Original Article

# YIELD, STRUCTURAL COMPOSITION AND NUTRITIVE CHARACTERISTICS OF RYEGRASS CULTIVARS USED TO HAYMAKING IN LOWLAND SOILS

## *RENDIMENTO, COMPOSIÇÃO ESTRUTURAL E CARACTERÍSTICAS NUTRITIVAS DE CULTIVARES DE AZEVÉM UTILIZADAS PARA FENAÇÃO EM SOLOS DE VÁRZEA*

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**ABSTRACT:** This research aimed to evaluate the dry matter yield, structural composition and nutritive characteristics of diploid and tetraploid annual ryegrass cultivars on different phenological development to haymaking on lowland soils. The experimental design was developed based on randomized blocks with split plots, four cultivars of annual ryegrass (BRS Ponteio and FEPAGRO São Gabriel, diploid; INIA Escorpio and KLM 138, tetraploid), and three phenological crop phases (vegetative, pre-blossoming and blossoming). Were evaluated, dry matter yield, leaf:stem ratio, leaf weight ratio, tiller population density, specific leaf area, crude protein, neutral detergent fiber, and acid detergent fiber. All data were submitted to analysis of variance and the means were compared by Tukey-Kramer test ($p \leq 0,05$). Highest forage mass is obtained with harvest in blossoming stage. Tetraploid cultivars present better leaf proportion and higher content of crude protein during vegetative stage. The decrease the in concentration of protein with the change of phenological stage is less evident on diploid cultivars. The vegetative stage enables harvest forage with high nutritional value, with lower production of biomass.

**KEYWORDS:** *Lolium spp*. Hay. Phenological stages. Ploidy

## INTRODUCTION

The italian ryegrass (*Lolium multiflorum*, L.) is the most widely grown forage species for grazing in Southern Brazil. This fact is due its wide adaptation to soil and weather conditions, high capacity regrowth, and forage production, as well as dry matter with a view to permanence of straw for direct sowing crops in succession (PEDROSO et al.; 2004; SILVA et al.; 2011).

Characteristics that also make it a target species for use as grass and conserved fodder and are interesting option for silage process and haymaking. As it presents a high leaf: stem ratio and thin stem (OLIVEIRA et al.; 2015), the mown of ryegrass mass has high dehydration rate by favoring it, which has short drying time on pitch and few turns required for hay cure, which makes the loss smaller sheets and nutrients (PEREIRA; REIS, 2001).

Given those characteristics, recently new genotypes of ryegrass have been introduced in Brazil, attracting attention by a high dry matter yield, nutritional quality, differentiated growth cycles and higher number of defoliation (FLORES et al.; 2008; GILLILAND et al.; 2007; DORS et al.; 2010; OLIVEIRA et al.; 2015). However, there are few studies on productivity and quality of these new materials in the ecosystems of the state of Rio Grande do Sul, at lowland soils.

Therefore, the objective of this study was to evaluate the agronomic characteristics of ryegrass cultivars grown at lowland soils (hydromorphic), harvested at different growth stages, for the production of hay.

## MATERIAL AND METHODS

The experiment was conducted in the experimental field of Centro Agropecuário da Palma- UFPEL, in partnership with the Empresa Brasileira de Pesquisa Agropecuária (Embrapa Clima Temperado – Estação Terras Baixas). The soil is classified as Solodic Eutrophic Haplic Planosol, belonging to Pelotas mapping unit (STRECK, 2008). With wet subtropical climate (Cfa), according to Köppen classification. The sowing was in 05/12$^{th}$/2012, by density of 25 $kg.ha^{-1}$ of pure viable seeds. The soil was properly prepared with plowing and disking, limed and fertilized as



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recommended by the Official Network of Soil and Vegetable Tissue Analysis Laboratories of the Rio Grande do Sul e Santa Catarina States (ROLAS) to winter fodder, following the analysis of ground.

The experimental design was a randomized complete block in a split plot, with four repetitions. The cultivars of annual ryegrass (*Lolium multiflorum*) BRS Ponteio (diploid), FEPAGRO São Gabriel (diploid), INIA Escorpio (tetraploid) e KLM 138 (tetraploid), allocated on the plots, and the phenological phases: vegetative, pre-blossoming, and blossoming on the subplots. The subplot area was 66,6 m². After pasture establishment, when the canopy reached an average height of 20 cm, a cut was made to standardize the experimental area. When the plants reached again height of 20 cm was held court for making hay in vegetative stage. The other subplots were not cut. At the time, the plants come into pre- blossoming (20% of inflorescence emergence) was held cut for the preparation of hay on the subplots of phase. Likewise, when the remaining subplots entered blossoming (20% of spikelets formed with grains) was taken harvest of this material to haymaking. All cuts were made to 7 cm up ground (OLIVEIRA et al.; 2014). The uniformity cut took place on 09/05$^{th}$/2012. The cut of vegetative phase took place on 09/25$^{th}$/2012 for all cultivars. Cuts were performed in subsequent diploid cultivars in 16 October (pre-blossoming) and 31 October (blossoming) and the tetraploid in 11/20$^{th}$ and 12/04$^{th}$/2012, pre-blossoming and blossoming, respectively.

Preceding each cut, on square of 0,04 m$^2$, samples were collected for the tiller count and separation of fodder structural components. These components were shared into leaves, stem (stem + sheath + inflorescence) and dead material. It was determined the leaf area through the leaf area integrator Liquor LI2600. Based on these results was calculated as Oliveira et al. (2014) the specific leaf area.

Samples for obtaining the dry matter (DM) 0,25 m² were cut, and the structural components, weighed and brought to the air circulating oven at 55°C for 72 hours, together with the structural components. Thus informations, were assessed the harvested dry matter yield (DMY), leaf:stem ratio - L:S (DM leaves/DM stem), tiller population density (tillers/m$^2$), leaf weight rate - LWR (DM leaves/DM total), and specific leaf area - SLA (leaf area/DM leaves).

The dried samples were ground (1 mm screen) for bromatological analysis. Total nitrogen content (N) was determined by the Kjeldahl method (method 984.13, AOAC, 1995). From the levels of nitrogen were calculated the crude protein content (CP) by the correction factor CP= N*62,5. The neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents were determined using autoclave (SENGER et al.; 2008).

The data were submitted to PROC MIXED (mixed models) and the variables means were compared by the Tukey-Kramer test, (SAS/STAT® 13.1 USER'S GUIDE, 2013). Were used the maximum likelihood method (REML), which is an array of variances and covariance that best fits the data, using the corrected Akaike value (AICc) (LITTEL et al.; 2006). The SAS University Edition was used.

## RESULTS AND DISCUSSION

According to the criteria adopted for the structures of variances to cultivar, stage and interaction between them, it is observed that only DMY and L:S were not influenced by the effect of the interaction (Table 1), presented significant difference for the cultivar and developmental stage factors. The other variables had a highly significant effect on the cultivar*stage interaction.

**Table 1:** P-values of the studies variables.

| Variables | Cultivar | Stage | Cultivar*Stage |
|---|---|---|---|
| DMY | 0,0059 | <0,0001 | 0,2809 |
| L:S | <0,0001 | <0,0001 | 0,0529 |
| Tillers | <0,0001 | <0,0001 | <0,0001 |
| LWR | 0,0030 | <0,0001 | <0,0001 |
| SLA | 0,5550 | 0,0006 | <0,0001 |
| CP | 0,0157 | <0,0001 | <0,0001 |
| NDF | 0,0711 | <0,0001 | 0,0008 |
| ADF | 0,0420 | <0,0001 | 0,0047 |

DMY=Dry matter yield; L:S=Leaf:stem ratio; Tillers= Tiller population density; LWR= leaf weight ratio; SLA= specific leaf area; CP= crude protein; NDF= insoluble fiber in neutral detergent; ADF= insoluble fiber in acid detergent.

Among the cultivars, the highest DMY was observed in BRS Ponteio, which did not differ FEPAGRO São Gabriel (Table 2), however, these cultivars showed a decreased between L:S (Table 2). The ploidy influenced these results, considering that the diploid cultivars had higher yield dry matter with smaller mass of leaves than tetraploid cultivars. Taking into account the characteristics of plants, tetraploid cultivars have larger leaves and fewer stems compared to diploid (SUGIYAMA, 2006), which is reflected in higher relationships between L:S, as also observed by Rocha et al. (2007) and Oliveira et al. (2015).

DMY results of this study are lower than those presented by Flores et al. (2008) that found 5.1 tons DM.ha$^{-1}$ of production with 5 cuts, to ryegrass cv. Comum RS. However, it should be acknowledged that on this research, the objective was to haying, was evaluated only the production of the respective cut for this purpose.

**Table 2.** Harvested dry matter yield and leaf:stem ratio of ryegrass cultivars in different growth stages.

| | Phenological stages | Ryegrass cultivars | | | | |
|---|---|---|---|---|---|---|
| | | INIA Escorpio | KLM 138 | FEPAGRO São Gabriel | BRS Ponteio | Mean |
| Dry Matter Yield (g.kg$^{-1}$ DM)* | Vegetative | 1118,0 | 1266,3 | 1215,3 | 1177,7 | 1194,3 c |
| | Pre-Blossoming | 1704,0 | 1809,5 | 2730,5 | 2776,5 | 2255,1 b |
| | Blossoming | 2173,5 | 2803,0 | 3322,0 | 3651,0 | 2987,4 a |
| | Mean | 1665,2 b | 1959,6 ab | 2422,6 a | 2535,05 a | - |
| Leaf:Stem ratio | Vegetative | 1,77 | 1,93 | 0,69 | 0,61 | 1,25 a |
| | Pre-Blossoming | 1,31 | 1,24 | 0,32 | 0,42 | 0,82 b |
| | Blossoming | 0,17 | 0,18 | 0,07 | 0,12 | 0,13 c |
| | Mean | 1,08 a | 1,12 a | 0,36 b | 0,38 b | - |

Means followed by the same lower case letter in the row and column do not differ significantly among themselves by Tukey-Kramer test ($p \leq 0,05$); CV: DMY=25,62%; L:S=61,82%; SEM for cultivar: DMY= 257.23; L:S=0,176; SEM for stages: DMY=158,7, L:S=0,114.

Tonetto et al. (2011) increasing the number of cuts results in higher forage production. Thus, it is assumed that any of the cultivars are more susceptible to increased production with increased number of cuts.

Among the phenological stages, have occurred superiority of the DMY at the blossoming over others (Table 2), as a result of natural accumulation of dry matter from both, growth, and development of plants. Thus, the mass obtained from cutting on vegetative was composed primarily of leaves while at the pre-blossoming, per inflorescence and stems expanding. Meanwhile, when obtained on blossoming, the total dry mass was formed primarily per reproductive structures and grain in filling process. The most DMY were in pre-blossoming, follow by lower ratio L:S (Table 2) came from the internode lengthening that normally occurs from beginning of reproductive phase. The decrease of almost 90% of the ratio L:S from vegetative to blossoming reflects on significant drop in nutritional forage quality with the phenological development.

The plant nutritional value tends to decrease with maturity progress, when changes occur that result in high levels of structural compounds, such as cellulose, hemicellulose, and lignin, while simultaneously reduce the cellular content (MINSON, 1990; PEREIRA; REIS, 2001; VAN SOEST, 1994). Usually, emerging pastures, despite the high quality, are linked to low forage yield. Therefore, pastures at advanced development phase have increased production for lower CP and higher levels of NDF and ADF resulting low relation L:S, a greater proportion of structural tissues as plant components.

Three cultivars showed higher tiller values on vegetative compared to the other stages (Table 3). The change in tillers number occurred from the pre-blossoming stage. Only the FEPAGRO São Gabriel cultivar presented no significant variation in the tiller population density between plant development, demonstrating adaptability to cultivation conditions mentioned above, but with low proportion of leaves. The high mortality of tillers observed in tetraploid cultivars on pre-blossoming, can be explained mainly by the high density of leaves that these cultivars had on vegetative, which probably led to excessive shading the lower part of the canopy, causing the death of smaller tillers.

**Table 3.** Tiller population density, leaf weight ratio and specific leaf area of ryegrass cultivars in different phenological stages.

| | Phenological Stage | Ryegrass Cultivar | | | |
|---|---|---|---|---|---|
| | | INIA Escorpio | KLM 138 | FEPAGRO São Gabriel | BRS Ponteio |
| Number of Tillers.m-2* | Vegetative | 2912,5 Aa | 3185,4 Aa | 2662,5 Ba | 3162,5 Aa |
| | Pre-Blossoming | 703,1 Bb | 721,9 Bb | 2237,5 Aa | 1675,0 Bb |
| | Blossoming | 975,0 Bb | 1018,7 Bb | 2087,5 Aa | 1712,5 ABb |
| LWR** | Vegetative | 0,54 Aa | 0,55 Aa | 0,35 Ba | 0,32 Ba |
| | Pre-Blossoming | 0,18 Ab | 0,17 Ab | 0,21 Ab | 0,25 Aa |
| | Blossoming | 0,06 Ac | 0,06 Ac | 0,06 Ac | 0,07 Ab |
| SLA ($cm^2.g^{-1}$) *** | Vegetative | 166,32 Aa | 91,78 ABb | 54,58 Bc | 154,06 Aa |
| | Pre-Blossoming | 124,16 BCa | 61,68 Cb | 250,49 Aa | 162,13 Ba |
| | Blossoming | 130,20 Ba | 305,56 Aa | 158,82 Bb | 200,82 Ba |

Means followed by the same lower case letter in the column and capital letters on the line do not differ significantly from each other by the Tukey-Kramer test ($p \leq 0,05$). *CV=14,09%, SEM =177,81; ** CV=17,6%, SEM=0,03; *** CV=37,76%; SEM=27,22.

LWR for all cultivars showed higher values in vegetative, decreasing on subsequent development stages (Table 3). On vegetative, the tetraploid cultivars showed higher values of LWR, but it was not repeated in the pre-blossoming and blossoming, phases, when differences had not been noticed.

The attention of the assay of LWR in crops for haymaking is directly related to plant capacity to be dehydrated. According Pereira and Reis (2001) the leaves of the grasses lose water 15 times faster than the stems. However, 25% of the moisture of the stems is lost through of the leaves. These authors describe that, vegetative tillers (80% of leaves) drying in 1/3 the time required by those who are in stage pre-blossoming (40% of the leaves). After the pre-blossoming, the plant dehydration rate is fast, due to the lower water content of plants and exposing the rods. As the lower internodes elongation and high proportion of leaves presented by tetraploid cultivars (ROCHA et al.; 2007), these tend to show greater facility for water loss by high proportion of leaves (LWR). However, the high content of leaves may prolong the time of dehydration due to reabsorption of water, especially if the weather conditions are not optimal for cutting and drying into of hay mass, especially at soil of low drainage and in cold season, where humidity tends to be higher.

The cultivars BRS Ponteio and INIA Escorpio presented higher values of SLA on the vegetative, which was not maintained in subsequent stages (Table 3). This cultivar showed a similar mean in the three growth stages, and does not demonstrated variation of SLA with the advancement of the productive cycle. SLA differences between species can occur as a genetic trait of the plant, possibly indicating greater or lesser ability to survive in shaded environments (BERLYN; CHO, 2000; OLIVEIRA et al.; 2014). The SLA may also be considered a marker of response to soil fertility, in which, high SLA levels are related to high soil fertility and low SLA indexes with low fertility (WRIGHT et al.; 2005).

For crude protein, higher contents were found in cultivars INIA Escorpio and KLM 138 on vegetative, probably as a result of the higher leaf proportion of these cultivars demonstrated, since the sheet fraction is usually the most nutritious part of fodder. On pre-blossoming, the cultivar FEPAGRO São Gabriel was superior when compared to the INIA Escorpio, keeping the crude protein content similar to vegetative (Table 4). It is important to mention that, despite the reduction of CP observed in pre-blossoming stage in most cultivars, the importance of this decreased was less on the cultivar BRS Ponteio (26,3%) than cultivars INIA Escorpio and KLM 138 (54,16% e 42,1% respectively).

**Table 4.** Crude protein, insoluble fiber in neutral detergent and acid detergent, of ryegrass cultivars in different phenological stages.

| | Phenological Stage | Ryegrass Cultivar | | | |
|---|---|---|---|---|---|
| | | INIA Escorpio | KLM 138 | FEPAGRO São Gabriel | BRS Ponteio |
| CP ($g.kg^{-1}$ DM)* | Vegetative | 171,5 Aa | 169,2 Aa | 135,9 Ba | 133,7 Ba |
| | Pre-Blossoming | 78,6 Bb | 98,0 ABb | 121,1 Aa | 98,5 ABb |
| | Blossoming | 74,3 Ab | 94,7 Ab | 75,8 Ab | 76,8 Ab |
| NDF ($g.kg^{-1}$ DM)** | Vegetative | 504,9 Bb | 510,4 ABb | 528,5 ABc | 569,3 Ac |
| | Pre-Blossoming | 676,9 Aa | 687,6 Aa | 653,0 Ab | 644,0 Ab |
| | Blossoming | 698,5 Aa | 684,8 Aa | 726,9 Aa | 740,7 Aa |
| ADF ($g.kg^{-1}$ DM)*** | Vegetative | 350,8 Ab | 346,5 Ab | 353,8 Ac | 366,0 Ac |
| | Pre-Blossoming | 467,0 Aa | 467,9 Aa | 461,1 Ab | 446,3 Ab |
| | Blossoming | 493,5 ABa | 464,1 Ba | 528,3 Aa | 537,7 Aa |

Means followed by the same lower case letter in the column and capital letters on the line do not differ significantly from each other by the Tukey-Kramer test ($p \leq 0,05$). CP=Crude Protein; NDF=Insoluble neutral detergent fiber; ADF= Insoluble acid detergent fiber; *CV=12,84%; SEM=12,35; **CV=3,84%; SEM=11,05; ***CV=4,81%; SEM=7,58.

In blossoming stage, there wasn't difference in CP content among cultivars, indicating that, for harvest at this development phase, the CP content is not a decisive criterion for choice the cultivar and deploy it.

On vegetative stage, the greatest content of NDF was found on the BRS Ponteio (Table 4), while the other cultivars presented no significant differences among themselves. The cultivars significantly increased the NDF content from vegetative to blossoming, showing the relationship between this variable and the DMY increase and the decreasing of L:S ratio (Table 2). With advancement development cycle occurs modification of both, botany and structural composition of pasture, reducing its nutritional value (SKONIESKI et al.; 2011), because there is elongation of internodes and issuance of inflorescences on passage from vegetative to blossoming. With the maturity, there is increasing DMY by area, there is, however, decreased nutritional value due to changes in the structure of plants. By this change, Lopes et al. (2006) recommend cut of grasses for hay at the beginning of elongation and should not exceed the average silking.

The NDF content of tetraploid cultivars didn't changed of the pre-blossoming to the blossoming while the diploid cultivars increased their levels in such phase. In addition, the NDF content on FL was lower in INIA Escorpio and KLM 138 (tetraploid), when compared to the others.

The variation in ADF contents occurred milder compared to the variation of NDF (Table 4). There was no significant difference between cultivars in vegetative and pre-blossoming, however, cultivars differed in blossoming phase where the tetraploid cultivars presented the lowest ADF values. On phenological stages, the ADF content in cultivars showed similar behavior to the NDF. Thus, diploid cultivars demonstrated increasing the ADF between stages and tetraploid maintained similar averages in the pre-blossoming and blossoming, these being larger than the vegetative. The lower NDF and ADF values presented by tetraploid cultivars blossoming allow quality hay even with late harvest. However, the vegetative showed advantage over other stages of development as it allows the execution of other cuts in a function of the regrowth.

Compared to area occupation, tetraploid cultivars remained, respectively, 35 and 34 days the longer than the diploid cultivars on pre- blossoming and blossoming. This fact may hinder hay production tetraploid cultivars in more advanced development phases, when in systems of integration with summer crops.

## CONCLUSIONS

Highest forage mass is obtained with harvest in blossoming stage.

Tetraploid cultivars present better leaf proportion and higher content of crude protein during vegetative stage.

The decrease the in concentration of protein, with the change of phenological stage, is less evident on diploid cultivars.

The vegetative stage enables harvest forage with high nutritional value, with lower production of biomass.

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**RESUMO:** O objetivo do trabalho foi avaliar o rendimento de matéria seca, composição estrutural e características nutritivas de cultivares de azevém anual, diploides e tetraploides em diferentes estádios fenológicos, para fenação, em solos de várzea. O delineamento experimental foi de blocos ao acaso, com parcelas divididas, com quatro cultivares de azevém anual (BRS Ponteio e FEPAGRO São Gabriel, diploides; INIA Escorpio e KLM 138, tetraploides) e três estádios fenológicos (vegetativo, pré-florescimento e florescimento). Foram avaliadas: rendimento de matéria seca, relação folha/colmo, razão de peso foliar, densidade populacional de perfilhos, área foliar específica, proteína bruta, fibra em detergente neutro e fibra em detergente ácido. Os dados foram submetidos à análise de variância e as médias comparadas pelo teste Tukey-Kramer (p <0,05). A maior massa de forragem é obtida com a colheita no estádio de florescimento. As cultivares tetraploides apresentam melhor proporção foliar e maior teor de proteína bruta durante o período vegetativo. A diminuição na concentração de proteína, com a mudança de estádio fenológico é menos evidente nas cultivares diploides. O estágio vegetativo possibilita a colheita de forragem com alto valor nutricional, mas com menor produção de biomassa.

**PALAVRAS-CHAVE:** Estádio fenológico. Feno. *Lolium spp*. Ploidia

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