crop producers and researchers can make informed decisions to improve yield and nutritional quality, contributing to more efficient and sustainable agricultural practices.

ACKNOWLEDGEMENT

The present study is derived from the doctoral thesis of Ceyda YILDIZTEKİN.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Ethics and conflict of interest

The authors declare no ethical issue or conflict of interest.

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