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Evaluation of the Consortium with *Salicornia Neei* for use in the Semi-arid of Pernambuco. II - *Sorghum Sudanense* (Sudan Sorghum)

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ABSTRACT

The Brazilian Semi-arid region is characterized by strong sunlight, high temperatures, irregularity and scarcity of rain, the main obstacles to the development of agrarian and agricultural activities. In addition to these factors, the salinity of water and / or soil contributes to limiting the growth and productivity of crops. The survival of the semi-arid population is associated with the characteristics of climate, vegetation and soil, causing environmental, social and economic impacts. As a way of mitigating these dilemmas, it is necessary to seek alternatives for planting that are resistant to soil salinity and that serve as human and animal food. Therefore, the cultivation of halophyte plants is an excellent option-inaddition to serving as food, they are phytoremediation, collaborating for the recovery of saline soils, collaborating significantly for agricultural maintenance. The objective of this work was to evaluate the effect of the consortium between Salicornia neei and Sorghum sudanense, on growth and productivity in greenhouse cultivation, with three soil textures. The experimental design used was that of randomized blocks, with Salicornia neei and Sorghum sudanense, individualized and intercropped and irrigated with water (control) and with desalinator reject, with three replications. After 180 days, it was observed that planting only Sorghum sudanense showed a better production of green and dry matter, when irrigated with desalinator reject and cultivated in the soil with a clay texture. Salicornia neei in consortium with Sorghum sudanense showed better absorption of sodium, potassium, calcium and magnesium in the soil with a clayey texture and irrigated with desalinator reject. Therefore, the intercropping of Salicornia neei and Sorghum sudanense can be favored by the nutrients provided by the halophyte salicornia, with a consequent increase in the production of dry matter and total fiber.

Keywords: *Halophyte; plant growth; saline water; sorghum.*

INTRODUCTION

Salinity is one of the abiotic stresses that most limits growth and agricultural productivity, especially in Semi-arid Regions, due to high rates of evapotranspiration and low rainfall, associated with inadequate soil and water management, contributing to the emergence of salinized soils. The cultivation of halophyte plants is necessary to mitigate such difficulties, especially *Salicornia neei*, popularly known as "green salt", which can replace salt in foods, being well accepted in the gourmet market, due to its high nutritional power, in terms of vitamins and minerals. The cultivation of *Sorghum sudanense* can be a viable alternative for the use of water resources and affected by salts, as it is a plant that serves as an energy source, presenting good digestibility, productivity and adaptation to dry and hot environments and with low soil fertility, serving as silage, green cutting and grazing; and its grains serve as animal feed and can grow again after the first harvest[1,2,3,4,5].

Forage availability in Brazil is irregular, due to climatic conditions, especially in *Semi-arid Region* where water resources are insufficient to meet the needs of human consumption and agricultural activities as groundwater and surface water sources present high levels of salts; this water starts to be used for irrigation of plants tolerant to salinity. *Sorghum sudanense* is a favorable plant for the ensiling process, due to its phenotypic peculiarities that determine the ease of planting, treatment, harvesting and

storage. For the choice of forage to be used it is important to evaluate the productivity characteristics and the structural and bromatological composition of the plant [6,7,8].

In Brazil, it was from the 70s that the culture of the *Sorghum sudanense* began to be intensified, becoming significantly commercial when the planting area reached 80 thousand hectares, mainly concentrated in Rio Grande do Sul and São Paulo. The cultivation of *Sorghum sudanense* is gaining prominence due to the increase in planted area, the use of new technologies and the use of more productive genotypes adapted to climatic and soil conditions.[9,10].

In the Northeast Region of Brazil, about 70% of its area is included in the Semi-arid Region, characterized by climatic conditions that cause seasonal variation in forage production. *Sorghum sudanense* has stood out for presenting greater flexibility in planting times and high productive potential, constituting forage alternatives in times of scarcity [11].

Sorghum sudanense is a typical grass from a hot climate, with xerophytics characteristics, which besides its low requirement in terms of mineral richness of the soil, has tolerance and resistance to abiotic factors, such as: water stress, salinity and water logging. It is a culture that can be adjusted accordingly as an alternative for the Brazilian *Semi-arid Region* due to its adaptive features to low rainfall and uneven distribution of rainfall, a factor that interferes with the development of most forage plant and cultivated grain producers, especially in arid and semi-arid regions of Brazil [9].

Sorghum sudanense (*Sorghum sudanense*) or Sudan grass is an annual, early grass, with high growth speed, of African origin and adapted to the semi-arid region. It has high water use efficiency, high nutritional quality, reaching three meters in height, offering expressive aptitude for the production of forage, in the form of hay, silage and grazing, making it a viable alternative to high value nutritious green forage. It was introduced in the state of Pernambuco, Brazil, in the early 1980s, through the Brazilian Agricultural Research Corporation (Embrapa Corn and Sorghum).The characteristics of the cultivar Sudan 4202 from the Agronomic Institute of Pernambuco (IPA) are of great relevance, as it is a plant that has a short flowering period (40 to 50 days), high tolerance to salinity, great potential of dry matter and very efficient forage yield, with hay as its main suitability [10, 12].

The use of the halophytes *Sorghum sudanense* and *Salicornia neei* in consortium in the semi-arid of Pernambuco is of great relevance for local farmers, because besides being plants with high potential for phytoextraction, they are cultures resistant to high temperatures and have high biomass production, being a nutritious and good quality food[13,14].

Given the above, the objective of this work was to evaluate the effect of the consortium between *Salicornia neei* and *Sorghum sudanense* on growth and productivity in greenhouse cultivation, submitted to irrigation with desalinator reject in three soils with different textures.

MATERIALS AND METHOD

Obtaining Seedlings

The production of seedlings by vegetative propagation of *Salicornia neei* Lag. was performed directly on the vessels to be used in the experiments. Stem fragments (cuttings) 10 cm long were removed from the matrix plants, with the lower part in a bevel. These cuttings were placed in pots with saline soil with clayey, average and sandy textures. For 30 days, the plants were irrigated with drinking water and, every three days, they were sprayed with desalinator reject to acclimatize them until rooting.

The seeds of the *Sorghum sudanense* cultivar Sudan 4202 were supplied by the Seed Chamber of the Agronomic Institute of Pernambuco (IPA), Recife, Pernambuco, Brazil.

Conducting the Experiment

The experiment was carried out under greenhouse conditions, located at the headquarters of the Agronomic Institute of Pernambuco (IPA), using black polyethylene pots, with eight kilos of saline soil with clayey, average and sandy textures, from the Experimental Station of São Bento do Una, from IPA, air-dried, ground, homogenized and sieved in 2mm mesh for fertility analysis [15], according to Table 1.

Table1. *Soil fertility analysis used in the experiment*

Determination	Soil texture		
	Sandy	Average	Clayey
pH (H_2O)	6.40	5.50	7.40
P, mg/dm^3	13	105	209
Ca, cmol$_c$/dm^3	0.40	0.90	12.40
Mg, cmol$_c$/dm^3	0.60	0.60	2.20
Na, cmol$_c$/dm^3	0.05	0.11	4.09
K, cmol$_c$/dm^3	0.08	0.05	0.60
Al, cmol$_c$/dm^3	0.00	0.30	0.00
H, cmol$_c$/dm^3	0.33	1.35	0.25
S, cmol$_c$/dm^3	1.1	1.7	19.3
CTC, cmol$_c$/dm^3	1.5	3.3	19.5
V, %	77	50	99
m, %	0	15	0

Where: *S = Sum of Bases; CTC = Cation ExchangeCapacity; V = Percentage ofSaturation by Base; m = Percentage of Saturation by Aluminium.*

Source: *Soil Fertility Laboratory of the Agronomic Institute of Pernambuco - IPA, Recife, Pernambuco (2019).*

The treatments consisted of the individual planting of *Salicornia neei* and *Sorghum sudanense*, as well as in consortium, in the three types of soil textures, with irrigation with water (control) and with the desalinator reject, observing the development of the plants for up to 180 days.

The experimental design used was that of randomized blocks, with the treatments: *Salicornia neei* and *Sorghum sudanense* individualized and in consortium, three soil textures (clayey, sandy and average), with two types of irrigation (water and desalinator reject), with three repetitions, totaling 54 experimental units.

Throughout the experiment, humidity was maintained in the pot capacity, by weighing the pots and daily watering with drinking water and with the desalinator rejectfrom the municipality of Riacho das Almas, Pernambuco, to complement the water lost through evapotranspiration, with the following features: Electrical Conductivity = 11.54 mS/cm at 25ºC, Ca^{2+} = 403 mg/L, Mg^{2+} = 393.09 mg/L, Na^{+} = 200 mg/L and K^{+} = 40 mg/L, Sodium Adsorption Ratio (SAR) = 23.67, pH = 7.9, Classification for irrigation = C4S4 (Very high salinity water and high sodium concentration).

Collection of the Experiment

After the experimental period, the aerial part of the *Sorghum sudanense* and *Salicornia neei* were collected, separating them at the height of the plants' neck and washed with deionized water.To evaluate the yield of cultivated plants, the weight of fresh matter (FMW) was analyzed on the day of harvest.That done, all the material was packed in paper bags, dried in an air circulation oven, at 60^{0}C, for 72 hours, to determine the dry matter yield (DMP).

Soon afterwards, the material was ground, in a Wiley mill, provided with a 42mm sieve to, by means of nitroperchloric digestion [16], determine the contents of the absorbed elements (Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}) and the bromatological analysis [16].

Statistical Analysis

The data obtained were submitted to individual and joint statistical analysis, relevant to the variables studied, using appropriate mathematical models. The analysis of variance was tested by the F test. The data were run using the Minitab US.2018 software.

Results and Discussion

In Fig. 1a, it is possible to observe that the treatment with only *Salicornia neei* showed a better production of green matter (GMP), equal to 400 kg/ha, when irrigated with desalinator reject and grown in soil with clayey texture, compared to soil with clayey texture, irrigation with water, only *Sorghum sudanense* (0.00kg/ha) and soil with sandy texture, irrigation with waste, only *Sorghum sudanense*.

The researchers [17] evaluated, under field conditions, 22 new hybrids, belonging to the Sorghum Genetic Improvement Program of Embrapa Corn and Sorghum, with three control hybrids (BR 601, BR700 and Volumax), and observed a higher dry matter weight for the Volumax genotype (1.608 kg / ha).

[18], in a field experiment, used *Sorghum sudanense* cultivar IPA Sudan 4202 for salinity tolerance (up to 100 mS / m), finding a high dry matter weight - DMW (800.0 to 1,200.0 kg/ha).

In Fig. 1b it is possible to observe that the treatment with only *Salicornia neei* showed a better production of dry matter (DMP), equal to 80 kg/ha, when irrigated with desalinator reject and grown in soil with medium texture, compared to soil with clayey texture, water irrigation, only *Sorghum sudanense* (0.00kg/ha) and to soil with clayey texture, desalinator reject irrigation, only *Sorghum sudanense*. The dry matter production evaluated was lower than those obtained by [19], when they evaluated five sorghum hybrids grown in winter. The authors obtained, on average, 10 kg/ha of DMP, probably due to the prevailing climatic conditions in the winter period, with lower rainfall and low temperatures.

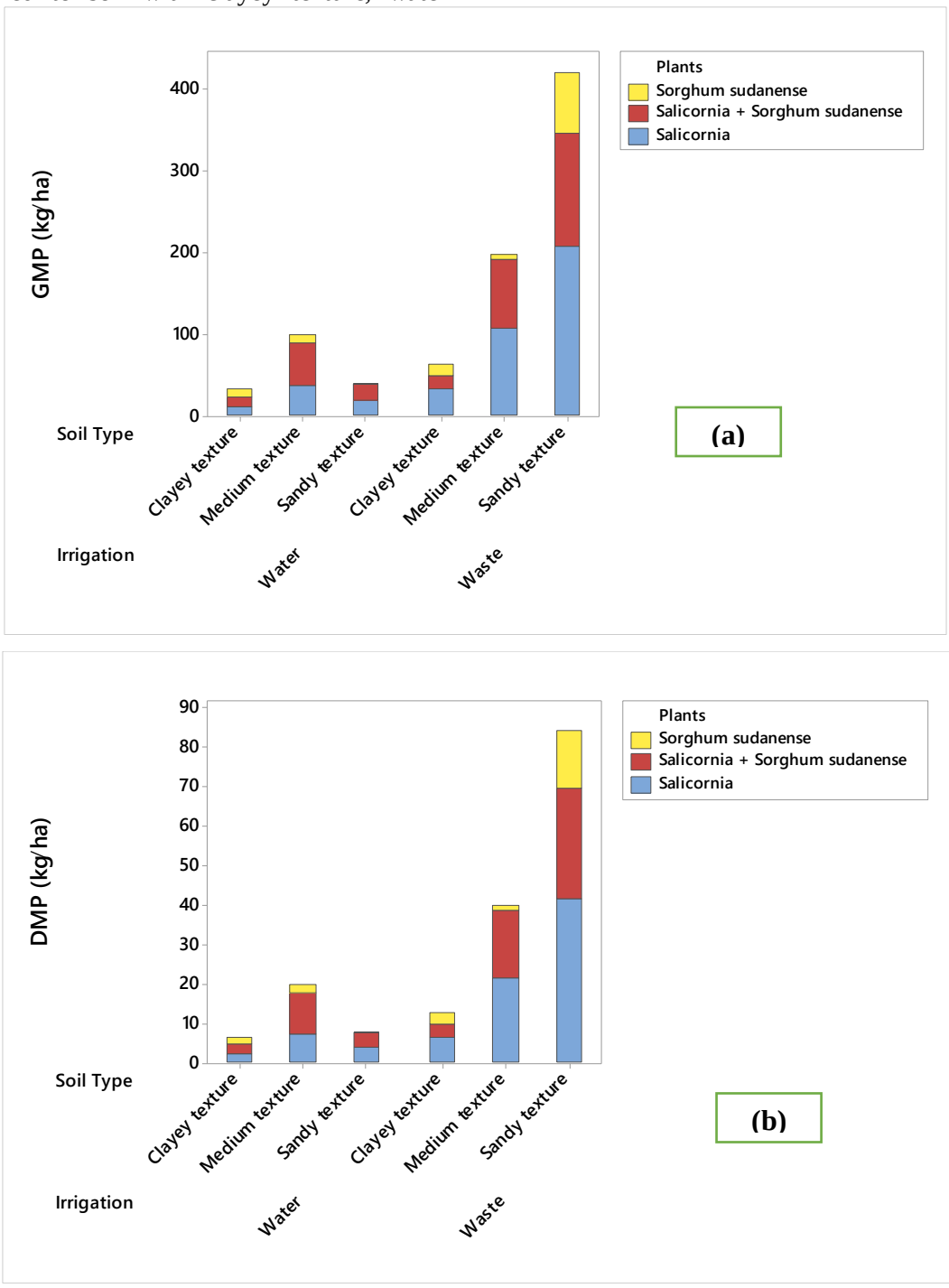

Fig1. *Results obtained for the production of green matter - (a) and dry - DMP (b) from Salicornia neeiin consortium, or not, with Sorghum sudanense, in three different textures of soil and irrigated with water and desalinator reject*

It can be seen from Fig. 2 (a) and (b) the growing effect on plant growth (increased production of green matter - GMP (a) and dry - DMP (b)) starting from the soil with clayey texture, reaching its peak in the medium texture and decreasing in the sandy texture. Likewise, analyzing the Plant factor: the use of the consortium of *Salicornia neei* and *Sorghum sudanense* did not show greater growth; however, with the use of only *Salicornia neei* there is a greater growth in GMP and DMP. Finally, analyzing the use of water or desalinator reject, a higher production of DM and GM is observed with the use of the desalinator reject.

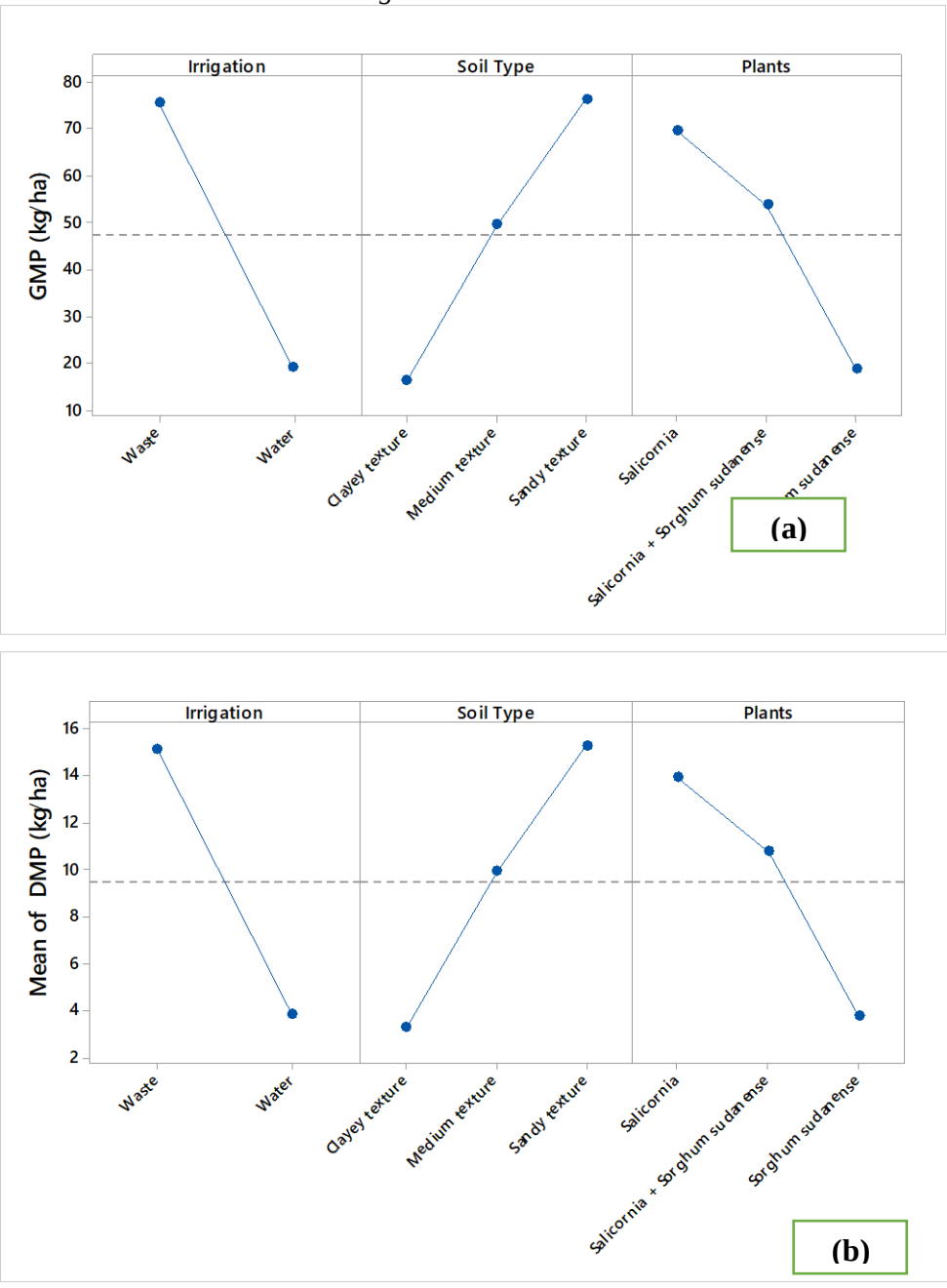

Fig2. *Results obtained for the upward effect of green matter - GMP (a) and dry - DMP (b) from Salicornia neeiin consortium, or not, with Sorghum sudanense, in three different textures of soil and irrigated with water and desalinator reject*

In Fig. 3, it is observed, through the simultaneous optimization of the studied variables, that the consortium between *Salicornia neei* and *Sorghum sudanense* responded satisfactorily to the absorption of Na^+ (5.91), Ca^+ (1.77%), Mg (3.29%), K (2.53%) and TF (18.71%) when irrigated with desalinator reject, in the soil with a clayey texture, increasing, therefore, the production of

green matter (GMP) and consequent production of dry matter (DMP).

In general, these results reported here expose evidence that the higher volumes of salts reduce the growth of plants and, consequently, delay their physiological maturity, implying lower levels of total fiber (TF).However, although it improves the nutritional value, lower growth rates result in lower forage productivity.[20] studying several grass cultivars, concluded that values above 65% are common in new tissues and contents between 75 and 80% are found in materials of very advanced maturity, which may indicate a negative correlation with forage consumption.

According to [21], there is a decrease in the levels of calcium, magnesium, potassium and an increase in sodium content, causing imbalance and nutritional stress in millet and sorghum plants.The levels of Ca^{2+} found for the culture of millet and sorghum were within the range considered adequate for sorghum (4.0 to 6.0 g/ kg), according to [22].

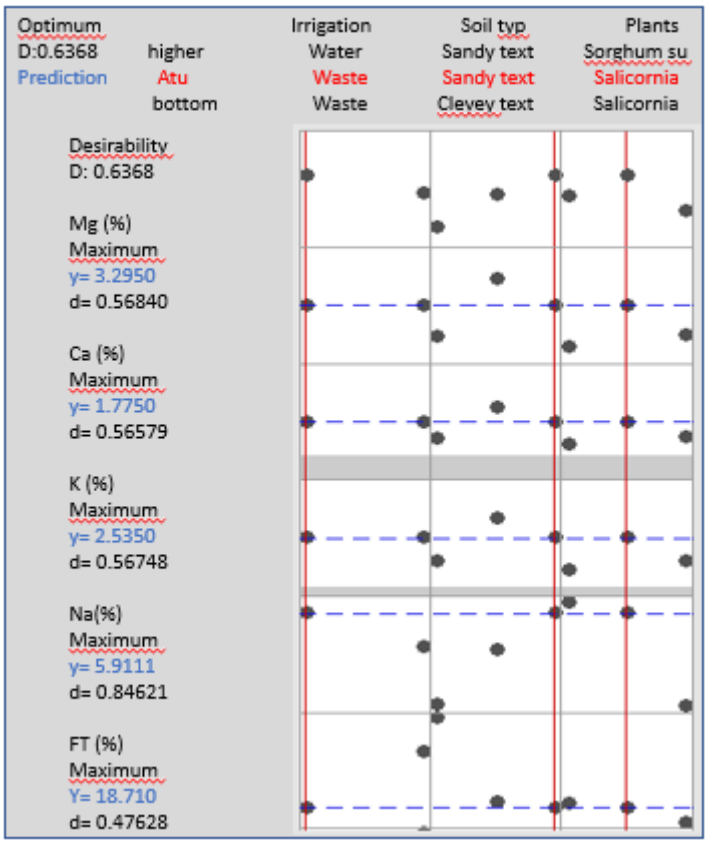

Fig3. *Results obtained for nutrient absorption by Salicornia neeiin consortium, or not, with Sorghum sudanense in three different textures of soils and irrigated with water and desalinator reject*

CONCLUSION

From the results obtained, it can be concluded that *Sorghum sudanense* presented a better production of green and dry matter, when irrigated with desalinator reject and cultivated in the soil with clayey texture. *Salicornia neei* in consortium with *Sorghum sudanense* presented better total fiber and absorption of sodium, potassium, calcium and magnesium in the soil with a clayey texture and irrigated with desalinator reject. Therefore, the consortium between *Salicornia neei* and *Sorghum sudanense* can be favored by the nutrients provided by *Salicornia neei*.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

[1] Silva AL, Edvan RL, Bezerra LR, Araújo MJ, Costa Filho JH, Torreão JNC, Amorim DS, Nascimento RR. Agronomic characterization and chemical composition of sorghum hybrids for silage making in rainfed conditions. Agrarian Sciences, 2020; 41 (2): 404-420.

[2] Silva KAV, Oliveira JP, Fernandes JG, Messias AS. Influence of Arbuscular Mycorrhizal Fungus in the Development of Salicornia um saline Water. Journal ofAdvances in Microbiology, 2019; 16 (4): 1-6.

[3] Albuquerque AS, Fonsêca NC, Santos, RV. Application of alternative correctives in salinized soil with cultivation of *Sorghum bicolor L.*Green Journal of Agroecology and Sustainable Development, 2018; 13 (4): 452-458.

[4] 4.Kurmanbayeva A, Bekturova A, Srivastava S, Soltabayeva A, Asatryan A, Ventura Y, Khan MS, Salazar O, Fedoroff N, Sagi M. Higher novel L-cys degradition activity results in lower organics and biomass in Sarcocornia than the related saltwort, Salicornia. Journal of Plant Physiology, 2017; 175 (1): 272-289.

[5] Feijão AR, Silva JCB, Marques EC, Prisco JT, Gomes Filho E. Effect of nitrate nutrition on tolerance of sudangrass plants to salinity. Agronomic Science Magazine,2011; 42 (3): 675-683.

[6] Rodrigues CR, Comasseto DS, Dornelles RR, Rosa FQ, Oiagen RP, Castagnara DD, Del Valle TA, Azevedo EB. Production, bromatological, and phenological composition of tropical forage in the South Region of Brazil. Agrarian Magazine, 2020; 13 (47): 82-92.

[7] Simões WL, Guimarães MJM, Araújo GGL, Willadino LG, Perazzo AF, Belfort LS. Chemical-bromatological characteristics of forage sorghum varieties irrigated with saline effluents from fish farming. Comunicata Scientiae, 2019; 10(1): 195-202.

[8] Tolentino DC, Rodrigues JAS, Pires DAA, Variato FT, Lima LOB, Moura MMA. The quality of silage of different sorghum genotypes. Acta Scientiarum, 2016; 38 (2): 143-149.

[9] Tabosa, JN, Barros AHC, Silva FG, Brito ARMB, Simões AL, Mesquita FLT, Nascimento MMA, Silva Filho JG, França JGE, Silva AB, Ferraz I, Carvalho EX, Cordeiro AL, Simplício JB.Importance of genetic improvement of diferente types of sorghumfor the mesoregions of Agreste, Sertão and the like in the Brazilian Semiarid. Embrapa/Solos, Cap. 4, 2019: 515-569.

[10] Lima MHM, Pires DAA, Moura MMA, Costa RF, Rodrigues JAS, KA. Nutritional characteristics of sorghum hybrids hay (*Sorghum sudanense* vs. *Sorgo bicolor*). Acta Scientiarum, 2017; 39 (3): 229-234.

[11] Morril WBB, Rolim MM, Bezerra Neto E, Pedrosa EMR, Oliveira VS, Almeida GLP. Production and mineral nutrients of forage millet and *Sorghum sudanense* fertilized with whey.Brazilian Journal of Agricultural and Environmental Engineering, 2012; 16 (2): 182-188.

[12] Agronomic Institute of Pernambuco (IPA). *Sorghum sudanense*. Sudan 4202.Cultivate tolerant to salinity and with aptitude for hay. Pernambuco, Brochure, 2. ed.2008: 2.

[13] Kirchner JH, Robaina AD, Peiter MX, Torres RR, Mezzono W, Bem LHB, Pimenta BD, Pereira AC. Production functions and efficiency in the use of irrigated fodder water.Brazilian Journal of Agricultural Sciences, 2019; 14 (2): 1-9.

[14] Doncato KB, Costa CSB. Growth and mineral composition of two lineages of the sea asparagus *Sarcocornia ambigua* irrigated with shrimp farm saline effluent. Experimental Agriculture**,** Cambridge, 2018; 54(3): 399-416.

[15] EMBRAPA. Brazilian Agricultural Research Company. Manual methods of soil analysis. Rio de Janeiro: Embrapa Solos, 2011: 230.

[16] AOAC.Official Methods of Analysis. Association of Official Agricultural Chemists. 21. ed., 2019: 97.

[17] Magalhães RT, Gonçalves LC, Borges I, Rodrigues JAS, Fonseca JF.Production and chemical composition of twenty-five sorghum genotypes (Sorghum bicolor (L.) Moench). Brazilian Archive of Veterinary Medicine and Animal Science, 2010; 62: 747-751.

[18] Carvalho AA, Montenegro AAA, Tabosa JN, Almeida TAB, Silva AGO, Silveira AVM. Hydro-agricultural reuse: a solution for coping with water scarcity in the Sertão and Agreste of Pernambuco. Journal of Environmental Analysis and Progress, 2020; 5 (2): 140-150.

[19] Moraes SD, Jobim CC, Silva MS, Marquardt FI. Production and chemical composition of sorghum and corn hybrids for silage. Brazilian Journal of Health and Animal Production, 2013; 14 (4): 624-634.

[20] Santos FJS, Rodrigues BHN, Magalhães JA, Costa NL. Productivity of forage grasses irrigated with water of different electrical conductivities in the semiarid region of the nth of Piaui. Pubvet, 2019; 13 (4): 1-9.

[21] Ferreira PA, Garcia GO, Santos DB, Oliveira FG, Neves JCL. Saline stress in maize plants: II - Cationic macronutrients and their relations with sodium. Brazilian Journal of Agricultural and Environmental Engineering, 2005; 9: 11-15.

[22] Agronomic Institute of Pernambuco (IPA). Fertilization recommendations for the State of Pernambuco. Recife: IPA, 2008; 64.

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