

FEED QUALITY AND PRODUCTIVITY IN SOME VARIETIES OF ITALIAN RYEGRASS- *LOLIUM MULTIFLORUM* LAM.

Cristian BOSTAN^{1,2}, Dorin RECHIȚEAN¹, Christianna ISTRATE – SCHILLER¹, Nicolae Marinel HORABLAGA^{1,2,*}, Maria – Despina BORDEAN¹, Adina HORABLAGA, Natașa BOSTAN PÎNIȘOARĂ¹, Luminița COJOCARIU^{1,2}

¹University of Life Sciences „King Mihai I” from Timisoara, 119, Calea Aradului, 300645, Timisoara, Romania

²Agricultural Research and Development Station Lovrin, 307250, 200, Principala, Lovrin, Romania

*Corresponding author: hnm75@yahoo.com

Abstract. The Italian ryegrass (*Lolium multiflorum* Lam.) provide a large amount of feed per surface unit due to its high productivity. Due to its wide use, a number of varieties are found on the market, the farmer being put in the situation to choose between those varieties that best meet the needs of his own farm. In this context, the paper aims to evaluate the production capacity at anthesis and the content of feed in protein and fiber in two vegetation phenophases in three varieties of Italian ryegrass. Three varieties were used as biological material; two tetraploids (Linos and Ivan) and one diploid variety (Sprint), grown under the conditions of Agricultural Research and Development Station Lovrin, Romania. According to the research, the tetraploid varieties Linos and Ivan are more productive than the diploid variety Sprint. The Linos variety behaved the best, which in the anthesis phenophase (BBCH65) recorded a production of 92 t.ha⁻¹, with the feed containing 8.7 % protein and 36 % fiber. Regarding the protein and fiber content, the varieties analyzed are grouped according to the harvesting phase: BBCH49 and BBCH65. The highest content in the protein was found in the BBCH49 phenophase and decreased in the BBCH65 phenophase as the fiber content increased. These results can be useful for the farmer in making decisions on the choice of varieties of *Lolium multiflorum* Lam. and the harvest period.

Keywords: Italian ryegrass, tetra and diploid varieties, fresh fodder production, protein, fiber

INTRODUCTION

Lolium multiflorum Lam., is one of the most valuable forage plants, as it gives high yields with superior quality (Piskin, 2007, Li and Nishino, 2013, Abraha et al., 2015, Babu et al., 2021). It is especially used in the feeding of all herbivorous animals in different forms: fresh fodder, hay, semi-hay and silage (Moisuc et al., 1994, Choi et al., 2005) and is very well valorized, especially in dairy cow farms (Ozkul et al., 2012 ;Worku et al., 2021)

The Italian ryegrass (*Lolium multiflorum* Lam.) crop mixed with legumes allows to obtain a feed with a higher degree of consumability and digestibility (Karakurt and Ekiz, 1999, Marian et.al., 2011, Mullenix, et al., 2012, Rotar et al., 2016), with high yield per hectare (Cojocariu et al., 2008, Marian et.al, 2009, Kusvuran et al., 2014, Iuga et al., 2017) and a number of environmental advantages (Ranck et al., 2020). Rechițean et al. (2010) reports that the Italian ryegrass, cultivated in various rates, with *Trifolium incarnatum* increases the production of protein per hectare. A number of studies highlight the quality of the energy-protein feed obtained by ensiling Italian ryegrass (Lehel et al., 2011, Keles and Demirci, 2011, Baldinger et al., 2014).

In pure stands, the yield and quality of *Lolium multiflorum* Lam. feed depend mainly on =variety, environmental factors (Fang et al., 2017; Pan et al., 2018; Lin et al., 2018), technology (Moga an Schitea, 2005, Agapie et al., 2018, Hendrik et al., 2021; Suzukawa et al., 2021) and the interactions between them (Varga et al., 1998, Cojocariu et al., 2010).

The degree of rainfall is a characteristic of cultivated varieties with possible effects on yield at the annual

ryegrass (Kenworthy et al., 2016). Solomon et al (2017) shows that there are differences in yield between diploid and tetraploid varieties, so that tetraploid varieties have a higher protein content, which leads to increased digestibility of feed. Other studies show that tetraploid varieties are less tolerant to periods of water stress (Dornelles et al., 2021) but they have a high resistance to diseases.

The annual ryegrass lends itself to various technological variants, of which fertilization brings significant production increases (Wilman,1970, Eckard, 1989, Rossi et al., 1994, De Villiers and Van Ryssen, 2001, Fessehazion et al., 2014). An application of natural and synthetic biofertilizers improves the quality of feed by reducing the fiber fraction (Godlewska and Ciepiela, 2021).

Even though it is widely used for fodder, the annual ryegrass has also been identified as a weed with difficult control in other perennial or annual *Gramineae* crops (Stone et al., 1998, Sapkota et al., 2020).

The purpose of the paper is to evaluate the production capacity at anthesis and the protein and fiber content of Italian ryegrass feed, in two vegetation phenophases.

MATERIAL AND METHODS

Experimental site

The experimental field was carried out at the Lovrin Agricultural Research and Development Station, Timiș County, Romania (fig. 1), in the Banat Plain at an altitude of about 110 m. a.s.l.

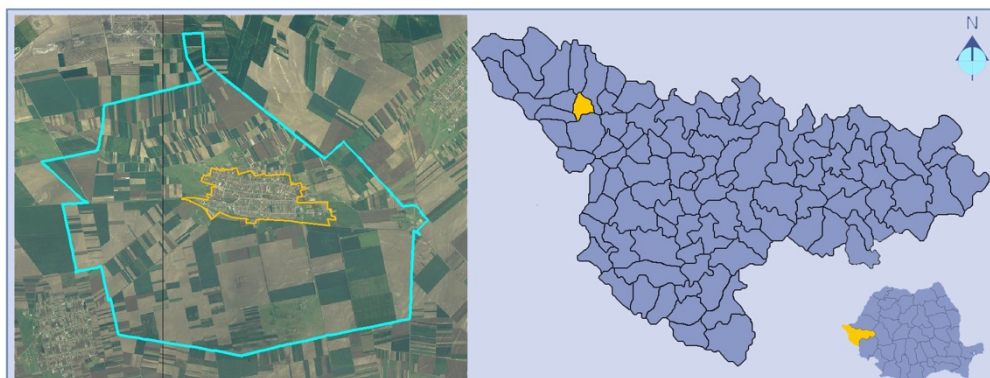


Fig. 1. Location of the study area
(processing after ANCPI, www.geo-spatial.org/, ArcGIS Documentation)

Analysis of environmental factors

The climatic data were taken from the meteorological station of ARDS Lovrin, between 2021 and 2022.

The Italian ryegrass was sown in September 2021, since September the relative humidity in the air is increasing with a maximum (99.96%) on 29.12.2021. The precipitations in September were more frequent, even if they recorded smaller quantities, being distributed as follows: in September 30.8 mm, in October 32.2 mm, in November 78.8 mm and in December 76.4 mm. Average temperatures in September were 17.30°C, lowering in October, November and December, the minimum value being 7.20°C in 13.12.2021. Climatic factors (temperature, precipitations) were favorable for the Italian ryegrass crop for the germination, its subsequent development and entry into winter.

In the early months of 2022, temperatures remain low until the end of March, after which they begin to rise. In April, during the period of maximum growth of the Italian ryegrass, the average temperature was 10.09°C against the background of well-distributed precipitation, the average month being 43.8 mm. In May the average monthly temperature was 17.96°C and the precipitation was 26.6 mm and in June the average monthly temperature was 23.25°C and the precipitation was 23.4 mm. We can say that for the first harvest of fodder, the Italian ryegrass plants had good conditions for development.

At the level of the study area, the class of cernisoles, with the type of cernozem, prevails.

Material and research methodology

As a biological material, we used three varieties of *Lolium multiflorum* L. (Zanandrea Sementi Company), respectively two tetraploid varieties Linos and Ivan and a diploid variety (Sprint) for feeding fresh fodder.

The experiment was established, according to the block method, in September 2021. The seed used for sowing was obtained a year earlier, in the same conditions at ARDS Lovrin.

The crop followed oil-seed rape crop and was fertilized with 150 kg of nitrogen active element. The distance between the rows was 12.5 cm.

For laboratory analyzes, the Italian ryegrass plants were harvested in two phenophases: When 10% of the inflorescences appeared (BBCH code 49) and at full anthesis (BBCH code 65), according to the BBCH code (Meier et al., 2009; Meier, 2018). From the mowed fresh fodder samples were taken to determine the dry matter, protein and fiber content.

The dry matter content was determined in the oven from average samples of 200 g.

The crude protein was determined with the Kjeldahl method (AOAC 1990). The crude protein (P) was calculated with the formula: $N \times 6.25$ (Simic et al., 2009, Radu et al., 2010)

The fiber content was determined using the Kjeldahl method, which involves degreasing the sample with petroleum ether, followed by treatment with sulfuric acid solution and sodium hydroxide solution, according to the standards AOAC 2003.06-2006 and ISO 6865.

Chemical analysis was determined in three replicates of 200 g.

The production of the fresh fodder was determined at the anthesis (code BBCH 65) by mowing the green mass.

Statistical evaluation of experimental results

For statistical analysis of experimental data was used: Excel 2010, Statistics 10 (free version).

RESULTS AND DISCUSSIONS

In the paper, three varieties of Italian ryegrass (Linos, Ivan and Sprint) were analyzed in terms of the vegetative mass (fresh and dry matter) at anthesis (code BBCH65) and the content in protein and fiber, with an influence on the quality of feed in two vegetative phenophases (code BBCH49 and code BBCH65).

The production of fresh fodder in the studied Italian ryegrass varieties was determined at the anthesis, according to the classical technology of harvesting with scythe for fodder. The maximum value was recorded in the Linos variety of 92 t. ha⁻¹, which also recorded the largest dry matter production, followed by the Ivan variety which generated a production of 58.50 t. ha⁻¹ fresh fodder.

In the Linos variety the protein content was 11.44 % in the BBCH49 phenophase and decreased to 8.7 % at full anthesis (BBCH65) and the fiber content ranged from 26 % (BBCH49) to 36 % at the BBCH65 phenophase.

The Ivan variety is distinguished by a protein content between 11.44 % at the BBCH49 phenophase and 8.6 % at full anthesis (BBCH65). The fiber content ranged from 26% (BBCH49) to 36% (BBCH65).

The Sprint variety with the lowest fresh fodder production is also not noticeable in terms of protein content, which was lower in both phenophases and also in fiber.

Cluster Analysis was performed using Ward's Method Algorithm and Euclidean Distances and the Corr. Coph = 0.7611 (Figure 2.).

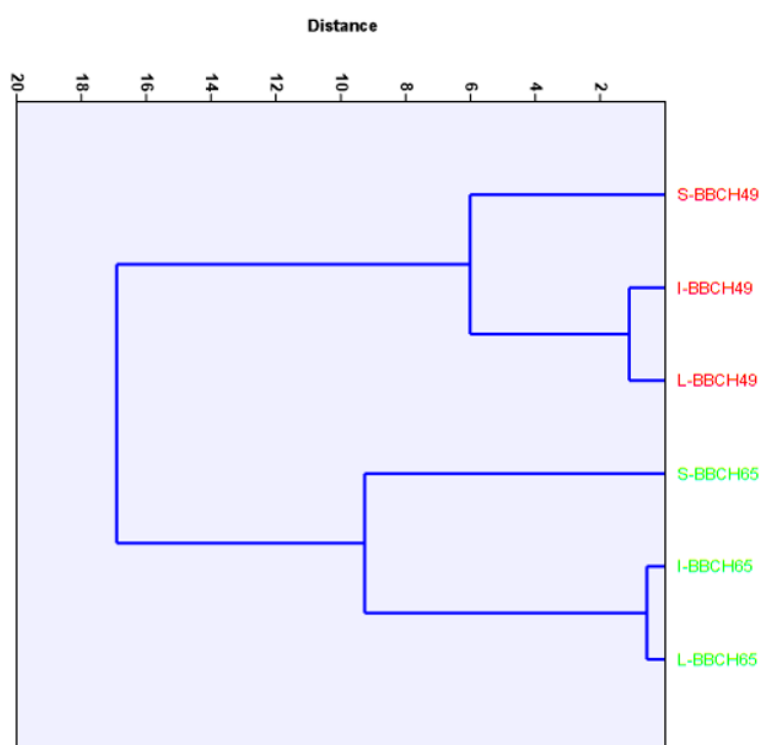


Figure 2. Cluster Analysis using Euclidean Distances for protein and fiber content

From Figure 2 it can be seen that the varieties of Italian ryegrass analyzed for protein and fiber content are grouped into two large clusters corresponding to the harvesting phenophases: BBCH49 and BBCH65. In both clusters, the Ivan and Linos varieties are grouped on the basis of similarity.

The results are consistent with a number of studies that show that younger plants have a higher content in nutritional principles (Binnie and Harrington, 1972; Filya, 2003; Coskun et al., 2014).

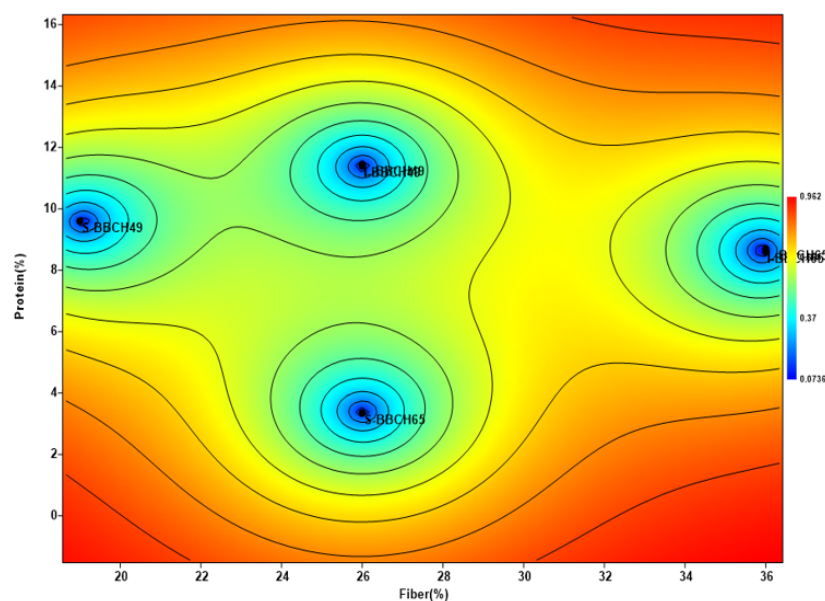


Figure 3. Spatial interpolation using Gridding Algorithm for protein and fiber content

From Figure 3 it can be seen that the results in protein and fiber content in the tetraploid varieties of Italian ryegrass Ivan and Linos overlap in both phenophases of harvest. The results are consistent with Solomon et al. (2017) research, which supports the idea that tetraploid varieties have a higher protein content.

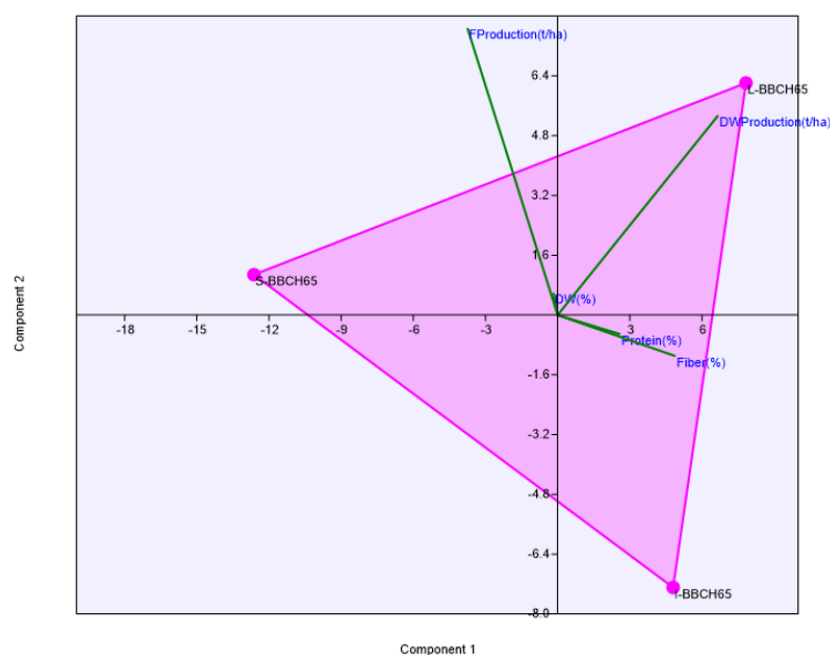


Figure 4. Principal component analysis (PCA) of *Lolium multiflorum* Lam. cultivars

The analysis of the main components shows the developed area of the analyzed parameters in the three varieties of Italian ryegrass in the anthesis phenophase (Figure 4). In the Ivan variety (I-BBCH65) are included traits associated with protein and fiber content, and in the Linos variety associations between dry matter percentage and dry matter production.

A number of studies, conducted in different pedoclimatic areas, point out that genotype and complex interactions with other factors (environment, fertilization etc.) have a decisive influence on the yield of annual ryegrass (Iacob et al., 2000, Van der Colf et al., 2015; Rios et al., 2019; Charné et al., 2020).

CONCLUSIONS

Following the research carried out, the idea that the Italian ryegrass can be successfully cultivated in the Banat Plain in Romania is drawn.

The Linos and Ivan tetraploid varieties are more productive than the Sprint diploid variety. The Linos variety was best behaved, which in the anthesis phenophase (BBCH65) recorded a production of 92 t.ha⁻¹, with the feed containing 8.7 % protein and 36 % fiber.

The results obtained in the analyzed Italian ryegrass varieties in terms of protein and fiber content are grouped according to the harvesting phase: BBCH49 and BBCH65. The highest content in the protein was found in the BBCH49 phenophase and decreased in the BBCH65 phenophase as the fiber content increased.

These results can be useful to the farmer in choosing the varieties and the harvest period.

ACKNOWLEDGMENTS

The authors thank SCDA Lovrin resort for facilitating the conduct of this study.

REFERENCES

1. Abraha A.B., Truter W.F., Annandale J.G., Fessehazion M.K. - Forage yield and quality response of annual ryegrass (*Lolium multiflorum*) to different water and nitrogen levels, African Journal of Range & Forage Science, 2015, 32:2, 125-131, DOI: 10.2989/10220119.2015.1056228.
2. Agapie A., Horablaga M., Suba D., Suba T. – Influence of the long-term fertilization on the wheat yield, in period 1996 - 2018, at ARDS Lovrin, “Ion Ionescu de la Brad” University of Agricultural Sciences and Veterinary Medicine, 2018, Iași.
3. Agenția Națională de Cadastru și Publicitate Imobiliară (ANCPPI) – baza de date geospațiale, online: <https://geoportal.ancpi.ro/portal/home/>.
4. AOAC (1990) Protein (Crude) Determination in Animal Feed: Copper Catalyst Kjeldahl Method 984.13. 15th Edition, Official Methods of Analysis of AOAC International, Gaithersburg.
5. AOAC 2003.06-2006 Crude Fat in Feeds, Cereal Grains, and Forages - Randall/Soxtec/Hexanes Extraction-Submersion Method, Pages 26.
6. ArcGIS Documentation - <https://desktop.arcgis.com/en/documentation/>.
7. Babu A., Tóthi R., Orosz, S., Fébel H., Kacsala L., Vermeire D., Tóth T. - Novel mixtures of Italian ryegrass and winter cereals: influence of ensiling on nutritional composition, fermentation characteristics, microbial counts and ruminal degradability. Italian Journal of Animal Science. 2021, 20. 749-761. 10.1080/1828051X.2021.1924883.
8. Baldinger L., Zollitsch W., Knaus W.F. - Maize silage and Italian ryegrass silage as high energy forages in organic dairy cow diets: differences in feed intake, milk yield and quality, and nitrogen efficiency. Renew Agric Food Syst. 2014, 29(4), pp. 378–387.
9. Binnie, R.C., Harrington, F.J. - The effect of cutting height and cutting frequency on the productivity of an Italian ryegrass sward. Grass and Forage Science, 1972, 27, pp. 177-182. <https://doi.org/10.1111/j.1365-2494.1972.tb00706.x>.
10. Catalogo-zanandrea-sementi-en.pdf. <http://www.zanandreasementi.it/wp-content/uploads/2018/03/catalogo-zanandrea-sementi-en.pdf>.
11. Charné V., Van der Colf J., Swanepoel P.A. - Benefits Are Limited with High Nitrogen Fertiliser Rates in Kikuyu-Ryegrass Pasture Systems, Land, 2020, 9:6, pages 173.
12. Choi G.J., Rim Y.W., Sung B.R., Lim Y.C., Kim M.J., Kim K.Y., Park G.J., Park N.G., Hong Y.K., Kim S.R. - Growth characters and productivity of Italian ryegrass (*Lolium multiflorum* L.) new variety "Hwasan 104". J.Korean Grassl. Sci. 2005, 25(4), pp. 275-280.
13. Cojocariu L., Moisuc A., Radu F., Marian F., Horablaga M., Bostan C. - Qualitative changes in the fodder obtained from forage legumes and *Lolium multiflorum* in the ecological conditions of Eastern Europe, Options Méditerranéennes, 2008, pp. 167-171.
14. Cojocariu L., Moisuc A., Samfira I., Horablaga M., Radu F., Lalescu D.V. – The study of the main production characters depending on dose of cattle manure applied to Italian Ryegrass, Research Journal of Agricultural Science, 2010, 42 (1), pp. 390 – 397.
15. Coskun B., Keles G., Inal F., Alatas S.M., Ates S. - Dry matter production and nutritive value of cereal species harvested at boot or dough stage of maturity. Scientific Papers. Series D. Animal Science, 2014, Vol. LVII, ISSN 2285-5761, pp. 85-89.
16. De Villiers J.F., Van Ryssen J.B.J. - Performance responses of lambs of various ages to Italian ryegrass (*Lolium multiflorum*) fertilized with various levels of nitrogen, South African Journal of Animal Science, 2001, Vol 31, Issue 3, pp. 142-148.
17. Renata da Rosa Dornelles R.R., Comassetto D., Faleiro E.A., Pinto A.G., Barreto M.T., Rodrigues C.R., Del Valle T.A., Azevedo E.B. - Forage production, morphological, and chemical composition of diploid and tetraploid cultivars of Italian ryegrass in hydromorphic soils, New Zealand Journal of Agricultural Research, 2022, 65, pp. 4-5, 365-378, DOI: 10.1080/00288233.2021.1980058.
18. Eckard, R.J. - The response of Italian ryegrass to applied nitrogen content in the Natal Midlands. J.Grassl. Soc. South Afr. 1989, 6, pp. 19 - 22.

19. Fang, Z. G., Hu, Z. Y., Zhao, H. H., Yang, L., Ding, C. L., Lou, L. Q., et al. - Screening for cadmium tolerance of 21 cultivars from Italian ryegrass (*Lolium multiflorum* Lam.) during germination. Grass. Sci. 2017, 63, 36–45. doi: 10.1111/grs.12138.
20. Fessehazion M.K., Annandale J.G., Everson C.S., Stirzaker R.J., Tesfamariam E.H. - Evaluating of soil water balance (SWB-Sci) model for water and nitrogen interactions in pasture: Example using annual ryegrass. Agricultural Water Management, 2014, 146, pp. 238-248.
21. Filya I. - Nutritive value of whole crop wheat silage harvested at three stages of maturity. Animal Feed Science and Technology, 2003, 103, pp. 85-95.
22. Godlewska A, Ciepiela GA. - Italian Ryegrass (*Lolium multiflorum* Lam.) Fiber Fraction Content and Dry Matter Digestibility Following Biostimulant Application against the Background of Varied Nitrogen Regime. Agronomy. 2021; 11(1), pp. 39. <https://doi.org/10.3390/agronomy11010039>.
23. Hendrik P., Smit J., Reinsch T., Kluß C., Loges R., Taube F. - Very Low Nitrogen Leaching in Grazed Ley-Arable-Systems in Northwest Europe. Agronomy 2021, 11:11, pp: 2155.
24. Iacob A., Vântu V., Samuil C. – Tehnologia producerii și conservării furajelor, Ed. Ion Ionescu de la Brad, Iași, 2000
25. ISO/TC 34/SC 10, Animal feeding stuffs, Edition: 1, <https://www.iso.org/standard/13377.html>.
26. Iuga V., Rotar I., Mălinaș A. - Some aspects concerning intra and interspecific competition and the food space requirements for Red clover and Italian ryegrass, Romanian Journal of Grassland and Forage Crops, 2017, Vol.15, 39-44.
27. Karakurt, E., Ekiz, H. - The effect of mixture of Alexandria trifolium (*Trifolium alexandrinum* L.) and grass (*Lolium multiflorum* Lam.) on herbage yield, Ankara University, Faculty of Agriculture, 1999, (44), pp. 97-104.
28. Keles G., Demirci U. - The effect of homofermentative and heterofermentative lactic acid bacteria on conservation characteristics of baled triticale-Hungarian vetch silage and lamb performance. Animal Feed Science and Technology, 2011, 164, pp. 21-28.
29. Kenworthy K., Reith P., Prine, G., Blount A., Quesenberry K. - Registration of ‘FL Red’, a Later-Maturing Tetraploid Annual Ryegrass. Journal of Plant Registrations. 2016, 11. 10.3198/jpr2016.02.0009cre.
30. Kusvuran A., Kaplan M., Nazlı R.İ. - Effects of ratio and row spacing in hungarian vetch (*Vicia pannonica* Crantz.) and annual ryegrass (*Lolium multiflorum* Lam.) intercropping system on yield and quality under semi arid climate conditions, Turkish Journal of Field Crops, 2014, 19(1), pp. 118-128.
31. Lehel L., Orosz S., Tóthné Polner A., Sümeghy L., Hajda Z., Sipiczki B., Várhegyi J., Fébel H. - The rye grass silage apparent digestibility, rumen protein degradability, content of metabolizable protein and net energy. AWETH, 2011, 7, pp.149–157.
32. Li Y., Nishino N. - Effects of ensiling fermentation and aerobic deterioration on the bacterial community in Italian ryegrass, Guinea grass, and whole-crop maize silages stored at high moisture content. Asian Australas J Anim Sci. 2013, 26(9), pp.1304–1312.
33. Lin J., Hua X., Peng X., Dong B., Yan X. - Germination Responses of Ryegrass (Annual vs. Perennial) Seed to the Interactive Effects of Temperature and Salt-Alkali Stress. Front. Plant Sci. 2018, 9:1458. doi: 10.3389/fpls.2018.01458.
34. Marian F., Moisuc A., Cojocariu L., Horablaga M. - The effect of Italian ryegrass and crimson clover mixture on the production capacity in Timisoara condition, Research Journal of Agricultural Science, 2009, vol.41(1), pp. 185-188.
35. Marian F., Moisuc A., Cojocariu L., Lalescu D., Horablaga M., Grosz D., Jurmescu I. - Optimization of the dry matter production based on the percentage participation of Italian ryegrass in mixtures with Crimson clover, Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 2011, vol. 68 (1), pp. 201-206.
36. Meier U., Bleiholder H., Buhr L., Feller C., Hack H., Heß M., Lancashire P., Schnock U., Stauß R., Boom T., Weber E., Zwerger P. - The BBCH system to coding the phenological growth stages of plants-history and publications. Journal für Kulturpflanzen. 61., 2009, pp. 41-52. 10.5073/JfK.2009.02.01.
37. Meier U. - Growth stages of mono- and dicotyledonous plants: BBCH Monograph. Quedlinburg: Open Agrar Repositorium, 2018, DOI 10.5073/20180906-074619.
38. Moga I., Schitea M. – Tehnologii moderne de producere a semințelor la plantele furajere, Editura Ceres București, 2005.
39. Moisuc A., Breazu L., Samfira I. - Lucrări practice „Cultura pajiștilor și a plantelor furajere”, Editura Euroart, 1994.
40. Mullenix, M.K. & Bungenstab, E.J. & Lin, John & Gamble, B.E.. - CASE STUDY: Productivity, quality characteristics, and beef cattle performance from cool-season annual forage mixtures. The Professional Animal Scientist, 2012, 28, pp. 379-386. 10.15232/S1080-7446(15)30371-5.
41. Ozkul H., Kirkpinar F., Tan K. - The use of Caramba (*Lolium multiflorum* cv.Caramba) grass in ruminant feeding, Animal Production, 2012, 53(1), pp. 21-26.

42. Pan L., Meng C., Wang J., Ma X., Fan X., Yang Z., Zhou M., Zhang X. - Integrated omics data of two annual ryegrass (*Lolium multiflorum* L.) genotypes reveals core metabolic processes under drought stress. BMC Plant Biol. 2018, 18(1), pp. 26. doi: 10.1186/s12870-018-1239-z.
43. Piskin M. - Effects of different seed amounts on yield and some yield components of perennial grass (*Lolium multiflorum* Lam). – Master Thesis. Selcuk University, 2007: Graduate School of Natural and Applied Sciences, Konya.
44. Radu F., Ahmadi M., Cojocariu L., Marian F., Bostan C., Boroza A. - Genotype-biostimulations interactions in some high quality active principles appearance for alfalfa, Research Journal of Agricultural Science, 2010, 42 (1), pp 526-530.
45. Ranck E.J., Holden L.A., Dillon J.A., Rotz C.A., Soder K.J. - Economic and environmental effects of double cropping winter annuals and corn using the integrated farm system model. J Dairy Sci. 2020, 103(4):3804–3815.
46. România – Seturi de date geospațiale generale; date vectoriale – <http://www.geo-spatial.org/download/romania-seturi-vectoriale>.
47. Rechițean D., Dragoș M., Dragomir N., Horablaga M., Sauer M., Camen D., Toth I., Sala A. - Associated Culture of Italian Ryegrass (*Lolium multiflorum*) and Crimson Clover (*Trifolium incarnatum*) under Nitrogen Fertilization, Scientific Papers: Animal Science & Biotechnologies, 2018, Vol.51(1), pp. 130-132.
48. Rios E., Kenworthy K., Gezan S., Munoz del Valle P.. Genetic parameters for phenotypic traits in annual ryegrass (*Lolium Multiflorum* Lamarck). Crop Science. 2019, 59. 10.2135/cropsci2019.02.0126.
49. Rossi E.M., Gutierrez L.M., Moreno E., Mazzanti A. - Nitrogen fertilizer effects upon silage composition and quality of *Lolium multiflorum* L.CC, 1994, 276 (7620) Argentina.
50. Rotar I., Vidican R., Păcurar F., Mălinaș A., Vaida I., Deac V. - A Forage Mixture with Red Clover in the Fourth Experimental Year, Bulletin UASMV, 2016, Vol 73/2, 324.
51. Sapkota B, Singh V, Neely C, Rajan N, Bagavathiannan M. - Detection of Italian Ryegrass in Wheat and Prediction of Competitive Interactions Using Remote-Sensing and Machine-Learning Techniques. Remote Sensing. 2020; 12(18), pp. 2977. <https://doi.org/10.3390/rs12182977>.
52. Simic A., Vucković S., Kresović M., Vrbničanin S., Božić D. - Changes of crude protein content in ryegrass influenced by spring nitrogen application, Biotechnology in Animal Husbandry, 2009, 25(5-6), pp. 1171-1179.
53. Solomon, J., Macoon B., Lang D., Vann R., Ward, S. - Animal and forage responses on Maximus, a tetraploid cultivar vs Marshall, a diploid cultivar of annual ryegrass. Grass and Forage Science, 2017, 73. 10.1111/gfs.12331.
54. STATISTICA 10 (free version) – https://software.informer.com/go/g.php?go=https%3A%2F%2Fen.freedownloadmanager.org%2Fuserschoice%2FFree_Download_Statistica_10_Program.html&hs=2329911785&oe14sa&sid=1006&q=Statistica%2010%20download%20full%20version.
55. Stone, M.J., Cralle H.T., Chandler J.M., Miller T.D., Bovey R.W., Carson K.H. - Above-and belowground interference of wheat (*Triticum aestivum*) by Italian ryegrass (*Lolium multiflorum*). Weed Sci. 1998, 46, pp. 438–441.
56. Suzukawa A.K., Bobadilla L.K., Mallory-Smith C., Brunharo CACG - Non-target-Site Resistance in *Lolium* spp. Globally: A Review. Front Plant Sci. 2021 Jan 22;11:609209. doi: 10.3389/fpls.2020.609209.
57. Van der Colf J., Botha P.R., Meeske R., Wayne W., Truter F. - Seasonal dry matter production, botanical composition and forage quality of kikuyu over-sown with annual or perennial ryegrass, African Journal of Range & Forage Science, 2015, 32:2, pp. 133-142, DOI: 10.2989/10220119.2015.1018945.
58. Varga P., Moisuc A., Savatti M., Schitea M., Olaru C., Dragomir N., Savatti M.Jr. – Ameliorarea plantelor furajere și producerea semințelor, Ed. Lumina Drobeta Turnu – Severin, 1998.
59. Wilman D. - The effect of nitrogenous fertilizer on the rate of growth of Italian ryegrass. Growth up to ten weeks. J. Br. Grassld. Soc. 1970, 25, 242 – 245.
60. Worku A., Tóthi R., Orosz S., Fébel H., Kacsala L., Vermeire D., Tóth T. - Novel mixtures of Italian ryegrass and winter cereals: influence of ensiling on nutritional composition, fermentation characteristics, microbial counts and ruminal degradability, Italian Journal of Animal Science, 2021, 20:1, pp. 749-761, DOI: 10.1080/1828051X.2021.1924883.