



Study on Vegetative Propagation of *Elionurus latiflorus* (Nees Ex Steud.) Hack

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: *Elionurus latiflorus* (Nees ex Steud.) Hack. commonly known as Brazilian lemongrass is a medicinal plant native to Brazil. Present experiment was conducted to study the effect of number of tillers/vegetative unit of transplants on biomass production in a period of 480 days.

Study design: The experiment was conducted by using completely randomized design with three treatments i.e. plants transplanted with one tiller (T1), plants transplanted with 2 tillers (T2) and plants transplanted with 3 tillers (T3). These treatments were replicated eight times where transplantations were done in polybags which containing mixture of soil, dung and carbonized rice in 3:1:1 ratio. These polybags were kept for 160 days in greenhouse and pruning was done in every plant by maintaining 5 cm of the plant biomass for its regrowth.

Duration of Study: This experiment was carried out over 16 months.

Methodology: Every plant seedling was submitted to a cut maintaining approximately 5 cm of the plant biomass for its regrowth. After each pruning, survival percentage, increment in the number of tillers propagated, rise of plants height, fresh as well as dry mass weight were evaluated.

Results: Lower initial number of main stems influenced survival only in the early growth phase after transplantation with a loss of 73% of the population transplanted with an unique main stem. Survival kept a constant value without plant mortalities in the successive 320 days evaluated after the first pruning. The number of tillers propagated weren't affected significantly by the number of initial main stems in a single period. In the other hand, in the comprehensive period of the

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experiment there was a change with mean variation from 9.68 to 36.75. Height decreased the mean from 102.82 cm to 26.66 cm. Fresh and Dry Plant Mass increased from 5.19 g/plant to 11.47 g/plant and from 2.17 g/plant to 4.93 g/plant respectively, $P < 0.05$.

Conclusion: This study even if elementary represents a required approach for the domestication of the species avoiding the waste of time and plant material for successive propagation works. It represents a suggestion for further research work in greenhouses with this specie for a validation of these results.

Keywords: Brazilian lemongrass; tillers; biomass production.

1. INTRODUCTION

Elionurus from the greek word eleuin (to bend) and oura (tail), alluding that the cylindrical inflorescences are curved [1].

The genus *Elionurus*, Humb. and Bompf ex Willd, belongs to the Poacea family with about 15 species distributed in subtropical and tropical countries, especially in Africa [2], in Australia, Central America, South America, Temperate Asia [3,4,1].

Its perennial, agglomerated and herbaceous species reaches upto one meter in height. Leaves are cetaceous, sometime flat with parallel venation. The roots can be aromatic. Its flowering often occurs between October and December. Due the transplantation and removal of apices of the plants on September, this phonological event happened later, between May and June. The colour of the flowers is white. The species can be propagated by seeds but usual method is to divide clumps. Most grasses are propagated by division to preserve cultivar identity besides resulting in high success rate [5,6].

Grasses are preferably transplanted in-between March-November, however, in colder places it is recommended during March-May or September-November [7].

Among the species of the genus *Elionurus* is present the specie *Elionurus latiflorus* (Nees ex Steud.) Hack, Fig. 1, agreed by some authors as a synonym of *Elionurus muticus* (Spreng.) Kuntze, in controversy with a previous publication in which it is recognized as *Elionurus latiflorus* (Nees ex Steud.) [8-10].

Commonly known as goat's beard grass or Brazilian lemongrass, it is one of the species of *Elionurus* native to almost the entire coast of Brazil, mainly from the Northeast till Paraná, where plants with different genetic characteristics

such as width, length, color of leaves and flavoring exhaled, can be found, even if practically extinct due to the destruction of their natural occurrence areas caused by the occupation of intensive agriculture [11-13,3,7].

The "Botanical Studies of the Northeast" refers *Elionurus latiflorus*, and classifies it as part of the savanna vegetation where the soil is dry and stony, which shows that the species has a great adaptability; other studies related also the maintenance of the plant characteristics even in a mild climate [13-14].



Fig. 1. Plant of *Elionurus latiflorus*

The term "lemongrass" attributed to *Elionurus latiflorus*, as already cited, refers to the high presence of citral in the aerial part of the plant, compound widely used in food, cosmetic and pharmaceutical industries, and often obtained through the *Cymbopogon citratus* (DC) Stapf [11,7], this term must be always accompanied by "Brazilian" to understand the denomination avoiding further confusion regarding the name and the discoveries. The citral is a compound inherent to *Elionurus latiflorus* found in a high

concentration in the leaves can be used as a marker by chemical companies, attesting the genuineness of the origin of the species, once the same compound wasn't found in a research about the chemical composition of the essential oils of *Elionurus muticus* [15,16]. In the pharmaceutical industry, citral is used as a raw material for the synthesis of a series of ionones, with beta-ionone being specifically used as a starting substance for the synthesis of vitamin A [17]. In recent studies, *Elionurus latiflorus* was also tested for its antioxidant and antibacterial activities related to its phenolic compounds and other minor compounds [18,19].

Vegetative propagation by tillers is a method often employed in studies about propagation of grasses and can be considered important because tillers are the modular units of growth for grasses [20]. Tillers can be classified as vegetative or reproductive, in function of the development stage [21]. Vegetative tiller is younger and shorter, more numerous and have also higher morphological composition and nutritive value than reproductive tiller that presents stem elongation with inflorescence emission what is important for the continuity of species population [22].

Studies related to the management and cultivation of *Elionurus latiflorus* are still scarce despite their fundamental importance, this experiment about vegetative propagation development focused to provide information to fill the lack of knowledge in this regards.

1.1 Description of the Study Area

The present experiment was carried out at the Department of Medicinal Plants/Horticulture, São Paulo State University, Botucatu (22°53'09"S 48°26'42"W, 840 m) São Paulo, Brazil. This zone has a humid-subtropical weather, with dry cold winters.

2. METHODOLOGY

Natural Plants of a single variety of *Elionurus latiflorus* with good health aspect was removed from the collection of medicinal and aromatic plants and their tillers were separated in the month of September. Collected plants were transplanted in polybags filled with mixture of soil, manure, and rice straw in the ratio of 3:1:1. The statistical design was entirely randomized with three treatments having eight replications of ten plants per plot, in a total of 24

plots with 240 plants comprehending the whole experiment. The three treatments under this experiment include: transplants with 1 tillers (T1), transplants with 2 tillers (T2) and with 3 tillers (T3). All tillers were cleaned by cutting the leaves to a length of about 17 cm and were held in their roots and kept in greenhouse at 20°C mean temperature with irrigation mist for about 160 days (first pruning - 1st P), 320 days (second pruning - 2nd P) and 480 days (third pruning - 3rd P). After each cycle of 160 days a harvest was made for quantitative evaluations in which the following propagation parameters were observed: survival of plants (%), number of tillers propagated, height (cm), fresh and dry mass/weight (g/plant) of the aerial part. The estimated height of the plants was determined from the base to the apices of the developed leaf, with the aid of a ribbon ruler. After measurements of survival, number of tillers, height and fresh weight, plants were preserved with a label in paper bags and placed in a forced air oven at 70°C until constant weight for later weighing of the dry mass.

2.1 Statistical Analysis

Data obtained were submitted to analysis of variance and Tukey test at 5% of probability, through XLStat software package version 2013.2, France.

3. RESULTS AND DISCUSSION

Generally, as mentioned, grasses like *Elionurus latiflorus* should demonstrate an increase in the number of tillers when plants are shorter and parameter of biomass production (weight) follows this tendency, while when plants are higher should also present a lower density [23,24], it's a standard response that characterizes the phenotypical plasticity of the grasses and consists of a mechanism known as balancing between tiller size and density of tillers.

For a screening of the development of the *Elionurus latiflorus*, means of the variables were compared between the treatments for each one of the pruning in each 160 days, as well as for every treatment during the stages of its development for the whole period of 480 days, the statistical data is showed in the Table 1.

3.1 Survival (%)

In this experiment significant variation was observed between T2 and T3 as compared to T1

Table 1. Mean values of survival (%), number of tillers propagated, height (cm) fresh and dry plant mass (g/plant) of *Elionurus latiflorus* in 160, 320 and 480 days after transplantation

		Survival		Number of tillers		Height		FPM		DPM	
		(%)		propagated		(cm)		(g/plant)		(g/plant)	
1 st P 160 days	T1	0.73	^{bA}	10.7	^{aC}	82.60	^{bA}	5.19	^{bB}	2.17	^{aC}
	T2	0.89	^{aA}	9.92	^{aC}	102.82	^{aA}	6.93	^{aB}	3.05	^{aB}
	T3	0.90	^{aA}	9.68	^{aC}	102.07	^{aA}	6.19	^{abB}	2.92	^{aB}
2 nd P 320 days	T1	0.73	^{bA}	27.84	^{aB}	78.79	^{aA}	9.52	^{aA}	3.45	^{aB}
	T2	0.89	^{aA}	27.58	^{aB}	74.70	^{aB}	7.09	^{bB}	2.78	^{abB}
	T3	0.90	^{aA}	24.71	^{aB}	71.46	^{aB}	5.52	^{bB}	2.33	^{bB}
3 rd P 480 days	T1	0.73	^{bA}	34.51	^{aA}	42.19	^{ab}	11.47	^{aA}	4.93	^{aA}
	T2	0.89	^{aA}	36.75	^{aA}	45.70	^{aC}	10.43	^{aA}	4.68	^{aA}
	T3	0.90	^{aA}	34.27	^{aA}	26.66	^{bC}	9.88	^{aA}	4.32	^{aA}

Means followed by the same small letter in a single pruning and capital letter comparing the different pruning in the column do not differ significantly each other through Tukey test $p < 0.05$

for survival % initially but after first prune plant stabilized and the values remain constant, without new mortalities for all the three treatments. Low survival rate under T1 initially may be due to less availability of food reserves in single tillers which may not be able to cope up initial higher losses during transplanting and other factors that affect more initially like need of acclimatization, hardening off, root disturbance, weather conditions etc. Despite of lower survival percentage by T1, they also had as well an increase in new tillers significantly and comparable to the other two treatments, demonstrating that these plants were seeking for establishment, issuing new aerial parts able to improve necessary reserves to grow and develop.

Another factor that justifies the higher population density of dead tiller in taller plants is the phenological cycle of grass, in which the mortality of the reproductive tiller is natural, since the tiller life cycle ends with the emission of inflorescence and maturation of the seeds [25], in fact successively, after the increase of dead tillers above all for T1, but also observed in the other treatments with less intensity, the plants entered the reproductive tillering phase, with inflorescences at the beginning of the second cutting cycle.

3.2 Number of Tillers Propagated: Morphogenesis of Grasses

The number of transplanted main stems, Fig. 2.A, did not influence significantly the number of tillers propagated between treatments, this means that there was a compensation by plants of one initial main stem producing tillers enough in the same proportion the other treatments despite its

higher mortality in the first evaluation. This development was favored by the season of transplanting, once in September the levels of radiation raise in that region.

By the results after an initial stress in September with a vegetative tillering till March/April, in order to stabilize the plants, accumulating resources helped by the environmental conditions of Spring/Summer, but as noticed the resources increased after the first cut, in the first cycle plants were higher and number of tillers were enough to allow the start of the reproductive tillering, in fact the fresh/dry weight increased after flowering and reproduction in May/June, supported also lower temperature of these months, followed in sequence for a new vegetative phase coinciding with the end of the winter, with consequent advances in the vegetative rate again for the last cycle evaluated.

There is a positive and gradual evolution for every individual treatment along time, what shows the capacity of adaptation of the plants already in 320 days.

3.3 Height (cm)

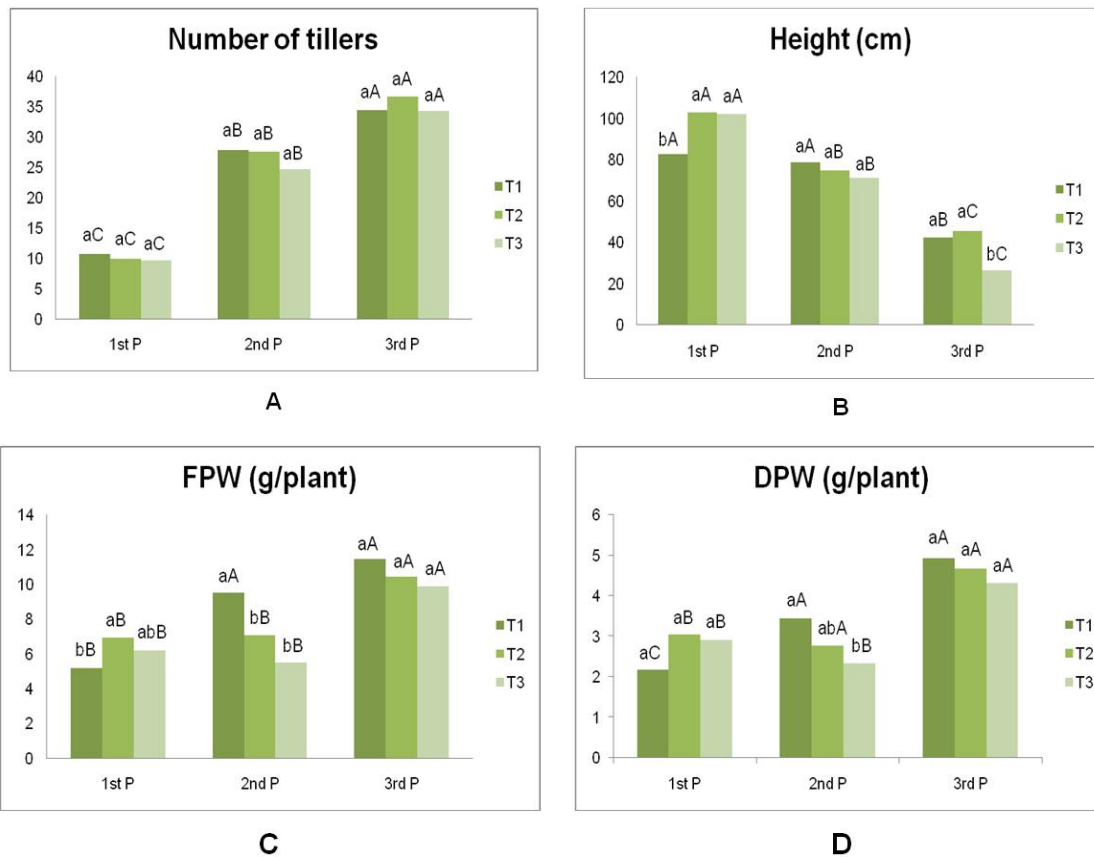
Concerning the parameter height, there was a decrease for all the treatments along time Fig. 2.B, in particular in plants initially with three main stems, this can be easily explained considering the increment in the quantity of tillers. Plants accumulated resources and propagated more vegetative tillers, as density increased the leaves were affected [26-29]. The arise rate of leaves is one of the morphogenic characteristics of great importance affecting directly three structural characteristics of lawns such as size of leaf, population density of tillers and number of tillers.

Competition between new leaves and tillers for growing factors, like light and nutrients, influences the production of a determined plant community. During the vegetative phase, however, leaves emission's rate is regulated by the processes of senescence and the appearance of leaves and tillers remain almost constant in this stage. From this moment when there is a big density of tillers, each new leaf formed start to shade in the older leaves. The total photosynthesis of this population do not increase, but the youngest leaves hinder the oldest leaves to do photosynthesis, due the shading and start to lose carbon through the respiration. The height between treatments, even if did not changed immediately in 160 days, had a drastic decrease in the following cuts. All treatments were reduced by at least 50% respect the initial height. In 480 days, the population with three initial main stems became the lower, with a decrease of 74% of height, in opposite of the increment of tillers propagated. This inversion is supported by the thinning law or tiller size /

density compensation mechanism [30]. But the result also drive to a reflection on the capacity of the plants with an unique main stem to be competitive with an equivalent production of tillers and biomass after its stabilization.

3.4 Fresh and Dry Plant Mass (g/plant)

Production of fresh plant mass was statistically different for the T1 but comparable to T3, much probably because of the accumulation of water in the plant tissues after cut. For the dry mass the mean was lower for T1 compared to other treatments, in fact, dry weight is considered a more precise parameter to indicate the productivity respect to fresh weight [31]. The reestablishment of a positive carbon balance for the plant presumes the increase of the number of the tillers propagated inverse to the leaves elongation [32]. A decrease of the height means an increase of the weight of the biomass, following the continuous propagation of new tillers. It was exactly what happened, there was a



Figs. 2. (A-B-C-D) Number of tillers propagated, height, fresh and dry weight at different stages of developmental of *Elionurus latiflorus*

positive ratio (direct proportion) between the number of new tillers/weight of vegetative tillers and a negative (inverse proportion) between number of new tillers/weight of reproductive tiller of higher height.

After 320 days, it was observed that the fresh weight for T1 had a higher value than the other two treatments, in contrast to what occurred in the first pruning, consequently the same occurred with dry weight; A slight difference was noted only in the second cut, in levels $T1 \geq T2 \geq T3$, however in the third pruning the fresh weight as well as the dry weight between the three treatments didn't present a significant difference, increasing with the increment of the number of tillers propagated.

Through the development of the three treatments, there is a positive increase for each of the three cases studied, both for fresh weight and dry weight (Fig. 2.C-D).

This increase explains the decrease in height in all treatments in each cut, verifying that the plant allocated its reserves after being subjected of cut off, rearranging the accumulation of biomass deposition in growth zones. This information is relevant for a later use in the production of biomass for the extraction of essential oil of *Elionurus latiflorus*, because it demonstrates that, despite a smaller number of tillers, the plant tends to reestablish producing homogeneously the biomass in a short time lapse.

4. CONCLUSION

Results of this study allows to understand that even in 160 days *Elionurus latiflorus* is able to reestablish itself with a minimum of two main stems in the transplantation, already in a second pruning cycle plants with one single main stem is able to produce enough quantity of biomass and offer a production through the propagation of tiller comparable to other treatments avoiding unnecessary use of raw material to successive experiments.

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although its potentiality for the production of citral and other compounds of interest for pharmaceutical and fragrance industry.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Watson L, Dallwitz MJ. The grass genera of the world. Cambridge: CAB International, (2nd ed.). 2006;365-367.
2. Clayton WD, Vorontsova MS, Harman KT, Williamson H. World Grass Species: Synonymy; 2016. Accessed 11 November 2020. Available:<http://www.kew.org/data/grasses-syn.html>
3. Araújo AA. Principais gramíneas do Rio Grande do Sul. 3rd ed. Porto Alegre: Sulina. Portuguese.1971;255.
4. Renvoize SA. Studies in Elionurus (Gramineae) Kew Bulletin. 1978;32(3):666-72.
5. Corley WL. Propagation of ornamental grasses adapted to Georgia and the U.S. South-east. Proc. Intl. Plant Prop. Soc. 1989;(39):332-337.
6. Simon RA. Propagation of ornamental grasses. Proc. Intl. Plant Prop. Soc. (32):517-521;1982.
7. Castro LO, Ramos RLD. Principais gramíneas produtoras de óleos essenciais: *Cymbopogon citratus* (DC.) Stapf., capim-cidró, *Cymbopogon martinii* (Rox.) J.F. Watson, palma-rosa, *Cymbopogon nardus* (L.) Rendle, citronela, *Elyonurus candidus* (Trin.) Hack., capim-limão, *Vetiveria zizanioides* (L.) Nash, vetiver. Boletim FEPAGRO. Portuguese. 2002;(11)31.
8. Filgueiras TS. *Elionurus*. In Catalogue of new world grasses (Poaceae): III. Subfamilies Panicoideae, Aristidoideae, Arundinoideae, and Danthonioideae. Contr. U.S. Natl. Herb. 2003;(46)225-229. Accessed: 11 November 2020. Available:<http://tropicos.org/Name/2552228049?tab=acceptednames>
9. FI Bras. In: Kew Names and taxonomic backbone. The Internations Plant Names and World Checklist of Selected Plant Families. 1883,2020;2(4):307. Accessed: 11 November 2020. Available:<http://www.ipni.org> and <http://apps.kew.org/wcsp/>

10. WCSP, *Elionurus latiflorus* Nees ex Steud, 1854. Syn. Pl. Glumac, In: Kew Names and Taxonomic Backbone. The Internations Plant Names and World Checklist of Selected Plant Families 2020;1:364.
Accessed: 11 November 2020.
Available: <http://www.ipni.org> and <http://apps.kew.org/wcsp/>
11. Buglia AG, Ming LC. Production of *Elionurus latiflorus* (Nees ex Steud) Hack in function of the number of the initial main stems In: III International Symposium Breeding Research on Medicinal and Aromatic Plants and II Latin American Symposium on the Production of Medicinal and Aromatic Plants and Condiments, Campinas, São Paulo, Brazil. 2004;258.
12. Davies P, Villamil JJ, Ashfield R. Fichas técnicas de cultivo. In: Studios en domesticacion y cultivo de species medicinales y aromaticas nativas. Serie FPTA-INIA. Canelones, Uruguay, Spanish. 2004;(6):35-115.
13. Czepak MP. Produção de Óleo Essencial de *Cymbopogon citratus* (DC.) Stapf e *Elionurus latiflorus* Nees em diferentes arranjos espaciais. Ph.D thesis. University of State of São Paulo, Botucatu, São Paulo, Brazil, Portuguese ; 2000.
14. Luetzelburg P. Estudo Botânico do Nordeste. Rio de Janeiro: Inspeção de Obras Contra as Secas. Portuguese. 1922;46.
15. Scramin S, Saito ML, Pott A, Marques MOM. Essential oil of *Elionurus muticus* (Sprengel) O. Kuntze (Gramineae), J. of Ess. Oil Res. 2000;12(3)298-300.
16. Hess SC, Peres MTL, Batista AL, Rodrigues JP, Tivoli SC, Oliveira LGL, Santos CWC, Fedel LES, Crispim SMA, Smania AJ. Evaluation of seasonal changes in chemical composition and antibacterial activity of *Elionurus muticus* (Sprengel) O. Kuntze (Graminae) Quím. Nova. 2007;(30):370-373.
17. Koshima FAT, Ming LC, Marques MOM. Produção de biomassa, rendimento de óleo essencial e de citral em capim-limão, *Cymbopogon citratus* (DC.) Stapf, com cobertura morta nas estações do ano. Rev. Bras. Pl. Med. Portuguese. 2006;8(4):112-116.
18. Puppim DGPB. Ação Antifúngica e toxicidade do óleo essencial de *Elionurus muticus* (capim-limão brasileiro). Master thesis. University of Campinas, Campinas, SP, Brazil. Portuguese; 2018.
19. De Oliveira Braga R. Controle Alternativo de Bactérias Fitopatogênicas por meio de óleos essenciais *Cymbopogon fluxuosus* e *Elionurus latiflorus*. Master thesis. Universidade Federal Fluminense, Niterói, RJ, Brazil. Portuguese; 2019.
20. Hodgson J. Grazing management. Science into practice. New York: John Wiley and Sons, Inc.; Longman Scientific and Technical; 1990.
21. Santos MER, Fonseca DM, Gomes VM, Balbino EM, Magalhães MA. Estrutura do capim-braquiária durante o diferimento da pastagem. Acta Sci. Animal Sci. Portuguese. 2010;32(2)139-145.
22. Santos MER, Fonseca DM, Balbino EM, Monnerat JPIS, Silva SP. Caracterização de perfilhos em pastos de capim-braquiária diferidos e adubados com nitrogênio. Rev. Bras. Zoo. Portuguese. 2009;38(4)643-649.
23. Sbrissia A, Da Silva S, Matthew C, Carvalho CAB, Carnevali RA, Pinto LFM, Fagundes JL, Pedreira CGS. Tiller size/density compensation in grazed Tifton 85 bermudagrass wards. Pesquisa Agropecuária Brasileira. 2003;38:459-1468.
24. Sbrissia AF, Da Silva SC. Compensação tamanho/densidade populacional de perfilhos em pastos de capim-marandu. Rev. Bras. Zoo. Portuguese. 2008;37(1):35-47.
25. Santos MER, Da Fonseca DM, Pimentel RM, Silva GP, Gomes VM, Da Silva SP. Número de perfilhos no pasto de capim-braquiária sob lotação contínua. Acta Sci. Animal Sci. Portuguese. 2011;33:131-136.
26. Chapman DF, Lemaire G. Morphogenic and structural determinants of plant regrowth after defoliation. In: Baker MJ (Ed.) Grasslands for our world. Wellington: SIR. 1993;55-64.
27. Briske DD. Developmental morphology and physiology of grasses. In: Heitshmidt RK, Stuth JW (eds), Grazing management: an ecological perspective. Portland: Timber Press. 1991;85-108.
28. Barhart S. How pasture plants grow. Iowa: Iowa State University; 1999.
Accessed: 11 November 2020.
Available:<http://store.extension.iastate.edu/Product/How-Pasture-Plants-Grow>

29. Gautier H, Varlet-Grancher C, Harzard L. Tillering responses to the light environment and to defoliation in populations of perennial ryegrass (*Lolium perenne* L.) selected for contrasting leaf length. *Annals of Botany*, Oxford. 1999;(83):423-429.
30. Yoda K, Kira T, Ogwa H, Hozumi K. Intraspecific competition among higher plants. XI self- thinning in overcrowded pure stands under cultivated and natural conditions. *J. of Inst. Polytech.* 1963;(14):107-129.
31. Dos Reis GG. Análise de Crescimento das Plantas - Mensuração do Crescimento. Programa Cooperativo para el Desarrollo de los Trópicos Americanos. Centro de Pesquisa Agropecuárias do Trópico Úmido. Curso Multinacional de Capatación de Sistemas Integrados de Producción Agrícola para la Amazonía - IICA Trópicos. Belém-Altamira-Pará Brasil. Portuguese; 1978.
32. De Visser R, Vianden H, Shnyder H. Kinetics and relative significance of remobilized and current C and N incorporation in leaf and root growth zone of *Lolium perenne* after defoliation: Assessment by ¹³C and ¹⁵N steady-state labeling. *Plant Cell. Environ.* 1997;(20):37-46.

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