Nutritional and Fertiliser Values of *Suaeda vera* J. F. Gmelin

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ABSTRACT

Suaeda vera *J. F. Gmelin, a shrub that is a frequent halophyte in the upper, clayish zones of the Guadalquivir river marshes, is an interesting fodder plant for the local livestock during dry periods, especially as a N supplement. Ash, Na, P, K, Mn, Ca/P, K/Ca+Mg, neutral detergent fibre, cellulose, lignin, dry matter digestibility, organic and protein N, free amino acids, and reducing and total soluble sugars have been determined in the branches and leaves of* Suaeda *plants and compared with these constituents in other species from the marshes, including grasses and legumes. In spite of its high Na and ash contents,* Suaeda *shows an adequate composition for the nutrition of local livestock, even when the plant grows in a sandy area. However, after a long dry period, P and some microelements decline to low levels.* Suaeda vera *seems also to be a useful plant for incorporation into the soil, because of its relatively high N content even in plants taken from a sandy area.*

Key words: *Suaeda vera,* nutritional value, organic fertiliser.

1 INTRODUCTION

Native pastures of many saline areas have a notable nutritive value, and, in some cases, a reasonable production of biomass.[1,2] The conservation and even the improvement of these pastures would be in line with the recent recommendations of the Council of Europe,[3] which suggest that the soil of some of these areas should be used in a traditional way, i.e. for grazing, so as to preserve plant and animal communities of interest. In the upper zones of the Guadalquivir river marshes, *Suaeda vera* J. F. Gmelin is an interesting halophyte, because cattle

often graze on its young shoots in late spring and summer, despite its extremely high salt content. Furthermore, local farmers occasionally incorporate this plant into the soil along with other halophytes such as *Sarcocornia* and *Arthrocnemum*, by means of surface tillage, thus increasing the profitable grazing area. The acceptable C/N ratio and high N content of *Suaeda* confirm its suitability for incorporation into the soil.

2 EXPERIMENTAL

2.1 Plant analysis

Plants of *Suaeda vera* J. F. Gmelin were collected in different seasons of 1986 from the marshes of the Doñana National Park and from a sandy area adjacent to the Villamanrique de la Condesa marshes (Spain). *Sarcocornia perennis* (Miller) A. J. Scott was also collected from the marshy soil in September, and the herbaceous species *Medicago polymorpha* L., *Melilotus segetalis* (Brot.) Ser., *Trifolium resupinatum* L., *Plantago lagopus* L., *Hordeum marinum* Hudson, and *Lolium rigidum* Gaudin in May 1986. Some aspects of the soil and climatic characteristics of the Guadalquivir marshes have already been described in a previous paper.[2] Whole plants of *Suaeda* were taken from random sampling sites in each homogeneous zone and separated into leaves and branches for analysis in the laboratory. All determinations were done in triplicate. Plants were taken to the laboratory in portable ice-boxes and washed with the following solutions: 0·1 g litre^{-1} phosphate-free detergent, 0·1 N HCl and distilled water. Plant material was freeze-dried and powdered. Mineral elements were extracted according to the Inter-Institute Committee[4] by dry ashing and treatment of the ash with concentrated HCl on a hot plate. Sodium and K were determined by flame emission, Ca, Mg, Mn and Zn by atomic absorption, and P by spectrophotometric determination of the phosphovanadomolybdic complex. Organic, soluble, protein and total N were estimated by Kjeldahl digestion after pretreating the samples with salicylic acid and thiosulphate for the total N determination, and with reduced iron for the soluble N determination. Crude protein was determined from the organic N content (N×6·25). Soluble N was extracted with 80% (v/v) ethanol, as described by Nowakowski and Byers,[5] using the residue for protein N determination. Total free amino acids were estimated according to Clark.[6] Total soluble and reducing sugars were extracted with 80 and 50% (v/v) ethanol, as described by Mazuelos *et al.*[7] Total sugars were determined by the phenol–sulphuric acid method[8] and reducing sugars by the Nelson–Somogyi copper reduction method.[9] For the C/N ratio determination, C and N were estimated by dry digestion of samples in a CHN analyser. Neutral detergent fibre (NDF), lignin (lig), cellulose (cel) and dry matter digestibility (DMD) were determined according to Goering and Van Soest.[10]

2.2 Soil analysis

Soil samples were collected from each zone at the beginning of the work. Soil pH was determined in 1 N KCl (1:2·5 soil/liquid ratio) and Na, K, Mg and electrical conductivity (EC) in the 1:5 soil–water extract.[11] The $CaCO_3$ content was estimated in a Bernard's calcimeter, and the particle size distribution by a chain hydrometer.[12]

3 RESULTS AND DISCUSSION

3.1 Nutritional value

Table 1 shows some chemical properties of the soil both from a clayish area and from a sandy area from which *Suaeda* was collected. As is to be expected in this species, high Na contents are found in its leaves and branches (Tables 2–5), even in plants growing in the sandy soil (Tables 4 and 5), whose matric suction may be

TABLE 1
Chemical Properties of the Soils Studied

Zone	Depth cm	EC µS	pH	$CaCo_3$ %	N %	Na µg g^{-1}	Na/K	Sand %	Clay+silt %
Doñana marsh	0–25	547	7·6	15	0·22	437·5	1·7	3·0	96·0
	25–40	1923	—	12	—	1800·0	8·6	2·5	97·0
Sandy area	0–25	275	6·9	<1	0·08	312·0	1·1	75·5	22·0
	95–110	1583	8·1	<1	—	1500·0	62·5	77·5	21·5

TABLE 2
Range of Variation of N and Mineral Elements in *Suaeda* from the Marshy Zone. Results on dry matter basis (l=leaves; b=branches)

		Organic N %	P %	K %	Na %	Ca/P	Mn ppm	Zn ppm
February	l	4·1–4·6	0·20–0·28	3·0–3·5	10–15	1·5–2·0	35–48	18–25
	b	2·6–3·1	0·10–0·15	2·0–2·5	6–8	3·5–4·0	40–52	22–31
April	l	4·0–4·6	0·18–0·22	2·5–3·1	11–15	1·5–2·2	29–38	16–22
	b	2·3–3·0	0·10–0·13	1·6–2·2	6–9	3·3–3·9	36–45	20–33
September	l	2·7–3·5	0·07–0·09	1·7–2·2	12–16	4·2–4·8	10–16	11–16
	b	1·8–2·6	0·05–0·07	1·0–1·4	7–10	5·7–7·0	15–22	13–18
November	l	3·7–4·2	0·16–0·21	3·0–3·4	10–13	1·8–2·2	29–33	14–21
	b	2·4–3·0	0·09–0·12	1·8–2·5	6–9	3·0–3·8	—	—

TABLE 3
Analyses of *Suaeda* (Young Branches) and Herbaceous Species from the Marshes. Species collected on May 1986; mean values on dry matter basis

Species	Organic N %	NDF %	Cel %	DMD %	P %	Ca/P	Mn ppm	Zn ppm
Suaeda vera	2·7	33·2	18·5	66·2	0·18	3·1	35	20
Medicago polymorpha	2·6	30·5	21·5	67·8	0·26	4·0	38	43
Melilotus segetalis	2·7	31·7	20·3	68·3	0·29	3·8	35	36
Trifolium resupinatum	2·4	31·6	22·3	68·8	0·24	4·2	35	30
Plantago lagopus	1·8	—	—	—	0·31	3·2	27	50
Hordeum marinum	1·5	54·9	23·0	66·2	0·20	1·0	22	30
Lolium rigidum	1·6	57·6	25·6	63·5	0·23	1·2	27	28

TABLE 4

Analyses of Leaves of *Suaeda*, September 1986. Mean values±standard deviations on dry matter basis

Zone	Ash %	Na %	K/Ca+Mg	Ca/P	Crude protein
Marsh	33.7±0.6	14.5±0.9	1.1±0.1	4.8±0.3	19.9±0.7
Sand	33.0±2.0	13.7±1.1	0.7±0.2	6.9±0.5	17.8±0.2

TABLE 5

Analyses of Branches of *Suaeda* and Stems of *Sarcocornia*, September 1986. Mean values±standard deviations on dry matter basis

Plant	Zone	Ash %	Na %	K/Ca+Mg	Ca/P
Suaeda	Marsh	20·3±2·1	8·6±0·9	1·0±0·1	4·4±0·2
Suaeda	Sand	16·8±2·3	7·6±1·1	1·1±0·4	6·0±1·6
Sarcocornia	Marsh	43·0±3·0	16·2±0·8	0·4±0·04	7·2±0·3
Plant	*Zone*	*Crude protein %*	*NDF %*	*Lig %*	*DMD %*
Suaeda	Marsh	14·0±1·3	35·1±2·6	5·3±0·3	66·1±0·3
Suaeda	Sand	11·1±0·4	41·5±3·6	7·0±0·2	56·6±2·1
Sarcocornia	Marsh	14·5±0·6	23·9±1·2	5·0±0·4	70·7±0·9

comparatively low in relation to the soil of the marsh, but whose Na content and electrical conductivity are quite high (Table 1). It is therefore not surprising that both groups of plants have a high Na content, as this element is used for osmotic adjustment in the Chenopodiaceae, the family to which *Suaeda* belongs. But in spite of this high Na content and ash levels, local cattle graze on the young branches in late spring and summer when the herbage begins to wilt.

As a fodder plant, it is interesting to note that the leaves and branches of *Suaeda* possess, in general, a satisfactory composition for animal nutrition (Table 2), according to the norms recommended by various authors.[13–15] Although these norms are only generalisations, and should be corrected to allow for differences in the feeding of animals in different geographical zones,[13] the dietary concentrations specified are quite sufficient for indigenous cattle. Only in late summer (September), after a long dry period, do some components such as P, Mn and Zn become too low, or a little unbalanced, as indicated, for example, by the Ca/P ratio. In November, after the first autumnal rains, these parameters again attain a more normal range (Table 2). However, the N content of the plant, leaves and branches is always high, much higher than the minimum for the ruminants considered in the cited references (1·44%).

Branches of *Suaeda* have, of course, lower N and mineral contents than the leaves (Table 2), but their composition is usually quite adequate for animal diets. Furthermore, the lower Na and ash contents are favourable for this purpose. The branches of *Suaeda* can certainly reach a reasonable nutritional value, a fact that is especially evident if this species is compared with some other valuable marsh

TABLE 6

Analyses of Leaves of *Suaeda*, September 1986. Mean values±standard deviations on dry matter basis

Zone	Organic N %	Protein N %	Free amino acids mg g^{-1}	Total soluble sugars mg g^{-1}	Reducing sugars mg g^{-1}
Marsh	3.2±0.1	2.4±0.1	8.9±0.6	61.0±1.7	40.5±1.3
Sand	2.8±0.03	1.7±0.1	9.5±1.1	70.3±2.1	40.0±1.7

TABLE 7

Analyses of Branches of *Suaeda* and Stems of *Sarcocornia* September 1986. Mean values±standard deviations on dry matter basis

Plant	Zone	Organic N %	Protein N %	Free amino acids mg g^{-1}	Total soluble sugars mg g^{-1}	Reducing sugars mg g^{-1}
Suaeda	Marsh	2·2±0·2	1·0±0·1	6·0±0·3	49·7±2·1	31·3±1·1
Suaeda	Sand	1·7±0·06	0·9±0·02	6·8±0·5	61·2±0·6	32·7±2·5
Sarcocornia	Marsh	2·3±0·1	1·3±0·04	8·3±0·2	53·3±1·5	21·6±1·2

fodder plants, as is shown in Table 3. In May, when the herbage is mature, the organic N content of branches of *Suaeda* is similar to that of some legumes and much higher than that of grasses and *Plantago*. The dry matter digestibility is also similar to that of legumes and grasses, and only the P and Zn contents may be lower in *Suaeda*, especially if compared with the contents in legumes. Furthermore, the Ca/P ratio is reasonably balanced in the branches of *Suaeda*, as in *Plantago* and species of grasses. Nevertheless the most remarkable nutritional feature of *Suaeda* is the high N content of the leaves and young branches.

Even in a sandy area, with a comparatively low soil fertility (Table 1), *Suaeda* can also reach a reasonable nutritional value for cattle as a nitrogen supplement. Tables 4–7 show some mineral and organic parameters of leaves and branches of *Suaeda* collected in the marsh and in an adjacent sandy area in September when the local livestock graze on it more extensively because of the lack of green pasture. Also shown is the composition of *Sarcocornia*, which although scarce and rarely grazed is the other member of the Chenopodiaceae present in the marshy zone studied. It can be seen from Tables 4 and 5 that leaves and branches of *Suaeda* possess a high crude protein content even in late summer, higher in the plants from marshy soil ($P<0·01$). Stems of *Sarcocornia* also have a notable crude protein content, but it is probably their higher levels of ash and Na, among other reasons, that make them less suitable for grazing (Table 5).

The Ca/P ratio is a very important parameter for animal nutrition. Its values should not increase beyond 6·0, and preferably should be within the range 0·5–2·0. As shown in Tables 4 and 5, the Ca/P ratio is more balanced in *Suaeda* than in *Sarcocornia*, and in *Suaeda* it is higher in leaves and branches of plants taken from sandy soil, due to a higher Ca content in the leaves and slightly lower P content in the branches (data not shown). As mentioned above, one of the most important

problems that affect *Suaeda* and other halophytes in later summer is a low P content, which rarely exceeds 0·1% on a dry matter basis and causes a high Ca/P ratio. But, even in this period, the ratio is not excessively unbalanced in leaves and branches of *Suaeda*.

The K/Ca+Mg ratio, the components of which are expressed in equivalents, is also an important parameter in animal nutrition because it may favour the appearance of grass tetany if it is consistently higher than 1·8. It can be seen from Tables 4 and 5 that this ratio never reaches the value of 1·8, being always higher in *Suaeda* than in *Sarcocornia*. This is a consequence of the higher K content in *Suaeda* leaves or branches, and the higher Ca and Mg content in the stems of *Sarcocornia* (data not shown).

In general, *Suaeda* possesses a reasonable nutritional value, even in the most extreme environmental conditions, its branches having a reasonable dry matter digestibility level, a little lower than in *Sarcocornia* (marshy soil), but with a higher fibre content ($P<0·01$), probably more adequate for rumination (Table 5). *Suaeda* has also a reasonable soluble sugar content in its leaves and branches during late summer (Tables 6 and 7), the total soluble sugars being higher in plants collected in sandy soil ($P<0·01$). The soluble sugar content is similar or even lower in the stems of *Sarcocornia* than in branches of *Suaeda* (Table 7), which shows again the good nutritional value of *Suaeda*, even in this part of the year. But the most relevant nutritional feature of *Suaeda* is its nitrogen content, some fractions of which are shown in Tables 6 and 7. In general, the organic and protein N contents are higher in plants from the marshy soil, unlike the free amino acid content which is slightly higher in plants from the sandy soil. In wetter months, *Suaeda* certainly possesses higher levels of organic N, but, as mentioned above, even in summer the N content is quite adequate for the nutrition of local cattle. In July, this parameter can still reach a level of *c.* 4% in the leaves, and in leaves of plants from the sandy area it is higher than 2·5% during late summer (Table 6). Therefore, *Suaeda* may be a suitable N supplement for dry periods, when the grassland herbage begins to wilt and its N content becomes very low (*c.* 1% or even lower).

The high Na and ash content of *Suaeda* is an adverse feature for animal nutrition, and *Suaeda* is most useful as an N supplement in dry periods, with other nutritional parameters reasonably balanced. Its intake must be supplemented with other low-Na food, such as dry pasture,[15] or a suitable P supplement. According to O'Leary *et al.*[16] halophytic forages will probably be limited to being used as components in feed mixtures rather than as sole sources of food. These authors obtained good results with two species of *Atriplex* (Chenopodiaceae) when they were included as 25% of the total diet. Their acceptability and digestibility by the animals were adequate. According to Pasternak *et al.*,[17] the acceptability of halophytes by animals is perhaps the major bottleneck in the process of developing seawater-irrigated fodder plants. In our case, the cattle seem to accept *Suaeda* whereas other halophytes, such as *Sarcocornia*, are almost completely rejected.

It would be of interest to carry out trials with different diets, in which *Suaeda* was present in different concentrations as a protein supplement, in order to ascertain the level of acceptability and the performance of the animals when given these kinds of diet. The results obtained with native cattle would perhaps be quite different from these obtained with more select races.

TABLE 8

Analyses of Leaves, Branches and the Whole Plant of *Suaeda* from the Sandy Soil, January 1986. Mean values on dry matter basis

Plant (fraction)	*Ash* %	*Na* %	*Total N* %	*Soluble N* %	*C/N*	*NDF* %	*Lig* %
Whole plant	10·8	1·7	2·5	1·1	17·3	55·4	9·5
Branches	16·5	5·5	2·8	1·0	14·3	44·1	6·4
Leaves	30·0	13·0	3·7	—	8·5	—	—

3.2 Fertiliser value

Suaeda can be a useful source of organic fertiliser following its incorporation into the soil by tillage, as is occasionally done by the local farmers when the soil is wet enough (usually January–March). The extent of cover by these plants in marshy areas can sometimes reach levels as high as 80% (García, L.V., unpublished). The important biomass of *Suaeda* can thus represent an inexpensive and useful contribution of fresh organic matter which can improve the properties of the soil, as reported by Moreno and Murillo.[18] These authors found that even four years after surface tillage, which incorporated *Suaeda* into the soil, the herbage production (dry matter) was *c.* 17% higher in the pasture ground (free of shrubs) of the tilled area than in the non-tilled. Tillage created more pores in the soil, within 9–0·6 μm range (containing useful water) and also in the range 300–30 μm (aeration capacity). The available space for grazing (free of shrubs) increased after the tillage, although *Suaeda* began to reappear (albeit in moderate quantities) a short time later, so it could be reused for livestock nutrition.

Suaeda certainly seems to be a suitable material for incorporation into the soil, as this plant has a high N content in the leaves and branches. This helps to provide an adequate C/N ratio, which is a very important factor for any material to be incorporated into the soil. This ratio should not be increased beyond 20, and, as shown in Table 8, the C/N ratio of the whole shrub shows an acceptable value even in a plant taken from the sandy area. Also the lignin content is not too high for the incorporation of *Suaeda* into the soil (Table 8).

Therefore, *Suaeda* may be a valuable plant for many areas of the Guadalquivir river marshes as a N supplement for native cattle during dry periods. Indirectly, *Suaeda* can also improve the nutrition of cattle by means of the improvement of the pasture ground, when it is incorporated into the soil. Thus, *Suaeda* is a suitable plant that can contribute to the improvement of many pasture areas of the Guadalquivir river marshes while maintaining the preservation of the distinctive flora and fauna.

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