Article

Yield and quality of guinea grass seed cv. Mombaza at different pre-cut dates

Bertín Maurilio Joaquín Torres[1]
Armando Gómez-Vázquez[2]
Jesús Alberto Ramos Juárez[1]
Emilio Manuel Aranda Ibañez[1]
José Alberto Pérez Amaro[3]
Santiago Joaquín Cancino[4§]

[1]Postgraduate College-*Campus* Tabasco. Periferico Carlos A. Molina s/n, highway Cárdenas-Huimanguillo km 3, H. Cárdenas, Tabasco. CP. 86500. (joaquin.maurillo@colpos.mx, ramosj@colpos.mx, earanda@colpos.mx). [2]Academic Division of Agricultural Sciences-Juárez Autonomous University of Tabasco, Villahermosa, Tabasco, México. CP. 86298. (armandoujat@outlook.com). [3]Chiapas Center Experimental Field-INIFAP. Panamerican Highway Ocozocoautla de Espinoza km 3, Chiapas, Mexico. CP. 29120. (amaro.jose@inifap.gob.mx). [4]Faculty of Engineering and Sciences-Autonomous University of Tamaulipas, Ciudad Victoria, Tamaulipas, Mexico. CP. 87149.

[§]Corresponding author: sjoaquin@docentes.uat.edu.mx.

Abstract

The objective of the present study was to evaluate the effect of the precut in the yield and quality of guinea grass seed (*Megathyrsus maximus*) cv. Mombasa. The study was carried out in the experimental field of the University of the Papaloapan Campus Loma Bonita, Oaxaca. Eight treatments were evaluated, which consisted in precuts every 10 days from the court of uniformity, which took place on July 1. The treatments were tested under a design of a randomized complete block with three replications per treatment. We evaluated the total seed yield, pure seed yield, yield of pure germinable seed, germination percentage of harvested seed, plant height, total number of panicles per m^2, ripe panicle number per m^2, panicle length, number of seeds harvested by panicle, seed weight per panicle, percentage of purity and weight of a thousand seeds. There were significant differences ($p< 0.05$) between treatments for pure seed yield and yield of pure germinable seed, where the highest values (205.2 and 103.1 kg ha^{-1}, respectively) were obtained with the precut the date July 20, there were also significant difference to the number of seeds harvested by panicle and weight of seeds per panicle. It is therefore concluded that the July 20 is the best date for precut to increase seed yield of *Megathyrsus maximus* cv. Mombaza.

Keywords: *Megathyrsus maximus*, yield components, seed production.

Reception date: December 2019
Acceptance date: March 2020

Introduction

Mombaza grass is a cultivar of the species *Megathyrsus maximus* (Simon & Jacobs), formerly *Panicum maximum* (Jacq.), its origin is Africa. It was first introduced to America in 1967 (Jank, 1995), it is a perennial grass with good agronomic characteristics, adaptable to soils with low fertility and resistant to drought (Papalotla, 2001), with a dry matter yield of 22.8 t DM ha^{-1} year^{-1} (García *et al*., 2008) and 14.89% of PC at 35 days of regrowth (Guerdes *et al*., 2000). However, there is low availability of seed in the national market.

Mombaza seed production has a high economic potential; however, seed yield is very low, and there is not enough information in Mexico on aspects such as reproduction and agronomic management in seed production, and the low availability and poor quality of the seed are factors that limit its use and the sowing of new areas with this forage grass.

There are several problems in seed production, where the main ones are the low yield and the poor quality of the harvested seed, due to a low number of inflorescences, poor timing of flowering and irregular maturation of the seed (Boonman, 1979). Other problems that this species presents is the height, lodging and fall of ripe spikelets, or inflorescences appear in different stages of development within the bunch, which causes a prolonged flowering period (García and Ferguson, 1983).

The Mombaza grass reaches a height of up to 4.5 m (Bogdan, 1977), which makes it difficult to harvest the seed, and causes lodging. Likewise, the presence of winds at the end of flowering and in times of maturation causes the loss of ripe seeds and, consequently, a low yield. Therefore, to increase seed production, it is essential to decrease plant height, increase the number of stems and achieve homogenization of flowering to achieve an efficient harvest (García and Ferguson, 1983). It has been pointed out that in addition to nitrogen fertilization and plant density, precutting is an agronomic practice that could increase seed yield and quality in tropical forage grasses.

The precut consists of making a uniform cut before flowering, in order to obtain a uniform flowering and reduce the plant height (Toledo *et al*., 1989). It has been shown that precut intervenes in the synchronization of the flowering, as well as in the decrease of the lodging and, consequently, the seed yield is increased. For example, in the *Andropogon gayanus* species, with precut made on July 31, a yield of 115 kg ha^{-1} of total seed was obtained, 40% more, compared to the control 82 kg ha^{-1}; Sosa *et al*. (2001).

Seed of *M. maximus* is not produced in Mexico because the technology to produce it is unknown; in addition to this, there is little information regarding the practice of precutting to improve seed yield in this species. For this reason, it is necessary to generate technologies to produce forage seed, especially in the tropical area, increasing the yield obtained and with a view to implementing a national seed industry to break dependence on imports. Therefore, the objective was to evaluate the yield and quality of guinea grass seed (*Megathyrsus maximus*) cv. Mombaza, at different pre-cut dates.

Materials and methods

The study was carried out in the experimental field of the University of the Papaloapan Campus Loma Bonita, Oaxaca, whose geographic coordinates are 18° 06’ north latitude and 95° 53’ west longitude, at 30 masl. The climate of the place is warm humid, with abundant rains in summer. The monthly average temperature and annual precipitation are 26 °C and 1 801.4 mm, respectively (FAM, 2015). The soil is of sandy loam texture, with pH 4.9 and 0.8% of organic matter, 14.8, 23.5, 37, 241 and 42.3 mg kg^{-1} of N, P, K, Ca and Fe, respectively.

The treatments consisted of eight precuts every 10 days from the uniformity cut, which was carried out on July 1, 2015 (Table 1). These treatments were distributed under a randomized complete block design, with three replications. The size of the experimental plot consisted of four furrows separated 80 cm and 70 cm between bushes. The dimensions of the plot were 3.2 × 5.6 m, for a total area of 17.92 m^2 and a useful plot of 6.72 m^2 located in the two central furrows, leaving the last tiller at each end.

Table 1. Dates in which the precuts of the experiment were performed ‘yield and quality of guinea grass seed (*Megathyrsus maximus*) cv. Mombaza, at different pre-cut dates.’

Treatment	Precut date
T1	Control (without precut)
T2	July 20
T3	July 30
T4	August 9
T5	August 19
T6	August 29
T7	September 8
T8	September 18

The grassland where the experiment was carried out was planted in November 2004. Botanical seed was used and 8 kg ha^{-1} of commercial seed was required. At the beginning of the rainy season, a uniform cut was made at a height of 15 cm and then pre-cuts were made on the dates indicated in Table 1. Immediately after each pre-cut and according to Joaquin *et al*. (2001) was fertilized with 100, 50 and 50 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively. Urea (46% N), triple calcium superphosphate (46% P_2O_5) and potassium chloride (60% K_2O) were used as the fertilizer source. Weeds were controlled by manual machete plating, from the beginning of the experiment to the beginning of flowering.

The seed was harvested manually 18 days after flowering (Joaquín, 2002; Padilla and Febles, 1975). The flowering time was considered when 50% of the panicles present were in anthesis, that is, with the anthers visible. To determine the anthesis moment, four tillers were selected at random within each useful plot, which were observed every third day (Joaquín *et al*., 2010a).

The seed harvest was carried out using the traditional technique for harvesting tropical grass seeds (Ferguson, 1979), which consists of cutting all the inflorescences present and subjecting them to a natural sweating process. All the panicles of the tillers were harvested in the two central rows, leaving the tillers of the shore unharvested at both ends. To simulate the sweating process, the harvested panicles were placed in blanket bags, which were grouped on the ground, and covered with the plant material that remained after the panicles had been cut. The sweat period was four days. Subsequently, threshing, cleaning and drying of the seeds were carried out naturally (in the sun). The obtained seed was weighed, packed in paper bags and stored under laboratory environmental conditions.

The variables evaluated were: plant height (cm), number of total panicles per m^2, number of ripe panicles per m^2, panicle length (cm), number of seeds harvested per panicle, weight of seeds per panicle (g), purity (%), thousand seed weight (g), total seed yield (kg ha^{-1}), pure seed yield (kg ha^{-1}), germinable pure seed yield (kg ha^{-1}) and seed germination harvested (%). To calculate the total seed yield, the area of the useful plot (6.72 m^2) was taken into account. To calculate the yield of pure seed took into account the percentage of purity. The purity percentage was determined by weighing a sample of two grams of seed and separating it into its components: pure seed, vain seed and impurities, as indicated by the ISTA (2005) rules. To calculate the yield of pure germinable seed took into account the percentage of germination.

For the height of the tiller, four tillering were measured at random per plot and the measurement was made from the base of the tiller to the upper end of the inflorescence. For the number of total panicles per m^2 and number of ripe panicles per m^2, all the inflorescences present in four previously randomly selected tillers within each useful plot were counted, and the estimation was made based on the density of tillers.

To measure the length of the panicle, the number of seeds harvested per panicle and the weight of seeds per panicle, 10 panicles were harvested per plot, taken at random within the tillers of the useful plot. The length of the panicle was measured from the insertion point of the first branch, to the upper end of the panicle. The number of seeds harvested per panicle was quantified as the number of spikelets per panicle at the time of harvest. The weight of 1 000 seeds was estimated as the average of eight repetitions of 100 pure seeds per plot and multiplied by 10 (ISTA, 2005).

For the germination test, 400 pure seeds were used in four replications of 100 seeds, which were placed in Petri dishes with a lid 9.5 cm in diameter and 1.5 cm deep, provided with absorbent paper, moistening the substrate with KNO_3 solution at 0.02% and placed on a table inside the laboratory at an ambient temperature of 30 °C and constant light, for 28 days. Three counts were performed at 10, 19 and 28 days, in each count the number of normal seedlings was quantified, according to the ISTA methodology (2005). The germination percentage was estimated from the normal seedlings.

Data were subjected to analysis of variance, based on a randomized complete block experimental design. The comparison of means of the treatments was carried out using the Tukey test, with a significance level of 0.05. In addition, a correlation analysis was performed to estimate the degree of association between seed yield and yield components: number of total panicles per m^2, number of ripe panicles per m^2, panicle length, number of seeds harvested per panicle and seed weight per panicle.

Results and discussion

Effect of precut on seed yield

Significant differences were detected between treatments for total seed yield ($p < 0.05$), where the highest value (251 kg ha^{-1}) occurred with treatment T7, a value that was similar ($p < 0.05$) to those obtained with treatments T1 , T2, T4, T5, T6 and T8 (207.6, 237.7, 78.9, 114.8 176.7 and 194.8 kg ha^{-1}, respectively), but different and superior ($p < 0.05$) to treatment T3 (63.8 kg ha^{-1}; Table 2).

Regarding the yield of pure seed, it was observed that there was a highly significant difference between treatments ($p < 0.01$), where the highest value (205.2 kg ha^{-1}) was obtained in treatment T2; treatments T1, T4, T6, T7 and T8 (150.1, 66.2, 87.3, 163 and 105.9 kg ha^{-1}, respectively) were similar ($p > 0.05$) to treatment T2, while the lowest yields were registered in treatments T3 and T5 with values of 56.2 and 28.9 kg ha^{-1}, respectively. Regarding the yield of pure germinable seed, a highly significant difference ($p < 0.01$) was observed, similar to the yield of pure seed, where the highest values (103.1 and 90.9 kg ha^{-1}) were presented with treatments T2 and T7, respectively T1, T3, T4, T6 and T8 treatments (60.8, 31.7, 37.6, 29.6 and 68.1 kg ha^{-1}, respectively) were similar ($p > 0.05$) to treatments T2 and T7.

Table 2. Yield of total seed, pure and germinable seed in guinea grass (*Megathyrsus maximus*) cv. Mombaza, at different pre-cut dates.

Treatment	Total seed yield (kg ha^{-1})	Pure seed yield (kg ha^{-1})	Germinable pure seed yield (kg ha^{-1})
T1	207.6 ab	150.1 ab	60.8 ab
T2	237.7 ab	205.2 a	103.1 a
T3	63.8 b	56.2 b	31.7 ab
T4	78.9 ab	66.2 ab	37.6 ab
T5	114.8 ab	28.9 b	9.9 b
T6	176.7 ab	87.3 ab	29.6 ab
T7	251 a	163 ab	90.9 a
T8	194.8 ab	105.9 ab	68.1 ab
SE	29.3	22.1	12.2

ab= different literals within each column, indicate significant difference ($p < 0.05$); SE= standard error; T1= control (without precut); T2= July 20; T3= July 30; T4=August 9; T5= August 19; T6= August 29; T7= September 8; T8= September 18.

The data obtained in the present study differs with the results obtained by Joaquin (2002), who obtained yields of 158.7 kg ha^{-1} of total seed with a pre-cut date of July 31 compared to the yield obtained with T3 (63.8 kg ha^{-1}), this difference could have been affected by torrential precipitation during the harvest date (193 mm).

Regarding the yield of pure seed, the highest value (205.2 kg ha^{-1}) obtained with the T2 treatment, agrees with that reported by Sosa *et al*. (2001), who in grassland plains (*Andropogon gayanus* Kunth) found that the best pre-cut date was from July 17 to 31, with an average total seed yield of 115 kg ha^{-1}. In guinea grass (*M. maximus*) cv. Tanzania reported a seed yield of 138.6 kg ha^{-1} with a pre-cut date of July 31 (Joaquín, 2002). In the present study it was observed that as the harvest date was prolonged there was a progressive decrease in the yield of pure seed. This decrease could be due to the higher percentage of thresh of the panicles. In another study, a pure seed yield was reported in guinea grass cv. Tanzania of 27.5 kg ha^{-1} with precut date of August 31 (Joaquín *et al*., 2010b).

The results obtained from the yield of pure germinable seed are similar to those obtained from the yield of pure seed, where treatment T2 had a value of 205.2 kg ha^{-1}, which was higher than that obtained by Joaquin (2002), who in *M. Maximus* cv. Tanzania obtained a pure germinable seed yield of 94 kg ha^{-1} with a pre-cut date of July 31. Other authors, in *M. maximus* cv. Tanzania reported a pure germinable seed yield of 87 kg ha^{-1} with precut date of September 4 (Joaquín *et al*., 2006).

Effect of precut on yield components

Table 3 shows the results of the yield component variables. Significant differences ($p< 0.05$) were observed between treatments for plant height, where the highest value (273.8 cm) was observed with treatment T2, which was similar to the control T1 (271.8 cm). Regarding the number of total panicles, no significant differences were observed between treatments. For the number of ripe panicles, significant differences were found ($p< 0.05$), where the largest number of panicles (58.9 m^{-2}) was obtained with the T7 treatment, a value that was similar ($p< 0.05$) to those obtained with the T1, T2, T3, T4, T6 and T8 treatments (45.7, 40.9, 52.8, 57.7, 54.1 and 50.8 panicles per square meter, respectively).

Table 3. Plant height and seed yield components in guinea grass (*Megathyrsus maximus*) cv. Mombaza at different pre-cut dates.

Treatment	AP (cm)	NPT (no. m^{-2})	NPM (no. m^{-2})	LP (cm)	NSC (no.)	PSP (g)
T1	271.8 a	51 a	45.7 ab	32.3 a	780.9 ab	0.44 b
T2	273.8 a	45 a	40.9 ab	29.6 abc	851.9 a	0.8 a
T3	242.1 b	52.9 a	52.8 ab	27.6 bc	266.4 b	0.28 b
T4	230 bc	65.5 a	57.7 ab	26.9 c	298.2 ab	0.33 b
T5	205 cd	43.2 a	40.6 b	25.9 c	696.6 ab	0.42 b
T6	183.3 de	60.8 a	54.1 ab	28.2 abc	763.6 ab	0.5 ab
T7	174.8 e	61.5 a	58.9 a	29.9 abc	675.7 ab	0.45 ab
T8	166.3 e	60 a	50.8 ab	31.6 ab	587.8 ab	0.4 b
EE	4.82	4.59	3.38	0.72	109.49	0.06

abcde= different literals within each column, indicate significant difference ($p< 0.05$); EE= standard error; T1= control (without precut); T2= July 20; T3= July 30; T4= August 9; T5= August 19; T6= August 29; T7= September 8; T8= September 18; AP= panicle height; NPT= number of total panicles; NPM= number of ripe panicles; LP= panicle length; NSC= number of seeds harvested per panicle; PSP= seed weight per panicle.

Significant differences ($p < 0.05$) were registered for panicle length, where the highest value was presented in T1 (control), with an average of 32.3 cm. For the number of seeds harvested per panicle, significant differences were observed between treatments ($p < 0.05$), where the highest value (851.9 seeds) was obtained with the T2 treatment, while the lowest number of seeds (266.4 seeds) was achieved with the T3 treatment. For the weight of seeds per panicle, the highest value (0.80 g) was presented with the T2 treatment, similar value ($p > 0.05$) to that obtained with the T6 and T7 treatments (0.5 and 0.45 g, respectively), but higher than the obtained with the treatments T1 (control), T3, T4, T5 and T8, with values of 0.44, 0.28, 0.33, 0.42 and 0.4 g, respectively.

Regarding the height of stems, differences were found between treatments ($p < 0.01$) where the control T1 and treatment T2 showed the highest values (271 and 273 cm, respectively). Similar results were reported by Sosa *et al*. (2001), who obtained a height of 252 cm in the control for plain grass (*Andropogon gayanus* Kunth). Also in llanero grass (*A. gayanus*), with a precut date of July 30, a height of 330 cm was presented (Terraza, 1991). In relation to the number of panicles per surface, in *Megathyrsus maximus* cv. Tanzania reported 40 total panicles for the precut date of September 4 (Joaquin *et al*., 2006), compared to the precut on September 8 (T7), with a value of 61.5 panicles.

Likewise, Joaquin (2002) making the precut on July 31, in *M. maximus* cv. Tanzania reported a panicle length of 27.3 cm. While Joaquin *et al*. (2010b) in the same cultivar Tanzania with a precut date of August 31 reported a panicle length of 27.8 cm, a value similar to that obtained in the present study with the precut date of August 29 (28.2 cm). Regarding the number of seeds harvested per panicle, Joaquin (2002) obtained *M. maximus* cv. Tanzania a value of 692 seeds with a pre-cut date of July 31.

Likewise, in the same cultivar they had 586 seeds harvested per panicle with a pre-cut date of September 4 (Joaquín *et al*., 2006). Also in the same cultivar Tanzania, a value of 501.5 seeds harvested per panicle was obtained with a pre-cut date of August 31 (Joaquin *et al*., 2010b). These values are lower than that obtained in the present study with a pre-cut date of August 29, with 763.6 seeds per panicle.

Effect of precut on seed quality

The purity percentage showed a significant difference between treatments ($p < 0.01$), where the highest value (87.5%) was obtained with treatment T3, a value that was similar ($p > 0.05$) to those obtained with treatments T1, T2 and T4 (72.7, 85.8 and 83.7%, respectively), but higher than the other treatments. Regarding the weight of a thousand seeds, there was also a significant difference between treatments ($p < 0.05$), where the highest value (1.22 g) was obtained with the T4 treatment, a value that was similar ($p > 0.05$) to those obtained with the T2, T3 and T7 treatments with averages of 1.18, 1.17 and 1.12 g, respectively (Table 4).

Joaquin (2002) reported a purity percentage for the cultivar of Tanzania of 86.3% and a weight of 1.26 g of one thousand seeds with a pre-cut date of July 31. In another study, Joaquín *et al*. (2010b) reported a weight of 1 228 g per 1 000 seeds with a pre-cut date of August 31 and an establishment fertilization of 150, 50 and 50 kg ha^{-1} of N, P and K, respectively. In the present study, with a pre-cut date of August 29, a weight of 1.05 g per 1 000 seeds was obtained. This difference could be due to management conditions and climatic conditions during crop development Albert *et al*. (2016).

Table 4. Percentage of purity, weight of a thousand seeds and percentage of germination in guinea grass (*Megathyrsus maximus*) cv. Mombaza at different pre-cut dates.

Treatment	Purity percentage (%)	Weight of a thousand seeds (g)	Germination percentage (%)
T1	72.7 ab	1.07 bcd	38.11 abc
T2	85.8 a	1.18 ab	50.44 abc
T3	87.5 a	1.17 ab	57 ab
T4	83.7 a	1.22 a	57.22 ab
T5	24.6 d	0.97 d	28.11 c
T6	49.8 c	1.05 bcd	35 bc
T7	65.2 bc	1.12 abc	55.89 ab
T8	54.3 c	1.01 cd	63.78 a
SE	3.37	0.02	4.43

abcd= different literals within each column, indicate significant difference ($p < 0.05$); SE= standard error; T1= Control (without precut); T2= July 20; T3= July 30; T4= August 9; T5= August 19; T6= August 29; T7= September 8; T8= September 18.

Relationship between yield and its components

Table 5 presents the correlation coefficients between the seed yield and the yield components. According to the results, the number of seeds harvested per panicle (r= 0.7; $p < 0.001$) and panicle length (r= 0.4986*) were the components with the highest degree of association with total seed yield; while, for the yield of pure seed, they were the weight of seeds per panicle (r= 0.6601; P<0.001), panicle length (r= 0.4934*) and number of seeds harvested per panicle (r= 0.5127*). Likewise, the components with the highest degree of association with the yield of pure germinable seed were the weight of seeds per panicle, and panicle length with values of r= 0.5748** and r= 0.4861*, respectively.

Table 5. Correlation coefficient (r) between seed yield and yield components in guinea grass (*Megathyrsus maximus*) cv. Mombaza.

Yield components	Total seed yield	Pure seed yield	Germinable pure seed yield
Number of ripe panicles	-0.01 ns	-0.03 ns	0.03 ns
Panicle length	0.5 *	0.49 *	0.49 *
Seeds harvested by panicle	0.7***	0.51 *	0.39 ns
Seed weight per panicle	0 ns	0.66 ***	0.57 **
Weight of a thousand seeds	-0.17 ns	0.2 ns	0.24 ns

*= $p < 0.05$; **= $p < 0.01$; ***= $p < 0.001$; ns = not significant.

In the present study, the number of seeds harvested per panicle presented a higher degree of association with the total seed yield (r= 0.69^{***}) and pure seed yield (r= 0.51271^{*}). The second component with the highest degree of association with pure seed yield was the weight of seeds per panicle with a value of r= 0.66^{***}. Similar results were reported by Joaquin (2002) for guinea cv. Tanzania, who found a correlation of 0.55^{**}, 0.37^{**} and 0.35^{**} between the yield of total seed, pure seed and germinable pure seed, with the number of seeds harvested per panicle.

Likewise, Joaquin *et al*. (2010a) for *Bracchiaria brizantha* cv. Insurgente indicated a positive correlation between the total seed yield with the number of seeds harvested per panicle of r= 0.4224^{*}. In *Brachiaria birzantha* cv. Insurgente, Joaquin *et al*. (2010a) obtained a correlation between the weight component of 1000 seeds with the yield of pure seed and the yield of germinable pure seed of 0.49^{*} and 0.42^{*}, respectively.

Conclusions

Based on the results obtained, it is concluded that precut has a positive effect on the yield and quality of guinea grass seed, where the highest yield was found with the precut date of July 20. The precut and its positive effect on the increase of seed, is due to the increase in the number of seeds harvested per panicle and the weight of seeds per panicle since they presented the highest correlation indexes. It is recommended to carry out the precut at the end of July, and to continue with this study in this and other cultivars and grass species in order to determine more precisely the precut date and its effect on the yield and quality of the harvested seed.

Acknowledgments

The Zootechnics area of the University of the Papaloapan is thanked for the facilities to carry out this study and the staff of the Chemical-Biological Laboratory for the support provided in determining seed quality.

Cited literature

Albert, G.; Alonso, N.; Cabrera, A.; Rojas, L y Rosthoj, S. 2016. Evaluación productiva del forraje verde hidropónico de maíz, avena y trigo. Compendio de Ciencias Veterinarias. 6(1):7-10.

Bogdan, A. V. 1977. Tropical pasture and fodder plants. 1rst edition. Longman Group Limited. London and New York. Longman Inc. 475 p.

Boonman, J. G. 1979. Producción de pastos tropicales en África, con referencia especial a Kenia. In: Tergas, L. E. y Sánchez, P. A. (Eds.). Producción de pastos en suelos ácidos de los trópicos. Centro Internacional de Agricultura Tropical. Cali, Colombia. 385-402 pp.

FAM. 2015. Fuerza Aérea Mexicana. Estadística meteorológica mensual. Dirección de servicio meteorológico. Estación Loma Bonita, Oaxaca, México.

Ferguson, J. E. 1979. Sistemas de producción de semillas para especies de pastos en América Latina Tropical. In: Tergas, L. E. y Sánchez, P. A. (Eds.). Producción de pastos en suelos ácidos de los trópicos. Centro Internacional de Agricultura Tropical (CIAT). Cali, Colombia. 275-283 pp.

García, C. R.; Martínez, R.; Cruz, A. M.; Romero, A.; Estanquero, L.; Noda, A. y Torres, V. 2008. Evaluación agronómica de Guinea Mombaza (*Panicum maximum* Jacq) en un suelo ferralitico rojo típico de la provincia. La Habana, Cuba. Rev. Cubana Cien. Agríc. 42(2):205-209.

García, D. A. y Ferguson, J. E. 1983. Cosecha de semilla de *Andropogon gayanus*: guía de estudio para ser usada como complemento de la unidad audiotutorial sobre el mismo tema CIAT. Centro Internacional de Agricultura Tropical. Cali, Colombia. 32 p.

Guerdes, L.; Werner, J. C.; Colozza, M. T.; Aparecida, P. R. e Aparecida, S. E. 2000. Avaliação de características de valor nutritivo das gramíneas forrageiras marandu, setária e tanzânia nas estações do ano. Rev. Bras. Zootec. 29(4):955-961

International Seed Testing Association (ISTA). 2005. International rules for seed testing. Switzerland. 288 p.

Jank, L. 1995. Melhoramento e seleção de variedades de *Panicum maximum*. *In*: 12. Simpósio sobre manejo da pastagem, anais. Fundação de Estudos Agrários Luiz de Queiroz. Piracicaba, Brasil. 21-58 pp.

Joaquín, T. B. M.; Hernández, G. A.; Pérez, P. J.; Herrera, H. J. G.; García, S. G. y Trejo L. C. 2001. Efecto del nitrógeno y fecha de cosecha sobre el rendimiento y calidad de semilla de pasto guinea. Téc. Pec. Méx. 39(3):245-254.

Joaquín, T. B. M. 2002. Fertilización nitrogenada, fecha de cosecha y reguladores del crecimiento en el rendimiento y calidad de semilla de pasto guinea cv. Tanzania. Tesis de doctorado. Colegio de Postgraduados, Montecillo Texcoco, México. 158 p.

Joaquín, T. B. M.; Moreno, C. M. A.; Martínez, H. P. A.; Hernández, G. A.; Gómez, V. A. y Pérez, P. J. 2006. Efecto de la fitohormona esteroidal cidef-4 en el rendimiento y calidad de semilla de pasto guinea. Téc. Pec. Méx. 44(2):193-201.

Joaquín, C. S.; Joaquín, T. B. M.; Ortega, J. E.; Hernández, G. A.; Pérez, P. J.; Enríquez, Q. J. F. y Quero, C. A. R. 2010a. Evaluación de la distancia entre plantas sobre el rendimiento y calidad de la semilla de *Brachiaria brizantha*. Rev. Mex. Cienc. Pec. 1(3):297-310.

Joaquín, T. B. M.; Moreno, C. M. A.; Joaquín, C. S.; Hernández, G. A.; Pérez, P. J. y Gómez, V. A. 2010b. Rendimiento y calidad de semilla de pasto guinea (*Panicum maximum* Jacq.) cv. Tanzania usando la fitohormona esteroidal cidef-4. Rev. Mex. Cienc. Pec. 1(3):237-249.

Padilla, C. y Febles, G. 1975. Determinación del momento óptimo de cosecha de la semilla de hierba de guinea (*Panicum maximum* Jacq.). *In*: Compendio del 1° Simposium Nacional de Semilla. La Habana, Cuba. 262 p.

Papalotla. 2001. Manual de actualización técnica. Asesoría Papalotla. Semillas Papalotla, SA de CV. 64 p.

Sosa, R. E.; Zapata, B. G. y Pérez, R. J. 2001. Fechas de precorte para la caracterización fenológica del pasto llanero (*Andropogon gayanus* Kunth) en Quintana Roo. Tec. Pec. Mex. 39(2):163-169.

Terraza, J. G. 1991. Efecto de la época de defoliación en la producción de semillas de *Andropogon gayanus* cv. Llanero. Pasturas Tropicales. 13(2):39-41.

Toledo, J. M.; Vera, R.; Lazcano, C. y Lenné, J. M. 1989. *Andropogon gayanus* Kunth: un pasto para los suelos ácidos del trópico. CIAT. Centro Internacional de Agricultura Tropical. Cali, Colombia. 406 p.