FERTILIZATION OF A HALOPHYTIC NATURAL GRASSLAND IN ARGENTINA: HERBAGE DRY MATTER, BOTANICAL COMPOSITION, AND MINERAL CONTENT[1] /

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Resumen

Se fertilizó un pastizal natural halofítico (pradera salada) con 0.381 ó 762 kg sulfato de amonio (SA) (ha/año) combinados factorialmente con 0 ó 208 kg superfosfato triple (ST) (ha/año), desde octubre de 1975 hasta octubre de 1978. La fertilización produjo cambios perceptibles en la composición botánica, si bien aquellos estuvieran influidos por la siega periódica del pastizal. Tanto SA como ST aumentaron la acumulación anual de materia seca (AAMS) en las fracciones graminosa y latifoliada. La respuesta de cada fracción estuvo relacionada, aparentemente, con las condiciones hídricas del suelo. La AAMS de la pradera aumentó en el tiempo y con la fertilización. El valor máximo de la AAMS (400 g/m² /año) se observó en el tercer año experimental y en las parcelas fertilizadas con 762 kg-SA + 208 kg-ST, las parcelas testigo correspondientes rindieron ca. 120 g/m² /año). Las gramíneas y las latifoliadas mostraron valores de concentración de N muy cercanos entre sí, más las concentraciones de P, K, Ca y Mg eran frecuentemente mayores en las latifoliadas. La composición mineral de cada fracción varió de un modo característico en el tiempo y con la fertilización. La dosis de fertilización mayor (762 kg-AS + 208 kg-TS) mejoró el valor nutritivo de la hierba para el ganado vacuno de cría. El incremento en la materia seca de la hierba ocasionado por la fertilización AS + TS fue consecuencia de deficiencias leves de N y severa de P en el pastizal; sin embargo, 762 kg-AS + 208 kg-TS no fueron suficientes para expresar su potencial de rendimiento de materia seca.

Introduction

The Salado River Basin comprises about 5.8 x 10^6 ha (15) or 21% of the area of the Province of Buenos Aires. It is a flat land, showing a remarkable microrelief, for which ten grasslands and one woody community of *Celtis tala* were described by Vervoorst (15). Among the former, the salt-prairie is characteristically associated with hydro-and halomorphic conditions in the soil (3).

Cattle-breeding is the most important enterprise in the basin, since it is based upon the extensive grazing of natural grasslands (3, 15). These may differ substantially in herbage yield and, as they are distributed in a mosaic pattern because of microrelief (15), pastures comprising more than one grassland are likely to be heterogeneous as a forage resource to cattle.

Reports on the chemical fertilization of these natural grasslands are scarce. Ginzo *et al* (6) studied the response of a sward (15) to a factorial combination of ammonium sulphate and triple superphosphate during three consecutive years. That grassland was bordered by a salt prairie, which was the object of the present report on the effects of chemical fertilization on its annual accumulation of dry matter in grasses and forb, and their respective N, P, K, Ca and Mg contents, as well as overall changes in botanical composition.

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Materials and methods

The location of the experimental site, together with the description of some climatic variables, have been published elsewhere (6). The experimental site was a homogeneous 0.25 ha stand of a salt prairie mainly composed of the species indicated in Table 1. The soil was a Typic Natraqualf (pH = 9.6 and E.C. = 1.9 mmho/cm in the upper 0.1 m) (C.R.O. Miacznski, personal communication).

Commercial ammonium sulphate (AS) and triple supersphosphate (TS) were applied at the following annual rates AS + TS - kg/ha yr: 0 + 0, 0 + 208, 381 + 0, 381 + 208, 762 + 0, and 762 + 208. Fertilizers were broadcast by hand twice each year: 70% of the annual rate in spring (17 October 1975, 1 October 1976, and 7 October 1977), and the rest in autumn (7 March 1976, 16 March 1977 and 30 March 1978). The fertilizer treatments were arranged into six randomized blocks.

A detailed account of plot size, herbage sampling and partition into grasses and forbs, and the procedure used for the phytosociological surveys have been described elsewhere (6). Herbage was cut at 0.03 m from 0.4 m^2 of 2 x 2 m plots. These were mowed down to 0.03 m at the end of each sampling occasion. The samples were ovendried at 70°C for 48 h and weighed. Eight cuts were made between October 1975 and October 1978. This three year interval was arbitrarily divided into 12-month periods, from October of one year to October of the next. Those experimental years were: I (1975-1976, three cuts); II (1976-1977, two cuts); and III (1977-1978, three cuts).

Herbage yield was expressed as annual dry matter accumulation (ADMA) (7). It was calculated on the basis of three compound replicates instead of the six sampled in the field. The former were the pairwise-combination of samples from adjacent blocks. This was done to reduce the number of samples for chemical analysis without altering the correspondence between dry matter and mineral content.

The contents (mg/mg) of N, P, K, Ca, and Mg in the hay of both grasses and forbs were measured by common analytic methods pointed out elsewhere (6). Mineral concentrations were calculated by dividing the amount of any nutrient accumulated in a botanical fraction over the corresponding ADMA.

Data were tested for normality by the Kolmogorov-Smirnov procedure (13). For normally distributed data, the statistical significance of differences among treatment means ($\alpha = 0.05$) were tested by standard analysis of variance procedures. Otherwise, the non-parametric Mann-Whitney test was used (8).

Results

Botanical composition

The comparison of the phytosociological surveys made before and after three years of fertilization

Table 1. Most frequent species present in the salt-prairie before (October 1975) and after (November 1978) fertilization.

	Oct./75	Nov./78					
Species		0 + 0	0 + 208	361 + 0	361 + 208	762 + 0	762 + 208
Distichlis scoparia	V^{3} ¶	V^{+}	IV^{+}	IV^{+}	III^{1}	III^{+}	I^{1}
Hordeum euclaston	V^{2}	V^{1}	V^{1}	V^{1}	V^{1}	V^{2}	V^{2}
Sporobolus pyramidatus	V^{2}	V^{1}	V^{1}	V^{1}	V^{1}	V^{1}	II^{1}
Plantago myosuros	V^{1}	V^{1}	V^{1}	IV^{1}	IV^{+}	V^{+}	V^{+}
Spergularia levis	IV^{1}	V^{+}	V^{1}	V^{1}	V^{1}	V^{1}	V^{1}
Sporobulus indicus	IV^{+}	V^{+}	IV^{1}	IV^{1}	V^{1}	IV^{1}	III^{2}
Lepidium parodii	IV^{+}	I^{+}	IV^{+}	IV^{+}	IV^{+}	II^{+}	V^{+}
Verbena spp	IV^{+}	NF	NF	NF	NF	NF	NF
Hypochoeris spp.	III^{+}	IV^{+}	IV^{+}	IV^{+}	V^{+}	V^{+}	V^{+}
Gaudinia fragilis	II^{2}	V^{1}	V^{1}	V^{1}	V^{2}	V^{2}	V^{1}
Distichlis spicata	I^{+}	V^{2}	V^{1}	V^{2}	V^{2}	V^{2}	V^{2}
Puccinellia glaucescens var. *osteniana*	NF	II^{+}	I^{+}	II^{1}	III^{+}	V^{1}	II^{1}

¶ **Frequency scale:** V: 80 – 100%; IV: 60 – 80%; III: 40 – 60%; II: 20 – 40%; I: up to 20%.
Cover – abundance scale (superscript): 2: any number of plants, with cover 5 – 25% of the reference area; 1: numerous plants, but cover < 5%, or scattered plants, with cover > 5%; ±: few plants, with small cover. NF: not found.

showed a change in botanical composition (Table 1). The most frequent species present in 1975 were the grasses *Hordeum euclaston, Distichlis scoparia, Sporobolus pyramidatus* and *S. indicus,* and the forbs *Lepidium parodii, Plantago myosuros, Spergularia levis* and *Verbena* spp. The former were more frequent than the latter; legumes were rare.

After three years of fertilization, the frequency of *H. euclaston* did not change much. The frequencies of *S. indicus, S. pyramidatus* and *D. scoparia* were decreased, the first two to a greater extent than the last. In the forbs, fertilization did not greatly change the frequency of *P. myosuros,* slightly increased the frequency of *S. levis,* and markedly increased the frequency of *L. parodii.*

The effect of mowing the plots after each sampling elicited changes in botanical composition. The effect of cutting was made plain by comparing control plots from both surveys. *Puccinellia glaucescens* appeared, and *Verbena* spp. disappeared from the plots. The frequencies of *Gaudinia fragilis, D. spicata* and *Hypochoeris* spp. increased markedly. Whereas the frequencies of the two former species were not much affected by fertilization, that of the latter was slightly increased.

Annual dry matter accumulation (ADMA)

The accumulation of dry matter in the grasses was always larger than in the forbs (Fig. 1). Differences between both fractions were 940, 250, and 420% in years I, II, and III, respectively. Ammonium sulphate and TS significantly increased ADMA in both fractions. The effect of the former was significantly larger in year II, and similar to TS in year III. In year I, on the other hand, the increase in ADMA because of AS-rates was steeper in the forbs irrespectively of TS level; but ADMA in the grasses was only increased by AS and TS together. The latter fertilizer increased ADMA in forbs.

Nutrient concentrations

The percent concentration of N, P, K, Ca and Mg in both grasses and forbs are shown in Fig. 2. It is clear, on inspection, that P, Ca, and Mg were always greatest in the forbs; N and K were greater in forbs than in grasses, or viceversa, depending on the year considered.

Percent of N in forbs was significantly greater than, similar to, or significantly less than that in grasses in years I, II, and III, respectively. Ammonium sulphate increased N significantly in both fractions to

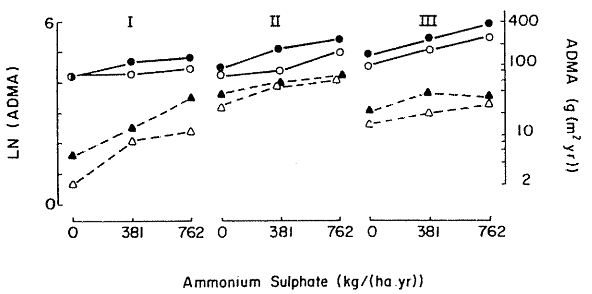

Fig. 1. Annual dry matter accumulation (ADMA) in grasses (circles) and forbs (triangles) in years I, II, and III. **Open symbols:** no TS; **closed symbols:** 208 kg-TA/(ha . yr). Vertical bars represent the standard error of a difference between two means.

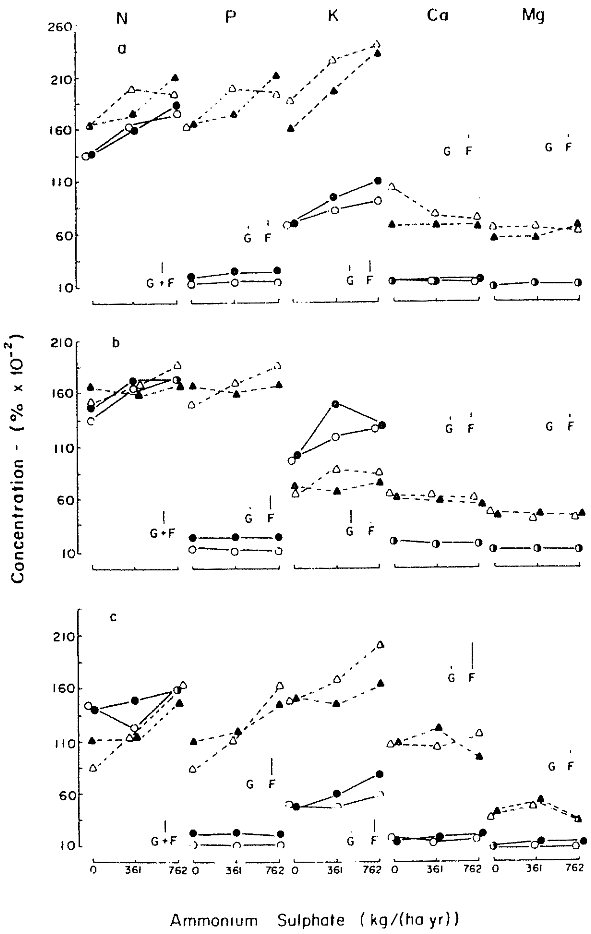

Fig. 2. Nutrient concentrations in grasses (circles) and forbs (triangles) in years I (a), II (b), and III (c). **Open symbols:** no TS; **closed symbols:** 208 kg-TS/(ha . yr). Vertical bars represent the standard error of a difference between two means.

the same degree in years I and II, and significantly more in the forbs in year III. Triple superphosphate did not alter N in any fraction.

The values of P, K, Ca, and Mg in grasses and forbs for the three years could not be pooled, as N data could, because they did not fit normal distributions. Hence, the effect of time could not be statistically compared. Ammonium sulphate always increased P in the forbs and did not vary it in the grasses. Triple superphosphate never changed P in the forbs, and always increased it significantly in the grasses. The interaction AS x TS was never significant.

The values of K in the forbs, compared to the grasses, were significantly greater in years I and III, and significantly lower in year II. Ammonium sulphate always increased K in both fractions, whereas TS did not. The interaction AS x TS was never significant

The concentration of Ca was never affected by AS. In year II, TS increased Ca significantly in both fractions, although to a greater extent in the forbs. In years I and III, TS did not change Ca in either fraction. The interaction AS x TS was never significant.

The concentration of Mg was varied by AS and TS in ways which were characteristic of each experimental year. In year I, AS increased Mg significantly in the grasses buth not in the forbs, while TS did it in the forbs but not in the grasses. In year II, MG was independent of AS and TS in both fractions. In year III, AS lowered Mg significantly in the forbs and did not affect it in the grasses; contrarily, TS decreased Mg significantly in the grasses and did not influence it in the forbs. The interaction AS x TS was never significant.

Discussion

The plant species which thrive in a grassland undergo population changes evoked by environmental and biological stimuli, which may lead to a particular botanical composition if these were steady and homogeneous enough (11, 14). At the time it was fertilized with AS and TS, the salt-prairie had endured continuous overgrazing by cattle. Hence, the most frequent species surveyed before the first input of those fertilizers were representative of a community in a state of "quasi-equilibrium" with its environment under that kind of livestock management. That botanical composition was presumably upset by both chemical fertilization and the replacement of grazing by mowing (cf. 2). Mowing seemed to be more drastic than fertilization, since it governed the presence or absence of some species, (e.g., *P. glaucescens* and *Verbena* spp), besides elicting changes in frequency and/or cover-abundance values, as fertilization also did. Very likely, the result of both practices was confused. Although the experimental design used did not discriminate between them, an insight into their relative influences on the population dynamics of some species was gathered from the comparison between *D. spicata* and *D. scoparia*. Whereas the population size (frequency) of the former was more sensitive to mowing than fertilization, the opposite seemed to hold for the latter species. In general, however, the changes in the prairie's species populations were not clear cut, presumably because the length of the experimental period was rather brief (14), not allowing the prairie to attain a new "quasi-equilibrium" botanical composition.

Each one of the experimental years showed particular hydrological regimes. Their soil-water balances showed a progressive accumulation of water from year I (strongly deficient) to III (excessive) through a mild water-deficit in year II (6). Flooding of the experimental site following peaks of rainfall was a common feature during year III. The ADMA in grasses appeared to be directly related to soil-water status, since it increased from year to year (Fig. 1). On the other hand, the variation of ADMA in the forbs indicated that their growth was depressed by either too much or too little moisture in the soil, although the former seemed to be more deleterious than the latter (Fig. 1).

Grasses and forbs were mildly deficient in N for growth, because AS enhanced both their ADMAs (Fig. 1 and Fig. 2) and N in each year (cf. 16). As the accumulation of dry matter in both fractions were exponentially related to AS rates, the former could have been even greater if AS rates above 762 kg/ha/yr had been applied. The effect of AS on the ADMAs of both fractions was not always even; it seemed to depend on the balance of water in the soil. When there was a mild deficit or an excess of water in the soil (years II and III, respectively), 762 kg/AS/ha/yr) increased the ADMA by 20% in both fractions, but in year I that rate increased the ADMA in grasses and forbs by 10 and 85% respectively (Fig. 1). These facts suggested that the forbs were better competitors than the grasses for available N under soil-water shortage conditions.

Triple superphosphate also elicited different dry matter responses in grasses and forbs during the drier year (Fig. 1). For the grasses, ADMA was not much affected by TS, although P increased significantly (Fig. 2); i.e., there was "luxury consumption" of P (16). On the other hand, dry matter increase in the forbs due to TS took place without any significant change in P, i.e., a condition of "severe" P deficiency (16). By the same reasoning, it was clear that P deficiency in the forbs persisted during the comparatively wetter years (II and III) but in the grasses, as TS increased both ADMA and P, their P status shifted to a condition of mild P deficiency These dissimilar changes in dry matter and P content suggested that the amount of P added did not satisfy completely the P requirements in either grasses or forbs when their growths were enhanced by an amelioration of soil-water balance.

The accumulation of dry matter by the prairie largely reflected the behaviour of grasses and forbs under the effect of fertilization (Fig. 3) As grasses accounted for the largest proportion of the prairie's ADMA (Fig 1), it was not surprising that the latter increased progressively from the first to the third year, in accordance with the progress of soil-water balance and dry matter in that fraction The prairie's herbage dry matter would have been increased much more had higher rates of AS been applied, because of the exponential relationship between the latter and the former. Triple superphosphate also stimulated dry matter accumulation because of its positive influence on both grasses and forbs —as in years II and III— or solely on the grasses, as in year I. It is likely that TS rates greater than 208 kg/ha/yr could have increased herbage dry matter even move because of the already discussed effects of TS on the growth and P status of both grasses and forbs. However, in view of the fact that soil physical conditions surely restrained the prairie's growth (9), it remains to be seen whether the rates of AS and TS tested would have elicited the potential herbage yield corresponding to them

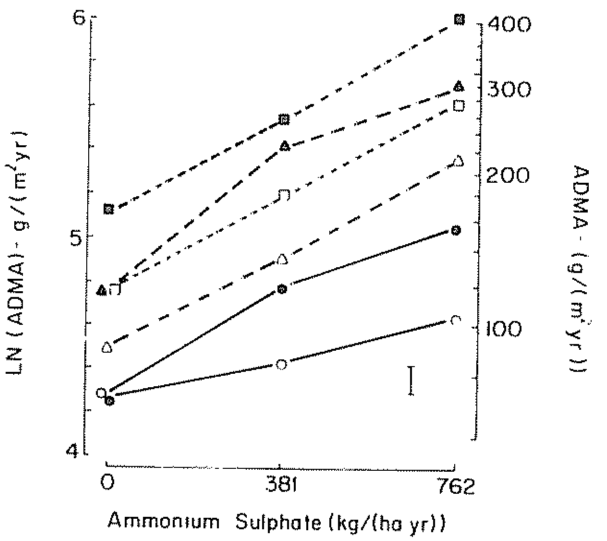

Fig 3 Annual dry matter accumulation (ADMA) in the prairie in years I (circles), II (triangles). and III (squares)
Open symbols: no TS; closed symbols: 208 kg-TS/(ha yr). The vertical bar represent the standard error of a difference between two means

As to the prairie's nutrient requirements for growth, the grassland was mildly deficient in N and P since dry matter accumulation (Fig 3), N, and P were all increased by fertilization (Fig 3 and Table 2). In this regard, it must be noticed that the high proportion of grasses (Fig. 1) alleviated the effect of the severe P deficiency in the forbs.

With regard to the efficiency of N recovery in herbage (Eff_N) and its mineral composition, only the combination of 762 kg/AS/ha/yr) with 208 kg/TS/ha/yr is considered because it gave the highest ADMA on every year. Efficiency values (Table 3) increased with time as if there had been a carry-over effect of AS fertilization (cf. 10). Nevertheless, the maximum reached in year III (30 6%) was low compared to Eff_{Ns} reported for other grasslands, either natural (5) or cultivated (17), fertilized with equivalent rates of N.

Table 2. Concentration of N and P in the prairie's hay.

Year	AS – rates (kg/ha.yr))			TS – rates (kg/(ha.yr))	
	0	380	762	0	208
	% N[a]			% P[b]	
I	1.37	1.65	1.82	0.15	0.25
II	1.46	1.67	1.75	0.16	0.27
III	1.37	1.33	1.59	0.14	0.23
mean	1.40	1.55	1.72	0.15	0.23
SE diff[d]	0.064			0.009	

a Values averaged over TS rates because their effects were non-significant ($\alpha = 0.05$)
b Values averaged over AS rates because their effects were non-significant ($\alpha = 0.05$).
d Standard error of a difference between two means.

Table 3. Efficiency of N recovery (Eff_N) in hay from the prairie fertilized with 762 kg-AS and 208 kg-TS/(ha.yr). (762 kg-AS = 160 kg-N).

	Years I	II	III
		– % –	
Eff_N[a]	12 4 ± 0.22[b]	24.7 ± 0.075	30 6 ± 0 031

a $\frac{\text{Total N in treatment} - \text{Total N in control}}{160} \times 100$

b mean ± S.D.; n = 3

The nutritive value of the prairie for breeding cattle, the principal stock of the region, was assessed from tabled values of P, K, Ca, and Mg (12), represented in Fig. 4. Percent of N (as a measure of protein) was not considered in this context because other variables relevant to animal performance (e.g., digestibility), were not measured. Presumably, the values of some of those variables were low (3). Percent of Mg in both control and fertilized hay satisfied cattle needs (Fig. 4). Unfertilized hay showed P values and occasionally these of Ca (year I) and K (years I and III), below their lowest threshold requirements. Whereas P was negatively correlated ($r = 0.831$; $\alpha = 0.01$) with the proportion of grasses in the prairie, Ca and K were not. Incidentally, those facts provide some insight into the relevance of botanical composition for animal nutrition. On the other hand, the addition of the highest rates of AS + TS raised P, K, and Ca to levels adequate for cattle nutrition (Fig. 4).

The effects of AS and TS fertilization reported here, although valuable in themselves for appraising the herbage potential of salt-prairies, become particularly relevant in view of the diversity of grassland communities which thrive interspersed with each other because of the Basin's noticeable microrelief

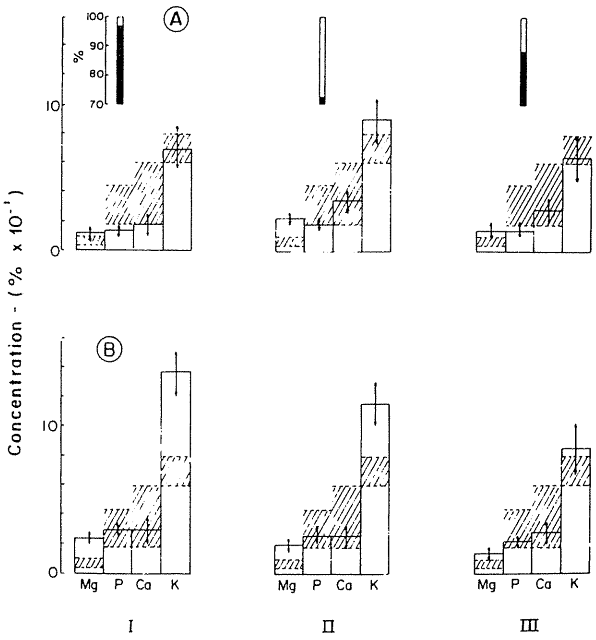

Fig. 4. Concentrations of Mg, P, Ca, and K in the prairie's hay not fertilized (A), or fertilized with 762 kg-AS + 208 kg-TS/(ha . yr) (B) in years I, II, and III. Hatched bars indicate the ranges of concentrations needed by breeding-cattle. Two-pointed arrows indicate 95% confidence intervals for concentration means.
Inset: Proportion of prairie's ADMA accounted for grasses (black bars).

(15). Ginzo *et al* (6) and Ginzo (5) measured the accumulation of dry matter and the mineral composition of a "flechillar" located 500 m away from the present salt-prairie. Both grasslands were similarly fertilized and sampled over the same experimental period. The flechillar differed from the salt-prairie in many aspects, viz: (a) maximum ADMA was about twice as large for the flechillar (800 $g/m^2/yr$); (b) the highest AS rate became progressively saturating for the flechillar's ADMA; and (c) its need for P was evident only when ADMA was greatly enhanced by AS. Clearly, species composition, soil type –Vertic Argiudol (flechillar) vis-à-vis Typic Natraqualf– and plant cover –ca. 80% (flechillar) vis-à-vis ca. 30%– were some of the causes underlying those differences. As it was pointed out earlier, Mendoza's (9) results suggest taht a salt-prairie should need some other cultural practices directed to the improvement of drainage and aeration conditions in the soil in order to show thoroughly its response to chemical fertilization.

Summary

A halophytic natural grassland (salt-prairie) was fertilized with 0.381, or 762 kg/ammonium sulphate (AS)/ha/yr factorially combined with 0 or 208 kg-triple superphosphate (TS)/ha/yr from October 1975 to October 1978. Fertilization evoked perceptible changes in botanical composition, although they were probably confused with mowing effects. The annual accumulation of herbage dry matter (ADMA) in both grass and fractions was increased by AS and TS every year, although the response of each fraction seemed related to soil-water conditions. The ADMA increased both with time and fertilization. Maximum ADMA (400 $g/m^2/yr$) was observed in the third year and in plots fertilized with 762 kg-AS + 208 kg-TS; the corresponding control plots yielded ca. 120 $g/m^2/yr$. Grasses and forbs showed very close N values, but P, K, Ca, and Mg were frequently higher in the latter. The mineral composition of each fraction varied correspondingly with time and fertilization. The highest fertilizer rate (762 kg-AS + 208 kg-TS) improved the nutritive value of herbage for breeding cattle. The increase in herbage dry matter due to AS + TS fertilization resulted from the prairie's mild N and severe P deficiencies; however, its potential for herbage yield did not seem to be realized with 762 kg AS + 208 kg TS/ha/yr.

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Reseña de libros

BEWLEY, J.D. y BLACK, M. Seeds. Physiology of development and germination. Plenum Press. New York. 1985. 367 p.

La amplia variedad de publicaciones que ilustran las bases teóricas de la fisiología de plantas y los conceptos de bioquímica asociados con ella se ven enriquecidos con la publicación de este libro, el que resume en forma adecuada los principales aspectos asociados con los procesos que conducen al desarrollo y germinación de las semillas.

El volumen está bien presentado y editado, entregando abundantes referencias bibliográficas, cuadros y gráficos concisos y buenas fotografías. El material cubierto en el texto posee una secuencia lógica y está bien organizado, de manera tal que es relativamente sencillo acompañar el desarrollo de los procesos químicos y biológicos que conducen a la germinación de las semillas y al subsecuente desarrollo de las estructuras vitales del embrión. Sin embargo, conviene enfatizar que el lector debe tener un conocimiento razonable de bioquímica para poder aprovechar integralmente el material contenido en el libro.

Sin duda alguna, esta publicación representa una contribución para los profesionales envueltos en la investigación agrícola y en la enseñanza superior. El libro puede servir de guía o texto para estudiantes avanzados. Para tecnólogos de semilla sirve como excelente libro de consulta, ya que aborda materias que, una vez comprendida su naturaleza, tienen aplicaciones prácticas para un manejo eficiente de lotes de semillas que deben conservar sus atributos fisiológicos intactos

Otro aspecto favorable es su fácil lectura, ya que no tiene muchas interrupciones en el texto, i.e. citando otros autores o publicaciones. Las referencias pertinentes se encuentran agrupadas al final de cada capítulo, de acuerdo a las materias tratadas en éste. Cuando no existen referencias que ayuden a explicar algunos procesos cuya síntesis y causas son desconocidas actualmente, los autores no se limitan a mencionar el hecho, sino que intentan deducir una teoría propia que pueda servir de explicación al fenómeno.

En el Capítulo 1 se resumen las estructuras básicas de las semillas con énfasis en aquellas de interés agrícola. Se explican los conceptos generales de germinación, haciéndose referencia a lo que realmente representa el concepto, a veces mal interpretado. Se describe la composición química normal de la mayoría de las semillas agrícolas, realizándose una descripción suscinta del tipo de reservas alimenticias almacenadas en las estructuras especializadas de los principales tipos de semillas.

Explicaciones detalladas se encuentran en el Capítulo 2 con relación a la síntesis de carbohidratos, grasas o lípidos, proteínas y fitina, extendiéndose también en la biosíntesis, metabolismo y posibles funciones de las hormonas. El Capítulo 3 está dedicado a la viabilidad de las semillas, explicándose, en detalle, las bases bioquímicas que inciden en la deterioración. Por otra parte, se explican los procesos que en una semilla viable y vigorosa, llevan a completar el proceso de germinación.

En el Capítulo se detallan aquellos procesos que, a nivel celular, se realizan con el fin de promover la síntesis de ATP y RNA principalmente y aquéllos otros que son promovidos por la inhibición de agua y la respiración. Extensa revisión del fenómeno de la latencia de las semillas es la materia del Capítulo 5. Principalmente este capítulo se refiere al papel biológico de la latencia, su desarrollo y los factores que inciden en su aparición.

Dónde y cuándo la semilla germina es el sujeto del Capítulo 6. La sensibilidad del proceso de germinación a factores externos – luz, temperatura, agua – y las interacciones entre agentes que influencian la latencia – luz, temperatura, madurez fisiológica – determinan la germinación de una semilla en situación y tiempo dados. Apropiadamente los autores llaman este capítulo de aspectos ecofisiológicos de la germinación.

En el Capítulo 7 se explican detalladamente los sistemas de movilización y catabolismo de las reservas alimenticias almacenadas, en su pasaje de los órganos de reserva a los puntos de crecimiento embrionario. Esta materia es complementada con el texto del Capítulo 8, que trata del control de dicha movilización. Se hace énfasis en el papel de las hormonas (giberelina, principalmente) en el estímulo para el inicio de los procesos de hidrólisis y la función de las enzimas, su formación y actividad.

Finalmente, en el Capítulo 9, se entregan algunas consideraciones prácticas de aplicación de principios envueltos en la germinación y crecimiento del embrión.

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