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PERFORMANCE OF *CENCHRUS PURPUREUS* VARIETIES TOLERANT TO SALINITY UNDER THE EDAPHOCLIMATIC CONDITIONS OF GRANMA PROVINCE, CUBA

COMPORTAMIENTO DE VARIEDADES DE *CENCHRUS PURPUREUS* TOLERANTES A LA SALINIDAD EN LAS CONDICIONES EDAFOCLIMÁTICAS DE LA PROVINCIA GRANMA, CUBA

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Using a random block design and four replications, the productive performance and quality of salinity - tolerant *Cenchrus purpureus* varieties (CT-500, CT-502, CT-504, CT-508) was studied and compared with CT-115 under the edaphoclimatic conditions of Granma province at different regrowth ages (45, 60, 75 and 90 days). There were evaluated length and width of leaves and internodes, plant height, leaves and stem percent, leaf area, Absolute Growth Rate and Relative Growth Rate, dry matter yield and the quality indicators CP, NDF, ADF, ADL, DMA and bovine intake index. There was significant interaction (P<0.05) and increases with the regrowth ages, for the length of leaves, internodes, plant height, leaves width and leaf area with 136.75 cm, 20.10 cm, 187.50 cm (CT-504), 4.18 cm and 549.75 cm^2 for CT-115 at 90 days, respectively, although there were not differences for this variable in CT-500 and CT-502 varieties. The highest Relative and Absolute Growth Rate during the rainy season were for CT-115 at 60 days with 3.12 $cm.day^{-1}$ and 0.0173 $cm.cm^{-1}.day^{-1}$, respectively, and for the components of the cell wall (NDF, ADF and ADL) with values of 70.93 %, 39.20 % and 4.89 % at 90 days for CT-504 (NDF and ADF) and CT-500 (ADL). There were decrease of CP and DMD in 6.64 and 16.59percentage units respectively, with the highest values at 45 regrowth age (11.90 and 67.73 %) in CT-115 and CT-502 varieties. The intake index was

Mediante un diseño de bloques al azar y cuatro réplicas se estudió el comportamiento productivo y calidad de variedades de *Cenchrus purpureus* tolerantes a la salinidad (CT-500, CT-502, CT-504, CT-508) comparados con el CT-115 en las condiciones edafoclimáticas de la provincia Granma a diferentes edades de rebrote (45, 60, 75 y 90 días). Se evaluaron longitud y ancho de hojas y entrenudo, altura de la planta, porciento de hojas y tallos, área foliar, Tasa de Crecimiento Absoluto y Tasa de Crecimiento Relativa, rendimiento en materia seca y los indicadores de calidad PB, FDN, FDA, LAD, DMS e índice de consumo bovino. Hubo interacción significativa (P<0.05) e incrementos con la edad de rebrote, para la longitud de las hojas, entrenudos, altura de planta, ancho de las hojas y área foliar con 136.75 cm, 20.10 cm, 187.50 cm (CT-504), 4.18 cm y 549.75 cm^2 para CT-115 a los 90 días, respectivamente, aunque no se presentó diferencias para esta variable en las variedades CT-500 y CT-502. Las mayores Tasa de Crecimiento Absoluto y Relativa durante la estación lluviosa fueron para CT-115 a los 60 días con 3.12 $cm.día^{-1}$ y 0.0173 $cm.cm^{-1}.día^{-1}$, respectivamente y también para los componentes de la pared celular (FDN, FDA y LAD) con valores de 70.93 %, 39.20 % y 4.89 % a los 90 días para el CT-504 (FDN y FDA) y CT-500 (LAD). Hubo decrecimiento de la PB y DMS en 6.64 y 16.59 unidades porcentuales respectivamente, con los mayores valores a los 45 días de rebrote (11.90 y 67.73 %) en las variedades CT-115 y CT-502. El índice de consumo se incrementó hasta los 60 días con su mayor valor (114.95 $g.kg^{-1}$ PV) para

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increased until 60 days with it highest value (114.95 g.kg^{-1} LW) for CT-115. The effect of the interaction variety x regrowth age in salinity -tolerant *Cenchrus purpureus* varieties in the morphological indicators, yield and nutritive quality was showed in this study and the best morphological indicators, yield, growth rate and components of the cell wall in CT-504 and CT-508 were obtained, while CT-115 was higher in leaf area, digestibility and intake index. These varieties can be an option for cattle feeding in soil of medium and low salinity of the eastern region of the country.

Key words: *nutritive quality, morphological indicators, yield, growth rate*

CT-115. El efecto de la interacción variedad x edad de rebrote en variedades de *Cenchrus purpureus* tolerantes a la salinidad en los indicadores morfológicos, rendimiento y calidad nutritiva quedó demostrado en el presente estudio y se obtuvieron los mejores indicadores morfológicos, rendimiento, tasa de crecimiento y componentes de la pared celular en CT-504 y CT-508, mientras que CT-115 fue superior en área foliar, digestibilidad e índice de consumo. Estas variedades pueden ser una opción para la alimentación del vacuno en suelo de mediana a baja salinidad de la región oriental del país.

Palabras clave: *calidad nutritiva, indicadores morfológicos, rendimiento, tasa de crecimiento*

Introduction

In Cuba, grasses and forage were, are and will be the feeding basis of cattle. The reasons that justify this foundation are, among others: possibilities to grow them all year, ability of the ruminant of using fibrous food, do not compete as a source of food with other species, it use is financially viable and contributes to the conservation and improvement of the environment (Herrera *et al.* 2017).

One of the factors that most influence on the yield and quality of forages is the soil in which they are developed, that can be alter by natural causes or provoked by human activity, in which the salinization process play an essential role. Worldwide are affected by these disaster millions of hectares and is estimated that are loss because this cause 1,5 million of hectares with irrigation, which means the reduction of 11 billion dollars in agricultural productivity (FAO 2018).

In Cuba there are damaged by salinity one million of hectares, around 15 % of the agricultural area and with serious risk of continuing increasing. In the eastern region of the country are the highest damages with about 650 000 hectares of soils destined to livestock and agriculture and is one of the main causes of the low economic and productive efficiency of the territory, by the decrease of grasses and forage production, up to 25 % in many of the enterprises from the region. In Valle del Cauto with an extension of 9 540 km^2, the salinization process reach 38 % of it area (INRH 2018).

As strategy to solve this problem, in Animal Science Institute through the *in vitro* tissue culture as a tool for the plant improvement new Cenchrus *purpureus* varieties with marked phenotypic differences were obtained and new expectations in their use were created. The CT-169 with forages characteristics and CT-115 for grazing were selected and biomass bank technology was developed to solve the lack of food in the dry season. This line of thought continuous developing and the physical and chemical mutagens were applied to obtain new *Cenchrus purpureus* varieties (Herrera *et al.* 2015), with possible tolerance to through and salinity (Herrera *et al.* 2003).

This alternative of using new varieties, obtained by tissue culture from CT-115, with salinity tolerance and under Granma conditions has being showed a promissory performance compared with their progenitor (Arias *et al.* 2018 and Ray *et al.* 2018) could be an option for animal feeding if they are favorably establishing under this edaphoclimatic conditions.

In accordance with the above, the objective of this research was to determine the productive performance and quality of *Cenchrus purpureus* varieties (CT-500, CT-502, CT-504 and CT-508, compared with CT-115) in soils from medium to low salinity of Granma province, Cuba.

Materials and methods

Location of the experimental area, climate and soil. The experiment was performed in the UBPC ¨Francisco Suárez Soa¨, belongs to the Agricultural enterprise from Bayamo, Granma province, located at 7, 5 km of Bayamo, in Holguin road. This one is located in an area with characteristics of semiarid regions in the province. Two seasonal periods were considered, rainy (May - October) and dry (November-April). During the experimental period in the rainy season the rainfalls were of 406 mm, the average, minimum and maximum temperature recorded values of 30.55 ^{0}C, 26.96 ^{0}C and 34.01 ^{0}C, respectively and the average relative humidity of 83 %. In the dry season the rainfalls reached the 67 mm, the temperature was of 24.1 ^{0}C, 18.5 ^{0}C and 29.8 ^{0}C for the average, minimum and maximum, respectively and the average relative humidity of 80.33 %. Values that are within the range of the historical mean, except the rainfalls, which are currently lower in the dry season.

The soil of the experimental area is of Pelic Vertisol type according to the new classification of soils of Cuba (Hernández *et al*. 2015), with extensive areas affected by salinization process of medium to low (2-4 ds.m^{-1}) and low organic matter content. The chemical composition of the soil is in table 1.

Experimental design and treatments. A random block design with four replications was used and the experimental units

Table 1. Chemical composition of the soil in the experimental area

pH		mg.100g^{-1} of soil		OM, %	Salinization, ds.m^{-1}
KCl	H_2O	P_2O_5	K_2O		
4.9	6.3	0.97	6.2	2.35	2.6

were the 20-m^2 plots. The treatments were four new *Cenchrus purpureus* varieties (CT-500, CT-502, CT-504 and CT-508) obtained by *in vitro* tissue culture in Instituto de Ciencia Animal (Herrera *et al.* 2003) and were compared with the progenitor (CT-115). All the varieties were molecularly identified (Álvarez 2021).

Experimental procedure. A flat area was selected, free of big stones and without low-lying areas, after a soil map to define a zone of medium to low salinity. The soil was conventionally prepared on April 2016 and the planting was on May. Five- months- old agamic seeds were used (from estación de pastos y forrajes del Instituto de Investigaciones Agropecuarias (IIA) "Jorge Dimitrov"), which were place at the bottom of the furrow of 20cm deep, place on top of the apical and basal part of the next one, later they were cut with a machete in pieces of 4-5 buds spaced at a meter between furrows and a density of 4 t.ha^{-1}. The covering was made with hoe with 10cm of soil. The same amount of seeds and buds per plots was guaranteed for having the same population. The establishment period lasted 180 days, the homogeneity cut was made, and the population per plot was of 99 %. There was not fertilization and irrigation during the experimental period. Manual labors to control the weeds were carried out.

Evaluations. From the establishment cut, the measurements in five plants per replication were carried out (Herrera 2005, 2007) at 45, 60, 75 and 90 regrowth days in each seasonal period. The length and width (cm) of the fourth leaf completely open and plant height (cm) were determined using a millimeter ruler. For length and diameter of the fourth internode (cm) from down to up a vernier was used. The leaf area (cm^2) was determined according to Ferraris and Wood (1980) recommendations, the percentage of leaves and stems was quantified through the weight of each part in five plants. The dead material was not counted due to their insignificant appearance at 90 d of regrowth.

The physiological variables Absolute Growth Rate (AGR) and Relative Growth Rate (RGR) were calculated according to the procedure described by de Armas *et al.* (1988) and the following formulas were used:

$$AGR = \frac{Difference\ \ of\ \ height}{Difference\ \ of\ \ time}\ \left(cm\,.\,day^{-1}\right)$$

$$RGD = \frac{Difference\ \ of\ \ height}{Difference\ \ of\ \ time} \times \frac{1}{Final\ \ height}$$

$$\left(cm\,.\,cm^{-1}\,.\,day^{-1}\right)$$

To determine the dry matter (DM) yield the cut and weighing of the plot was carried out in each of the evaluated ages (45, 60, 75 and 90 days), from November to January for the dry season and from May to July for the rainy season, at a height of 10 cm, to obtain the total volume of each plot. A length of 50 cm of border effect in the heads and a meter in the laterals were through away. To determine the DM percentage of the forage, a 200 g sample (with four replications per cut ages in each variety) was weighed in a digital scale with ± 1 g precision. This sample was for 72 h in an air circulation oven at 60 ºC to constant weight for their analysis (AOAC 2016).

Chemical composition. To the whole plant for each variety and regrowth age, after milled in a mill with 1mm sieve were determined dry matter (DM) and crude protein (CP) according to the AOAC (2016) methods and NDF, ADF, ADL according to Goering and Van Soest (1970), all by triplicate.

For the dry matter digestibility, the Ørskov *et al*. (1980) method was used, a total of two canulated bovine of 400 g weight from Criolla Cubana breed were used, which were treated against ecto and endoparasite before beginning the test. Before and during the experimental period, the animals were stabulated and received a basic diet of grasses at a rate of 10 % of their live weight, in proportions of 80:20 of *Cenchrus purpureus* vc. CT-115 and CT-169 and *Cynodon nlemfuensis* vc. Jamaican previous adaptation of two weeks to the food. The samples from each regrowth age were incubated by triplicate in each animal.

For this, nylon bags of 10 cm width x 15cm length with pore size of 50 µm diameter were used. A total 5 g of sample were weighed and added in each bag, which later were incubated by duplicate in each of the animals in times of 24 h. After taking away, the bags were washing with running water until it drain clean. Later they were put in aluminum tray and dried in an air circulation oven at 65 °C for 72 h, and finally were weighed. The difference between the initial weight of the simple put in the bags and the waste weight after the incubation was used to determine the DM intake in the rumen (Ørskov and McDonald 1979).

The Bovine Intake Index (BII), expressed in grams of dry matter per metabolic weight (gDM.LW$^{0.75}$), was determined by the intake in 24h, according to methodology proposed by Cáceres and González (2000), quantified by the low reject offer (intake (kg)= forage offer - reject). For which four male bovine crossbreeding of Cebu, healthy with an average weight of 317 kg ±15 were used, to those was supplied a basic diet of forage from the evaluated varieties at different cut ages at a rate of 15 % of their live weight, divided into two rations 08:00 and 16:00 hours. Supplements were not supplied and had water *ad libitum* in the pen, which has adequate vital space and front of feeding through for the category. Before the evaluation the animals were 15 days intake forage from this genus.

Statistical analysis The Statistica 12.0 (StatSoft 2011) program was used, the normal distribution of data was checked through Kolmogorov-Smirnov (Massey 1951) test and the homogeneity of variances according to Bartlett (1937) criteria. Analyses of variances according to the requirements of the experimental design were carried out. The means were compared through Keuls (1952) test. For the agronomical indicators the mean value and the standard error were determined.

Results

The morphological indicators during the rainy season (table 2) has interaction (variety x days for $P<0.05$) and there were increases with the regrowth age, for leaves length, internodes, plant height, leaves width and leaf area with 136.75 cm, 20.10 cm, 187.50 cm (CT-504), 4.18 cm and 549.75 cm^2 for CT-115 at 90 days, although there was not differences for this variable with CT-500 and CT-502. The internodes diameter increased up to 75 days to later decrease with the highest results with 2.00 cm for CT-500.

During the dry season (table 3), there was variability in their performance with respect to the rainy season, where length, leaves width and leaf area had their highest values at 75 days for CT-500 variety (107.30 cm, 3.60 cm and 380.63 cm^2, respectively). The internodes length and plant height was higher at 90 days in CT- 504 con 15.48 cm and 169.75 cm, respectively. On the other hand, the internodes diameter with 1.88cm was higher at 60 days in CT-500 variety for later decrease up to 90 days in 0.69 cm.

For the Absolute Growth Rate and the Relative Growth Rate (table 4) during the rainy season the highest values were for CT-115 at 60 days with 3.12 $cm.day^{-1}$ and 0.0173 $cm.cm^{-1}.day^{-1,}$ respectively and during the dry season the AGR was higher for CT-508 at 45 days with 2.32 $cm.day^{-1}$ and the RGR with 0.014 $cm.cm^{-1}.day^{-1}$ at 75 regrowth days for CT-115.

The yield indicators during the rainy season (table 5) had interaction variety x days for $P<0.05$, with increase in the stems percent and dry matter yield with the regrowth age with the highest values for CT-504 (71.90 % and 14.79 $t.ha^{-1}$); on the other hand, the leaves decreased with 57.98 % at 45 days for CT-500. During the dry season (table 6) there was a similar performance with 77.87 % of stems and 4.99 $t.ha^{-1}$ DM for CT-504 at 90 days, and 31.67 % of leaves at 45 days for CT-508.

The nutritive quality during the rainy season (table 7) had an exclusive performance of grasses with increases in the age of the cell wall components (NDF, ADF and ADL) with values of 70.93, 39.20 and 4.89 % at 90 days for CT-504 (NDF and ADF) and CT-500 (ADL), and decrease of CP and DMD in 6.64 and 16.59 percentage units with the highest values at 45 regrowth days (11.90 % and 67.73 %) in CT-115 and CT-502 varieties. The intake index increased up to 60 days with the higher result (114.95 $g.kg^{-1}$ LW) for CT-115.During the dry season (table 8) at 90 regrowth days was higher the cell wall, ADF and ADL for CT-508 with 73.55, 39.98 and 4.85 %, respectively. The CP and DMD were better for CT-500 and CT-502 at 45 days with 11.90 and 65.90 %, respectively and the BII with 116.70 $g.kg^{-1}$ LW was higher for CT-115 at 60 days.

Discussion

The changes in the morphological composition of the *Cenchrus purpureus* varieties (tables 2 and 3) are influenced by the edaphoclimatic conditions, which can increase or decrease the growth of leaves and stems, as well as varied their development. Ledea Rodríguez *et al.* (2017) and Arias *et al.* (2019) find that the leaves increase their appearance, when there are temperatures between 20 to 32.5 °C, and decrease if the temperature exceeds the 35 °C (Ledea Rodríguez *et al.* 2018a). In this research during the rainy season, these indicators were increased while in the dry season increased up 75 days and later decreased. In Arias *et al.* (2019) studies there were not marked differences in leaves width and their length showed the highest values at 90 days, response that was related with luminosity values which refers to the leaf area and interception of the radiant energy, hence the climatic season favors the leaves morphology and it seems not to has effect the mutual shading of leaves which contributes to the maintenance of the covering.

Superior results obtained Arias *et al.* (2018) when evaluating *Cenchrus* clones tolerant to salinity during the dry season in Valle del Cauto and also similar to those reported by Ledea Rodríguez *et al.* (2017), 2018a) and Álvarez *et al.* (2019), 2020) when studying the leaves length at 60 and 75 regrowth days in *Cenchrus purpureus* varieties tolerant to salinity and OM-22, in the western region of Cuba, respectively denoting the morphological response of this genus to the incidence of solar radiations which characterized the tropical belt but, they are marked mainly in the tropic.

In both seasonal periods, there was significant interaction varieties x regrowth age for plant height and the highest values were recorded in the dry season. In this sense, Herrera *et al.* (2019) in *Cenchrus* varieties for biomass production find differences in plants height in both climatic

Table 2. Performance of morphological indicators in the rainy season

Varieties	**Age, days**				**SE[1]±**	**p**
	45	**60**	**75**	**90**		
Leaf lenght, cm						
CT-500	88.25^{i}	100.75^{e}	93.00^{h}	129.75^{d}	1.85	0.0001
CT-502	88.24^{i}	100.70^{e}	92.97^{h}	129.70^{d}		
CT-504	86.25^{j}	97.75^{f}	97.75^{f}	136.75^{a}		
CT-508	84.75^{k}	95.50^{g}	95.00^{g}	127.25^{c}		
CT-115	86.75^{j}	97.13^{f}	95.75^{g}	131.88^{b}		
Leaf width ,cm						
CT-500	2.55^{e}	2.95^{cd}	3.35^{b}	4.18^{a}	0.33	0.001
CT-502	2.53^{e}	2.92^{cd}	3.33^{b}	4.16^{a}		
CT-504	2,43^{e}	2.48^{e}	3.38^{b}	4.13^{a}		
CT-508	2.33^{f}	3.03^{c}	3.30^{b}	3.38^{b}		
CT-115	2.53^{f}	2.68^{de}	3.30^{b}	4.18^{a}		
Internodes lenght,cm						
CT-500	9.76^{h}	9.18^{ij}	9.53	16.08^{cd}	0.55	0.001
CT-502	9.74^{h}	9.16^{ij}	9.52	16.04^{c}		
CT-504	8.48^{k}	10.60^{g}	11.38^{e}	20.10^{a}		
CT-508	9.33^{i}	8.88^{jk}	11.20^{ef}	16.60^{d}		
CT-115	9.05^{ij}	10.54^{g}	10.71^{fg}	19.04^{b}		
Internodes diameter,cm cmcm						
CT-500	1.64^{g}	1.80^{c}	2.00^{a}	1.50^{h}	0.05	0.001
CT-502	1.66^{fg}	1.78^{c}	1.99^{a}	1.48^{h}		
CT-504	1.70^{ef}	1.70^{ef}	1.88^{b}	1.51^{h}		
CT-508	1.50^{h}	1.73^{de}	1.90^{b}	1.28^{j}		
CT-115	1.78^{c}	1.76^{cd}	1.86^{b}	1.34^{i}		
Plant height,cm						
CT-500	78.75^{m}	132.00^{i}	147.25^{f}	180.25^{b}	3.25	0.0001
CT-502	78.76^{m}	128.00^{ij}	147.22^{f}	180.23^{b}		
CT-504	115.00^{k}	140.25^{h}	170.75^{d}	187.50^{a}		
CT-508	86.50^{l}	129.25^{j}	144.25^{g}	177.75^{c}		
CT-115	88.38^{l}	133.13^{i}	156.63^{e}	182.88^{b}		
Leaf area, cm^2						
CT-500	225.43^{h}	297.05^{e}	311.38^{d}	541.73^{a}	12.44	0.001
CT-502	225.41^{h}	296.98^{e}	311.35^{d}	541.70^{a}		
CT-504	208.90^{i}	240.23^{g}	330.50^{c}	478.93^{b}		
CT-508	196.55^{j}	288.98^{e}	313.15^{d}	486.68^{b}		
CT-115	218.49^{hi}	259.30^{f}	315.99^{d}	549.75^{a}		

^{a,b,c,d,e,f,g,h,i,j,k,l,m,n} Values with uncommon letters differ to $P<0.01$ Keuls (1952)

[1]SE, standard error of the interaction variety x days

seasons and decrease of this indicator from the second year of evaluation, which was attributed to the specific characteristics of each plant and their response to the conditions of climate, soil and manage since the study was carried out without the application of irrigation and fertilization. Villanueva Ávalos *et al.* (2022), when evaluating 16 varieties under the dry tropic conditions find the highest heights at 180 days for CT-169. Ray *et al.* (2018) in drought - tolerant clones under pre-mountain conditions when evaluating the growth curves find that all the varieties showed sigmoid growing typical of grasses, which showed that for *Cenchrus purpureus* varieties the pre-mountain conditions are favorable for their growing and developing.

The values of plants height in this study are lower to those reported by Reyes Pérez *et al.* (2021) for Maralfalfa (215 cm) with the use of fertilization under the conditions of María, Ecuador and Cruz Tejeda *et al.* (2017) when evaluating new *C. purpureus* varieties obtained by tissue culture tolerant to salinity from Cuba CT-115 in fragile systems of Granma province. These last authors notified

Table 3. Performance of the morphological indicators in the dry season

Varieties	Age, days				SE[1]±	p
	45	60	75	90		
			Leaf lenght , cm			
CT-500	93.25^{e}	98.52^{c}	107.30^{a}	96.08^{cd}	3.35	0.01
CT-502	93.22^{e}	98.48^{c}	107.28^{a}	96.07^{cd}		
CT-504	104.25^{b}	106.50^{ab}	107.25^{a}	97.63^{cd}		
CT-508	92.25^{e}	98.00^{c}	106.50^{ab}	92.48^{e}		
CT-115	86.00^{f}	102.75^{b}	103.63^{b}	94.85^{de}		
			Leaf width, cm			
CT-500	2.42^{f}	3.17^{cd}	3.60^{a}	3.13^{d}	0.11	0.01
CT-502	2.38^{fg}	3.13^{d}	3.59^{a}	3.11^{d}		
CT-504	2.33^{fg}	3.28^{c}	3.48^{b}	3.55^{ab}		
CT-508	2.25^{g}	2.90^{e}	3.58^{ab}	2.73^{f}		
CT-115	2.41^{f}	3.23^{c}	3.53^{ab}	3.11^{d}		
			Internodes lenght , cm			
CT-500	9.27^{h}	9.55^{gh}	10.10^{ef}	14.53^{b}	0.35	0.01
CT-502	9.23^{h}	9.53^{gh}	10.09^{ef}	14.51^{b}		
CT-504	10.43^{e}	10.98^{d}	11.15^{d}	15.48^{a}		
CT-508	9.63^{g}	9.40^{gh}	9.50^{gh}	13.08^{c}		
CT-115	8.15^{i}	10.06^{f}	10.36^{ef}	15.40^{a}		
			Internodes diameter, cm			
CT-500	1.73^{cd}	1.88^{a}	1.60^{ef}	1.20^{i}	0.09	0.01
CT-502	1.71^{cd}	1.87^{a}	1.59^{ef}	1.19^{i}		
CT-504	1.58^{ef}	1.65^{de}	1.60^{ef}	1.33^{h}		
CT-508	1.50^{g}	1.78^{bc}	1.55^{fg}	1.31^{h}		
CT-115	1.56^{ef}	1.84^{ab}	1.53^{fg}	1.29^{h}		
			Plant height, cm			
CT-500	84.25^{k}	102.75^{j}	136.40^{f}	157.25^{c}	4.78	0.001
CT-502	84.24^{k}	102.73^{j}	136.48^{f}	157.24^{c}		
CT-504	104.00^{j}	127.50^{g}	150.25^{d}	169.75^{a}		
CT-508	101.25j	113.25^{i}	136.13^{f}	159.50^{bc}		
CT-115	85.63^{k}	121.63^{h}	141.50^{e}	162.25^{b}		
			Leaf area, cm^2			
CT-500	223.70^{j}	310.50^{e}	380.60^{a}	300.29^{f}	9.67	0.001
CT-502	223.68^{j}	310.49^{e}	380.58^{a}	300.28^{f}		
CT-504	241.33^{i}	348.00^{c}	372.43^{ab}	346.50^{c}		
CT-508	207.95^{k}	283.75^{g}	380.63^{a}	252.02^{h}		
CT-115	207.31^{k}	330.61^{d}	364.89^{b}	296.78^{f}		

^{a,b,c,d,e,f,g,h,i,j,k} Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

2.1 m height in the establishment cut (180 days), while Ledea Rodríguez *et al*. (2017) notified 0.80 m, which showed the marked effect of the environmental on the plants performance.

Herrera *et al.* (2018) and Herrera (2020) stated that the climate elements interact and has marked effect on the growing and developing of species and varieties of grasses in the different month of the year, causing a seasonal imbalance in the growing mainly in the dry season. To this situation, it is added that, the soils destined to grasses growing most of them are of low fertility and bad drainage, that jointly with the climate, exert negative effects on the persistence of forages. Aspects that has taking into account for the introduction of improvements species with more adaptation to different livestock systems with better potentialities from the productive point of view.

The variability in the length and diameter of the internodes in both season of the year (tables 2 and 3) was similar to those reported for *Cenchrus* varieties by Arias *et al.* (2018, 2019). However, Álvarez *et al.* (2020) in

Table 4. Performance of the absolute and relative growth rate

Varieties	Regrowth age, days							
	AGR, cm.days^{-1}				RGR, cm.cm^{-1}.days^{-1}			
	45	60	75	90	45	60	75	90
				Rainy season				
CT-500	1.96^{e}	2.91^{b}	1.24^{j}	2.19^{d}	0.0110^{e}	0.0157^{b}	0.0066	0.0113^{e}
CT-502	1.97^{e}	2.69^{c}	1.53^{hi}	1.88	0.0111^{e}	0.0155^{b}	0.0061^{h}	0.0109^{e}
CT-504	1.97^{e}	3.17^{a}	1.65^{gh}	1.47^{i}	0.0107^{ef}	0.0173^{a}	0.0090^{g}	0.0080^{g}
CT-508	2.59^{c}	1.65^{g}	1.99^{e}	1.12^{j}	0.0138^{c}	0.0088^{g}	0.0105^{ef}	0.0059^{h}
CT-115	1.80^{f}	3.12^{a}	1.19^{j}	2.29^{d}	0.0100^{f}	0.0173^{a}	0.0065^{h}	0.0127^{d}
SE[1]±		0.101				0.0006		
P		0.012				0.01		
				Dry season				
CT-500	2.26^{ab}	1.02^{g}	1.11^{g}	1.30^{ef}	0.0123^{d}	0.0132^{bc}	0.0073^{h}	0.0084^{g}
CT-502	2.22^{ab}	1.06^{g}	1.17^{g}	1.32^{ef}	0.0122^{d}	0.0133^{b}	0.0072^{h}	0.0082^{g}
CT-504	2.14^{b}	1.05^{g}	1.19^{g}	1.19^{g}	0.0127^{cd}	0.0091^{f}	0.0101^{e}	0.0093^{f}
CT-508	2.32^{a}	1.46^{e}	1.68^{d}	1.29^{fg}	0.0134^{ab}	0.0087^{g}	0.0096^{ef}	0.0078^{h}
CT-115	1.84^{c}	1.40^{e}	1.15^{g}	1.09	0.0122^{d}	0.0074^{h}	0.0140^{a}	0.0084^{g}
SE[1]±		0.23				0.0004		
P		0.01				0.01		

[a,b,c,d,e,f,g,h] Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

Table 5. Performance of yield indicators in the rainy season

Varieties	Age, days				SE[1]±	p
	45	60	75	90		
			Leaf, %			
CT-500	57.98^{a}	47.03^{c}	35.90^{e}	29.53^{g}	1.30	0.01
CT-502	57.96^{a}	46.99^{c}	35.88^{e}	29.51^{g}		
CT-504	57.85^{a}	47.00^{c}	34.53^{f}	28.10^{h}		
CT-508	53.12^{b}	44.98^{d}	34.43^{f}	29.35^{gh}		
CT-115	57.00^{a}	45.54^{d}	34.79^{ef}	29.23^{gh}		
			Stems, %			
CT-500	42.02^{h}	52.97^{f}	64.10^{d}	70.47^{b}	1.43	0.01
CT-502	42.04^{h}	53.01^{f}	64.12^{d}	70.49^{b}		
CT-504	42.15^{h}	53.00^{f}	65.47^{c}	71.90^{a}		
CT-508	46.88^{g}	55.02^{e}	65.57^{c}	70.65^{ab}		
CT-115	43.00^{h}	54.46^{e}	65.21^{cd}	70.77^{ab}		
			Dry matter yield, t.ha^{-1}			
CT-500	6.11^{n}	8.78^{j}	11.68^{f}	14.22^{b}	0.660	0.001
CT-502	6.11^{n}	8.77^{j}	11.67^{f}	14.21^{b}		
CT-504	6.22^{m}	9.18^{i}	12.07^{e}	14.79^{a}		
CT-508	4.84^{p}	7.52^{l}	11.31^{g}	13.71^{c}		
CT-115	5.61^{o}	8.21^{k}	11.22^{h}	13.50^{d}		

[a,b,c,d,e,f,g,h,i,j,k,l,m,n] Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

Table 6. Performance of yield indicators in the dry season

Varieties	Age, days				SE[1]±	p
	45	60	75	90		
			Leaf, %			
CT-500	31.48[ab]	28.02[c]	24.80[f]	22.33[g]	1.19	0.01
CT-502	31.46[ab]	28.01[c]	24.79[f]	22.31[g]		
CT-504	30.30[b]	26.58[d]	26.13[d]	22.13[g]		
CT-508	31.67[a]	26.87[d]	25.50[e]	22.43[g]		
CT-115	32.41[ab]	26.91[d]	25.23[e]	22.59[g]		
			Stems, %			
CT-500	68.52[ef]	71.98[d]	75.20[b]	77.67[a]	1.24	0.01
CT-502	68.54[ef]	71.99[d]	75.21[b]	77.69[a]		
CT-504	69.70[e]	73.42[c]	73.87[c]	77.87[a]		
CT-508	68.33[fg]	73.13[c]	74.50[b]	77.57[a]		
CT-115	67.59[g]	73.09[c]	74.77[b]	77.41[a]		
			Dry matter yield , $t.ha^{-1}$			
CT-500	1.603[l]	3.02[h]	4.06[d]	4.75[b]	0.14	0.001
CT-502	1.602[l]	3.016[h]	4.062[d]	4.74[b]		
CT-504	1.79[k]	3.23[g]	4.31[c]	4.99[a]		
CT-508	1.35[m]	2.72[j]	3.83[e]	4.59[c]		
CT-115	1.26[n]	2.93[i]	3.69[f]	4.73[b]		

[a,b,c,d,e,f,g] Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

Cenchrus purpureus vc. OM 22 notified increase of these indicators with the regrowth age in the rainy period as in the dry season. It is important to highlight that in this research the indicators of the stem growth (length and thickness of internodes) were influenced by the interaction age x variety in both seasonal periods which show that the varieties as main effect only modified the number of nodes, this variations in the stems morphology are stimulated and show the possible adaptable processes to edaphoclimatic conditions of adverse ecosystems (soil salinity), structures that allow the plants more number of leaves, and in this way give more nutritive elements to the animals that intake.

The internode was superior to those reported by Ray *et al*. (2018) and Viana *et al*. (2018) in drought -tolerant varieties in the western of Cuba in five *Cenchrus purpureus* origins in a dry area from Pernambuco state, Brazil, respectively. On the other hand, Ledea Rodríguez *et al.* (2018a), find effect of the interaction climatic season with regrowth age, which influenced on some agronomic variables, among them stem thickness probably due to that the plant with the increase of the age in the rainy season, have advanced lignifications state and begin to send the reserve compounds to the roots and other organs, for to be used in the sprouting process of basal tillers, in ramifications and to be prepare for the regrowth after to be cut.

The highest values of CT-115 in AGR and RGR (table 4) with respect to rest of the varieties under study has been described by Ledea Rodríguez *et al.* (2017) when performing studies of interaction variety- regrowth age in CT-115 and CT-500 clones. The highest value of AGR was for CT-115 at 120 regrowth days, although at 90 days there was not differences in both varieties. This performance show that CT-500 and CT-115 grow at different absolute rates and accumulate DM at different speed, which means that are the intrinsic characteristics of each variety the ones that differentiate the phenotypìcal responses observed in the rainy season.

When evaluating drought- tolerant clones Ray *et al.* (2018), find for the AGR a sigmoid performance that is accelerate from 35 d, with a constant value of 2 $cm.day^{-1}$ up to 77 d of age, and an important decrease up to 119 d of planted, except for CT-605 that did not has this performance. The above is show in a similar way for three clones (CT-601, CT-603 and CT-115). While for RGR, showed high growth efficiency between the 35 and 39 days, with values of 0.035 to 0.040 $cm.cm^{-1}.d^{-1}$. Between 49 and 77 d showed moderate levels of relative growing (0.018-0.025 $cm.cm^{-1}.d^{-1}$) that decrease from this age (lower than 0.01 $cm.cm^{-1}.d^{-1}$), as similar tendency that the absolute grow rate fallow. This is due to, under different stimulus, environmental in this case, certain genes that stimulates a determine activity are activate, that in relation with the enzymatic and regulators factors can be show easier or not, effect that could be in the analyzed performance.

In this study was showed decrease of the number of leaves, increase of stems in all the varieties when the

Table 7. Nutritive quality of *Cenchrus purpureus* clones in the rainy season

Varieties	Age, days				SE[1]±	p
	45	60	75	90		
			CP, %			
CT-500	11.50^{ab}	9.10^{d}	7.26^{e}	5.53^{f}	0.35	0.001
CT-502	11.44^{b}	9.49^{c}	7.27^{e}	5.34^{fg}		
CT-504	11.29^{b}	9.00^{d}	7.32^{e}	5.41^{f}		
CT-508	11.26^{b}	9.23^{cd}	7.22^{e}	5.38^{f}		
CT-115	11.90^{a}	9.52^{c}	7.20^{e}	5.26^{g}		
			NDF, %			
CT-500	65.30^{h}	66.46^{g}	68.07^{e}	70.50^{ab}	0.71	0.01
CT-502	64.89^{hi}	66.63^{g}	68.71^{d}	70.78^{a}		
CT-504	64.98^{h}	66.17^{g}	69.61^{c}	70.93^{a}		
CT-508	64.81^{i}	66.67^{g}	69.29^{cd}	69.99^{bc}		
CT-115	64.76^{i}	67.33^{f}	68.63^{c}	69.43^{c}		
			ADF, %			
CT-500	33.37^{h}	36.72^{e}	37.99^{c}	38.98^{a}	0.435	0.01
CT-502	34.06^{fg}	36.47^{e}	37.10^{d}	38.13^{bc}		
CT-504	34.33^{f}	37.04^{d}	37.88^{c}	39.20^{a}		
CT-508	34.41^{f}	37.31^{d}	37.32^{d}	38.39^{b}		
CT-115	33.82^{g}	36.57^{cd}	37.23^{d}	38.13^{bc}		
			ADL, %			
CT-500	3.12^{kl}	3.32^{j}	4.14^{g}	4.89^{a}	0.08	0.01
CT-502	3.26^{k}	3.84^{h}	4.43^{d}	4.60^{c}		
CT-504	3.08^{l}	3.63^{i}	4.34^{e}	4.81^{a}		
CT-508	3.15^{k}	3.65^{i}	4.24^{f}	4.73^{b}		
CT-115	3.39^{j}	3.91^{h}	4.17^{fg}	4.52^{c}		
			DMD, %			
CT-500	66.63^{b}	62.13^{c}	56.87^{ef}	52.60^{g}	1.37	0.01
CT-502	67.37^{a}	61.70^{c}	57.03^{e}	52.77^{g}		
CT-504	67.37^{a}	62.03^{c}	58.43^{d}	50.78^{h}		
CT-508	66.80^{b}	62.00^{c}	57.30^{de}	51.90^{gh}		
CT-115	66.97^{b}	61.49^{c}	56.56^{f}	51.30^{h}		
			BII, g.kg^{-1} LW			
CT-500	109.67^{c}	114.00^{a}	111.50^{b}	104.71^{ef}	2.33	0.01
CT-502	109.45^{c}	114.43^{a}	111.59^{b}	105.48^{e}		
CT-504	109.05^{c}	114.20^{a}	110.85^{bc}	105.14^{e}		
CT-508	108.92^{d}	113.50^{ab}	111.47^{b}	103.13^{f}		
CT-115	108.75^{d}	114.95^{a}	111.31^{b}	106.57^{e}		

[a,b,c,d,e,f,g,h,i] Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

material became old and increase the yield and supporting tissue (tables 5 and 6), attributable to the senescence when the plant age increase. This is more marked in the season of high grass growing (rainy season). The seasonal and annual growing of the morphological components in the grass has direct relation of the climatic conditions, soil fertility and the management practices. The proportion of leaves, stems and roots that are generates by the genotype- environment interactions are indicators, which are reflected in the forage yield. The knowledge of the influence of the seasonal nature on the growing of interest species and the intrinsic characteristics of each variety, allows to identify the availability and, in consequence, to adopt management strategies (Ledea Rodríguez *et al.* 2018a). In this sense Retureta González *et al.* (2019) and Villanueva Ávalos *et al.* (2022), reported that the *C. purpureus* species have high variability and their genotypes has distinguish morphologic and productive characteristics.

Several studies have being carried out with different ecotypes and clones of *Cenchrus purpureus* in various

Table 8. Nutritive quality of *Cenchrus purpureus* clones in the dry season

Varieties	Age, days				SE[1]±	p
	45	60	75	90		
			CP, %			
CT-500	11.90[a]	9.40[e]	6.40[g]	6.25[gh]	0.215	0.01
CT-502	11.88[a]	9.25[e]	6.85[f]	6.15[h]		
CT-504	11.80[a]	9.39[e]	6.32[g]	6.40[g]		
CT-508	11.55[b]	9.77[d]	6.83[f]	6.00[h]		
CT-115	11.22[c]	9.27[e]	6.29[g]	6.55[g]		
			NDF, %			
CT-500	65.96[h]	67.14[g]	69.95[d]	72.57[b]	1.32	0.01
CT-502	65.54[hi]	67.78[fg]	69.12[d]	71.98[bc]		
CT-504	66.52[gh]	67.42[fg]	69.70[d]	73.13[ab]		
CT-508	64.87[i]	67.12[g]	69.93[d]	73.55[a]		
CT-115	65.71[h]	67.85[fg]	68.68[ef]	70.83[c]		
			ADF, %			
CT-500	35.75[f]	37.65[d]	39.67[ab]	39.66[ab]	0.86	0.03
CT-502	36.65[e]	37.60[d]	39.34[ab]	39.95[a]		
CT-504	37.10[d]	37.87[cd]	39.43[ab]	39.36[ab]		
CT-508	36.91[de]	38.18[c]	39.26[ab]	39.98[a]		
CT-115	36.98[d]	37.86[cd]	39.04[b]	38.80[ab]		
			ADL, %			
CT-500	3.60[i]	3.85[h]	4.24[d]	4.61[c]	0.09	0.01
CT-502	3.28[k]	4.05[f]	4.23[d]	4.80[ab]		
CT-504	3.51[j]	3.89[gh]	4.18[e]	4.76[bc]		
CT-508	3.47[j]	3.93[g]	4.21[de]	4.85[a]		
CT-115	3.54[ij]	3.96[g]	4.09[f]	4.24[d]		
			DMD, %			
CT-500	64.90[ab]	60.95[d]	55.95[ef]	51.66[gh]	1.22	0.01
CT-502	65.90[a]	62.04[c]	56.15[e]	50.37[h]		
CT-504	64.60[b]	60.68[d]	56.85[e]	51.09[gh]		
CT-508	64.90[ab]	60.85[d]	55.55[f]	50.66[h]		
CT-115	65.60[ab]	60.72[d]	56.70[e]	52.00[g]		
			BII, g/kg LW			
CT-500	110.85[d]	116.05[a]	112.85[bc]	107.90[e]	3.31	0.01
CT-502	111.70[d]	115.45[ab]	113.35[bc]	107.05[e]		
CT-504	112.30[c]	116.25[a]	112.70[bc]	105.30[f]		
CT-508	112.40[c]	115.75[a]	113.30[bc]	106.60[ef]		
CT-115	112.10[c]	116.70[a]	113.15[bc]	111.00[d]		

[a,b,c,d,e,f,g,h,i] Values with uncommon letters differ to P<0.01 Keuls (1952)

[1]SE, standard error of the interaction variety x days

regions from Mexico: Rueda *et al*. (2016), with Taiwán, CT-115, OM-22 and Roxo; Vázquez and González (2017) and Calzada *et al*. (2018) with Taiwán and López *et al*. (2020), with Maralfalfa and it was concluded that yield is influenced by the ecotype, environment and agronomical management (Arias *et al*. 2018). However, the forage yields in *Cenchrus purpureus* can also increased through nitrogen fertilization (Reyes Pérez *et al*. 2021).

The increase of biomass production with the age in all varieties were higher to those find by Caballero *et al.* (2016), Martínez and González (2017) and Ojeda *et al.* (2019) in west of Cuba and to those reported by Uvidia *et al.* (2013) in Maralfalfa and Álvarez *et al.* (2020) in OM-22 under the Ecuadorean Amazonia and Venezuela conditions, respectively. This corroborate the performance of rains, soil, sowing time and other climatic factors influence on the performance of one or other variety, Although the rainfalls and temperatures in this period were not limiting, the salts content in the soil of the experimental area could affect the use of humidity due to a decrease of the osmotic component.

High values in DM production, are associate with the AGR. Therefore, it should be considered that a continuous increase of the AGR not always should be interpret as positive, since one of the characteristics of tropical grasses in the biomass accumulation and rapid tissue maturity; the above, due to the wide assimilation capacity of radiation they have, which brings with it a chemical affectation by modifications of the cell wall with the consequent loss of nutritive value (Ledea Rodríguez *et al*. 2018a).

On the other hand, Arias *et al*. (2019) stated that the excess of ions as the Na^+ cause nutritional imbalances that makes difficult the absorption of certain ion as the K^+, Ca^{2+} and NO_3 that takes part of the active growing of plants and consequently in the biomass accumulation. The acceptable productivity of these varieties in this ecosystem affected by salts is an indicator to take decisions about the variety to be sowing, besides, of other factors considered important as the relation leaf/ stem, establishment, persistence and distribution of the annual production (Martínez and González 2017).

The variability between *Cenchrus* cultivars is high (Arias *et al.* 2018 and Duarte *et al.* 2018). Because of this, it is important to select varieties with high proportion of leaves for animal feeding. A higher stems yield can be important for other objectives as the production of biofuels or gasified biomass with which the spectrum of use of *Cenchrus purpureus* varieties is notably open for the agroindustry.

For the nutritive quality in both seasonal periods (tables 7 and 8), there was interaction variety x regrowth age for all the indicators. Ledea Rodríguez *et al.* (2018a) when determine the chemical composition of drought -tolerant clones of *C. purpureus* notified in leaves and stems protein decrease, increase of the cell wall components (NDF, ADF and ADL), most marked performance during the rainy season. Retureta González *et al*. (2019), did not find interaction age and irrigation in the CP content and the cell wall components of CT 115 leaves. Performance that is due, probably, to that when the nutritive value of forages is compared, the variability could be low between cultivars and varieties of a same genus, although their quality will depends on the intrinsic characteristics of each of them but, these indicators are affected by the variation of rainfalls and temperatures, hence the use of improvement grasses with adaptability to the different conditions of ecosystems and with few differences regarding their chemical composition, are elements that should be considered at a time of varieties selection.

On the other hand, Ledea Rodríguez *et al.* (2021), when evaluating in drought -tolerant varieties of *C. purpureus* the effect of the interaction regrowth age- variety find differences with increases of the structural carbohydrates and lignin up to 100days for later decrease up to 120, this performance was more marked when studying the whole plant than in the leaves, which showed that the differences in the content of the structural components in the leaves and whole plant of *C. purpureus* in the different regrowth days is related with phenological characteristics of each variety such as leaf biomass, leaf length, dry matter and plant age, which ones, influence on the content of the cell wall components (Rahman *et al.* 2019). In addition, several abiotic factors as the water, temperature and luminous intensity can influence on the thickness of the plants cell wall, modifying their structural components (Ledea Rodríguez *et al*. 2018a and Arias *et al.* 2019). The changes in the gene expression of plants face to an abiotic stress (by hot, cold or water) play an important role in the modification of the cell wall components.

On the other hand, if there is cellulose deposition in the cell walls of the plants as a secondary defense mechanism, could generate high tolerance and/or resistance to the external stress (Chupin *et al.* 2020). The xylane content increases the strengthening of the cell wall as a response to abiotic stressful factors (Yan *et al.* 2021). The nutrients content in the soil and the synthetic and organic fertilization are factors that intervene in the ADF and NDF concentration in leaves (Neves *et al*. 2018), mainly the nutrients such as nitrogen, phosphorous and potassium (Ramos Ulate *et al*. 2021) increase the availability of amino acids in the cell, which, promote a higher development of thin cell walls with the increase of the cellular lumen (Restrepo Correa *et al.* 2017).

The decrease with the regrowth age and values higher to 50 % of digestibility coincides with the reports of Ledea Rodríguez *et al*. (2018bc), Reyes Pérez *et al.* (2019) and Ledea Rodríguez *et al*. (2021) whose state that the increase of the plant age, join to the morphological, structural and chemical transformations reduce the nutritive value of the plant and their fractions ,also the differences of degradability intra and between species could be associated with the characteristics of each species and genus. In addition, it should has present the relation between the chemical indicators and the ruminal degradability not as an addition of factors so as the joint influence the chemical components has as a system in the degradability, in relation Ledea Rodríguez *et al*. (2018d), pointed out that in addition to the content of fiber in their different presentations, it should be considered the molecular relations and modifications of each structural compounds (lignin, cellulose and hemicellulose mainly), adding this authors that is the most probably cause of the limitations in the ruminal degradability and not the fibrous content and/or structural compounds, criteria that should be deepen in future researchers.

The dry matter intake was high up to 60 days for later decrease; these intakes were between 2.5 and 2.8 % of the live weight. Results similar to ours were finding by Pratti Daniel *et al.* (2019) when evaluating the dry matter availability, chemical composition and elephant grass intake. This indicator was related with the variation of the chemical composition at different cut ages. In relation to the digestibility, it can be considered that are within the range of values reported by the literature when considering that there were obtained under low rainfalls conditions. The low availability of soil humidity, linked to the salts content could has a negative effect on the general nutrition of plants and so an impact in chemical composition of varieties due to the alteration of the normal biological processes (Álvarez 2021).

Conclusions

The effect of the interaction variety x regrowth age in *Cenchrus purpureus* varieties tolerant to salinity in the morphological indicators, yield and nutritive quality was showed in this study. Where the best morphological indicators, yield, growth rate and cell wall components were obtained for CT-504 and CT-508. While, the progenitor CT-115 was superior in leaf area, digestibility and intake index; although their results were similar to those of CT-500 and CT-502, which did not have differences among them in the evaluated variables. In general, the new varieties showed that they adapt to the conditions of low to medium salinity of the soil and can be an option for cattle feeding in this type of soil in the western region of the country.

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