# Agronomic Performance, Hydrocyanic Acid Potential (HCN-p) and Heterosis in Forage Sorghum Hybrids[1]

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**ABSTRACT**

**In 1981 field studies at the Isabela Experiment Farm in northwestern Puerto Rico, we evaluated agronomic performance, hydrocyanic acid potential (HCN-p) and heterosis in forage sorghum hybrids (*Sorghum bicolor* (L.) Moench). Three cuttings were made at 60-day interval. The combined analyses showed significant differences in yields of green forage (GF), dry forage (DF) and crude protein (CP); contents of dry matter (DM) and crude protein; tillers/plant; height; leaf area; and HCN-p at 45 days. Harvests were not a significant source of variation in leaf/stem ratio or in HCN-p at 60 days. The $F_1$ hybrids of CK-60 × Fa357, CK-60 × Common and CK-60 × Lahoma produced the highest DF and CP yields across the three harvests. The DF and CP yields of these top sorghum-sudangrass hybrids—about 20 and 2 metric tons, respectively in 180 days—and their relatively low HCN-p values, establish these genotypes among the most promising forage material for use under irrigation. The HCN-p values of all genotypes were lower at the 60-day harvest than at the 45-day sample. There were some instances of HCN-p value exceeding the "threshold of danger" of 200 p/m. Midparent heterosis was manifested for GF, DF and CP yields, height, tillers/plant and leaf area, but not for DF and CP content. High parent heterosis was less than midparent heterosis for most traits studied and was not observed for DM and CP content or for tillers/plant. The $F_1$ hybrid of CK-60 × Common exhibited the greatest heterosis, producing 146 and 125% more DF than the midparent and high parent, respectively. Fa357 was superior to all other lines in having the lowest HCN-p among the male parents at 60 days. Lahoma had the highest yield potential of the male parent lines and an intermediate level of HCN-p compared to the other lines.**

## INTRODUCTION

Forage sorghums, *Sorghum bicolor* (L.) Moench, sudangrass, *S. sudanense* (Piper) Stapf., and sorghum-sudangrass hybrids are used extensively as forage or greenchop. Sorghums or sorghum-sudangrass hybrids have a great potential in tropical areas, especially where mechanization is possible. One hazard of sorghum or sudangrass utilization is the toxic potential of dhurrin [(S)-p-hydroxymandelonitrile $\beta$-D-glucopyranoside], which yields hydrocyanic acid when hydrolyzed enzymatically in disrupted plant tissues or in the rumen of animals that consume the forage (1). To alleviate possible toxicity from hydrocyanic acid breeders are developing forage sorghums, sudangrass and their crosses with lower hydrocyanic acid potential. In Puerto Rico, excellent single cross and three-way forage sorghum hybrids have been identified with low HCN-p and high yielding ability (9).

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In sorghum, heterosis has been characterized by earlier blooming, more tillering, greater height and greater forage yield, as reviewed by Quinby (4). According to this author, faster cell division is believed to be the basis of these heterotic manifestations. Greater dry forage yield (DF) of hybrids over that of parents has been reported in local studies of hybrids in which heterosis was evident (5, 8).

The objective of the present study was to evaluate single-cross forage sorghum hybrids from a single female parent and their male parents in terms of yield potential, heterosis, HCN-p, and other agronomic characters.

## MATERIALS AND METHODS

In 1979 hand crosses were made between male-sterile Combine Kafir-60 (A CK-60) and the following seven male parents: 'Roma', a forage sorghum, and six sudangrasses: 'Greenleaf', 'Common', 'Sweet sudan' (Tx372), Florida (fa) '357', 'Piper', and 'Lahoma'. The male parents were selfed for at least three generations before being crossed to A CK-60.

The male parents, B CK-60, and the hybrids were sown at the Isabela Experiment Farm of the Tropical Agriculture Research Station (TARS), USDA, ARS, S & E April 27, 1981, at a population density of about 125,000 plants/ha. The experimental design was a split plot arrangement in a randomized complete block with four replications. The main plots were the genotypes, and the sub-plots were the harvest dates. Plots consisted of two rows 6 m long spaced 1 m apart. Sampling area was 10 $m^2$.

The soil is a Coto clay (Tropeptic Haplorthox) with a pH of about 5.2. Immediately after planting, propazine [2-chloro-4,6-bis(isopropylamino)-s-triazine] was applied at a rate of 2.5 kg of active ingredient/ha. At planting and after each cutting 560 kg/ha of a 15-5-10 fertilizer was applied. Plants were irrigated as needed to prevent moisture stress.

The first cutting was made 60 days after planting followed by two subsequent harvests at 60-day intervals. Before each cutting, plant height (from the ground to the midpoint of the upper leaf blade) was measured and tillers counted (four plants/plot chosen at random). Leaf blade area was determined by measuring the second leaf blade from the top and multiplying maximum length $\times$ maximum width $\times$ 0.747 $\times$ number of leaves/plant. This calculation has been reported to give a close approximation to leaf area as determined by a planimeter (7). Yields of green forage (GF), dry forage (DF), and crude protein (CP), tillers/plant and leaf/stem ratio were calculated for each harvest. Samples from each plot were analyzed for dry matter (DM) and CP contents, and HCN-p at TARS laboratories.

Leaf tissue was analyzed for HCN-p with the spectrophotometric method of Gorz et al. (1) with modifications in sample preparation as reported by Torres-Cardona et al. (8). Data were subjected to analysis of variance and significant treatment differences were identified with the Duncan's multiple range test. Estimates of heterosis relative to the average of the two parent varieties (midparent), and to the high parent, were calculated as follows:

$$H_1 = (F_1 - [(P_1 + P_2)/_2])/[(P_1 + P_2)/_2] \times 100$$

$$H_2 = [CF_1 - P_1)/P_1] \times 100$$

where $H_1$ = heterosis relative to the average of the two parent varieties (midparent)

$H_2$ = heterosis relative to the high parent variety

$F_1$ = mean of $F_1$ hybrid

$P_1$ = mean of pollinator parent (CK – 60)[3]

$P_2$ = mean of female parent

## RESULTS AND DISCUSSION

Table 1 shows that harvest 2 produced the highest GF and DF yields. These findings are in agreement with previous studies at Isabela (5). Yields of GF and DF in harvests 1 and 3 were very similar. The CP content was highest at harvest 1. At each of the three harvests hybrids were significantly better to male parents in all characters except HCN-p at 45 and 60 days, and DM and CP contents, in which the difference was not significant, and also tillers/plant, which was significantly higher in male parents. Both $F_1$'s and MP's were tallest and had the most numerous tillers at harvest 2 and the largest leaf blade area at harvest 3.

### Combined Harvest

Table 2 shows the *F* values for the combined analysis of the various criteria. Significant differences among genotypes were observed for all traits. Differences among male parents and among $F_1$ hybrids were significant for all traits except DM content and HCN-p for the hybrids. The interaction of male parents × hybrids was highly significant except for CP and DM contents. Harvests also differed significantly in all traits except leaf/stem ratio and HCN-p at 60 days. Genotypes × harvest interactions were significant for most traits except DM and CP content, leaf area and leaf/stem ratio.

The $F_1$ hybrids yielded more GF, DF and CP; they were taller and had

[3] B CK-60 included in the planting scheme was used for the heterosis comparisons only.

TABLE 1.—*Mean yields of green and dry forage and crude protein contents of dry matter and crude protein; mean height, leaf area, tillers/plant, leaf stem ratio and hydrocyanic acid potential (HCN-p) in seven $F_1$ hybrids of sorghum and their male parents at each harvest at Isabela, Puerto Rico*

| Trait | Mean of $F_1$'s and male parents at each harvest every 60 days | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | | |
| | $F_1$ | $F_1$'s vs MP | MP | $F_1$ | $F_1$'s vs MP | MP | $F_1$ | $F_1$'s vs MP | MP |
| Green forage yield, t/ha | 32.53 | **[1] | 23.83 | 40.31 | ** | 34.91 | 36.21 | ** | 26.27 |
| Dry matter content, % | 15.24 | | 15.35 | 14.95 | | 14.95 | 14.91 | | 14.83 |
| Dry forage yield, t/ha | 4.95 | ** | 3.65 | 6.96 | ** | 5.22 | 5.54 | ** | 3.87 |
| Crude protein yield, t/ha | 0.64 | ** | 0.47 | 0.61 | ** | 0.56 | 0.48 | ** | 0.36 |
| Crude protein content, % | 13.04 | | 12.93 | 8.88 | | 10.58 | 8.85 | | 9.29 |
| Plant height, cm | 268 | ** | 212 | 297 | ** | 246 | 276 | ** | 219 |
| Leaf area, $cm^2$ | 6,148 | ** | 4,086 | 6,160 | ** | 4,160 | 6,232 | ** | 4,350 |
| Tillers/plant, no. | 3.9 | ** | 7.1 | 5.3 | ** | 10.04 | 4.5 | ** | 7.4 |
| Leaf/stem ratio | 0.5613 | ** | 0.4700 | 0.5526 | ** | 0.4820 | 0.5400 | ** | 0.4883 |
| HCN-p, ppm | | | | | | | | | |
| 45 days | 300 | | 304 | 284 | | 242 | 305 | | 295 |
| 60 days | 199 | | 226 | 237 | | 192 | 199 | | 202 |

[1] Significant at the 0.01 probability level.

TABLE 2.—F *values for the combined analyses of green and dry forage and crude protein yields; dry matter and crude protein contents; tillers/plant, height, leaf area, leaf/stem ratio and hydrocyanic acid potential (HCN-p) at 45 and 60 days of sorghum genotypes across three-harvests*

| Source | Green forage yield | Dry matter content | Dry forage yield | Crude protein content | Crude protein yield | Tillers/ plant | Height | Leaf area | Leaf/ stem ratio | HCN-p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 45 days | 60 days |
| Genotypes | 83.1**[1] | 5.3** | 65.2** | 3.5** | 24.0** | 314.2** | 204.3** | 262.3** | 57.4** | 16.7** | 12.6** |
| Male parents | 33.6** | 1.7 | 28.1** | 2.8 | 26.4** | 408.6** | 69.0** | 127.9** | 129.9** | 41.9** | 33.8** |
| Hybrid | 223.2** | 0.0 | 192.8** | 10.5** | 79.0** | 735.4** | 295.5** | 871.6** | 234.1** | 6.7* | 1.0 |
| Male parents × hybrids | 33.7** | 6.2 | 30.4** | 1.5 | 22.6** | 374.9** | 40.9** | 138.7** | 36.5** | 27.1** | 15.6 |
| Harvests | 187.0** | 5.4** | 137.0** | 135.5** | 49.8** | 71.3** | 76.4** | 4.2** | 0.6 | 9.9** | 2.6 |
| Genotypes × harvest | 6.1** | 0.7 | 4.4** | 1.3 | 2.9** | 6.6** | 2.1** | 1.6 | 1.2 | 8.3** | 5.5** |

* Significant at the 0.05 probability level; **significant at the 0.01 probability level.

more leaf area and greater leaf/stem ratio than the male parents (table 3). However, the male parents had the advantage of more tillers/plant and less HCN-p than the $F_1$ hybrids at 45 days of growth. The DM and CP contents as well as HCN-p at 60 days were similar for $F_1$ hybrids and male parents (table 3). The evident superiority of $F_1$ hybrids over male parents in most of the important agronomic traits indicates the desirability of utilizing hybrids rather than parental lines at the farm level.

The $F_1$'s of CK-60 × Fa357, CK-60 × Common, CK-60 × Lahoma, and CK-60 × Sweet sudan and male parents Lahoma, Roma and Sweet sudan produced the highest GF and DF yields within their respective groups, surpassing the remaining genotypes (table 4). The mean DF yield for $F_1$

TABLE 3.—*Means and coefficients of variation (c.v.) for 11 traits of $F_1$ sorghum hybrids and parents across three harvests at Isabela, Puerto Rico*

| Trait | $F_1$'s | Male parents | $F_1$'s vs Male parents | C.V. |
|---|---|---|---|---|
| | | | | % |
| Green forage yield, t/ha | 114.75**[1] | 84.99** | ** | 9.69 |
| Dry matter content, % | 15.03 | 15.04 | | 4.18 |
| Dry forage yield, t/ha | 15.64** | 12.72** | ** | 11.02 |
| Crude protein content, % | 10.26** | 10.93 | | 11.26 |
| Crude protein yield, t/ha | 1.74** | 1.39** | ** | 16.78 |
| Tillers/plant, No. | 4.58** | 8.18** | ** | 14.28 |
| Height, cm | 280** | 226** | ** | 5.04 |
| Leaf area, cm | 6,180** | 4,199** | ** | 5.19 |
| Leaf/stem ratio | 0.5500** | 0.4801** | ** | 6.31 |
| HCN-p, 45 d. | 296** | 280** | ** | 16.67 |
| HCN-p, 60 d. | 211 | 207** | | 17.43 |

[1] Significant differences at the 0.01 probability level, for entries within $F_1$'s and within males, and for $F_1$'s vs males.

hybrids was 23% more than for parents. The DF yield of $F_1$ hybrid CK-60 × Fa357 (slightly over 20 t/ha) in about 180 days compared favorably with other high-yielding forage sorghums previously studied at Isabela (3, 5, 8). The CP yields of about 2 t/ha, produced by CK-60 × Fa357, CK-60 × Lahoma and CK-60 × Common, are excellent and also compare favorably with top-yielding tropical grasses at Isabela (6). The average CP yield was 25% greater for $F_1$ hybrids than for parents, whereas the latter exceeded in CP content by 7%.

Among the $F_1$ hybrids and male parents CK-60 × Fa357, Common and Lahoma, respectively, were significantly taller than the remaining genotypes (table 5). The average plant height for $F_1$ hybrids was 24% more than for parents. The $F_1$ hybrids of CK-60 × Fa357, CK-60 × Common,

and CK-60 × Lahoma and male parents Lahoma significantly exceeded the remaining genotypes in leaf blade area. The $F_1$ hybrids had 47% more leaf blade area than parents. The average number of tillers/plant ranged from 6.5 to 1.3 and 21.9 to 3.2 among $F_1$ hybrids and male parents, respectively. Male parent Common had the highest number of tillers among all genotypes. Tillers were 79% more numerous for parents than

TABLE 4.—*Mean yields of green and dry forage and crude protein, and contents of dry matter and crude protein of seven $F_1$ hybrids of sorghum and their parents across the three harvests at Isabela, Puerto Rico*[1]

| Genotypes | Green forage yield | Dry forage yield | Dry matter content | Crude protein yield | Crude protein content |
|---|---|---|---|---|---|
| | *t/ha* | *t/ha* | % | *t/ha* | % |
| $F_1$'s | | | | | |
| CK-60 × Fa357 | 135.42 a | 20.10 a | 14.82 a | 2.13 a | 10.73 ab |
| CK-60 × Common | 131.76 a | 19.65 a | 14.94 a | 1.98 a | 10.20 abc |
| CK-60 × Lahoma | 130.59 a | 20.49 a | 15.75 a | 2.07 a | 10.30 abc |
| CK-60 × Sweet sudan | 117.33 b | 17.67 b | 15.05 a | 1.71 b | 9.94 bc |
| CK-60 × Piper | 104.31 c | 15.78 c | 15.16 a | 1.47 bc | 9.34 c |
| CK-60 × Greenleaf | 101.37 c | 15.81 c | 15.62 a | 1.50 bc | 9.87 bc |
| CK-60 × Roma | 83.31 d | 11.52 d | 13.84 a | 1.32 c | 11.42 a |
| $\bar{X}$ | 114.75 | 15.64 | 15.03 | 1.74 | 10.26 |
| C.V. (%) | 9.94 | 10.70 | 4.19 | 17.31 | 13.02 |
| Male parents | | | | | |
| Lahoma | 115.86 a | 16.65 a | 14.34 a | 1.77 a | 10.70 a |
| Roma | 104.58 b | 15.84 a | 15.19 a | 1.77 a | 11.32 a |
| Sweet sudan | 103.71 b | 15.69 a | 15.16 a | 1.83 a | 11.60 a |
| Fa357 | 86.04 c | 13.08 b | 15.30 a | 1.41 b | 10.70 a |
| Greenleaf | 68.23 d | 10.08 c | 14.74 a | 1.02 c | 10.28 a |
| Common | 58.44 d | 8.91 c | 15.24 a | 0.99 c | 11.25 a |
| Piper | 58.23 d | 8.94 c | 15.32 a | 0.93 c | 10.68 a |
| $\bar{X}$ | 84.99 | 12.72 | 15.04 | 1.39 | 10.93 |
| C.V. (%) | 7.76 | 10.48 | 4.11 | 15.22 | 10.29 |

[1] Means within $F_1$'s and means within male parents were compared using Duncan's multiple range test. Means within each group followed by the same letter do not differ significantly at the 0.05 probability level.

for $F_1$ hybrids. The $F_1$ hybrids of CK-60 × Roma, CK-60 × Common and CK-60 × Greenleaf and male parent Roma had the highest leaf/stem ratio among all genotypes. The average leaf/stem ratio exhibited by $F_1$ hybrids was 15% more than that of parents. Lahoma had the highest yield potential among male parents and showed an intermediate level of HCN-p compared to the other lines. The $F_1$ hybrids of CK-60 × Roma and CK-60 × Sweet Sudan were superior to all other crosses for low

HCN-p, although they were not among the highest yielders. Of the highest yielding hybrids, CK-60 × Common, and CK-60 × Lahoma contained the highest level of HCN-p, whereas CK-60 × Fa357 was intermediate in HCN-p. Therefore, CK-60 × Fa357 was the only $F_1$ hybrid that combined high yielding potential with HCN-p below the threshold danger of 200 p/m. Male parent Fa357, which had the lowest overall HCN-p, appeared to be a useful parent in producing forage sorghum-sudan hybrids of acceptable HCN-p and high yield.

TABLE 5.—*Mean height, leaf area, tillers/plant, leaf/stem ratio and hydrocyanic acid potential (HCN-p) in seven $F_1$ hybrids of sorghum and their parents across three harvests at Isabela, Puerto Rico*[1]

| Genotypes | Plant height | Leaf area | Tillers /plant | Leaf/stem ratio | HCN-p | |
|---|---|---|---|---|---|---|
| | | | | | 45 days | 60 days |
| | | | *p/m* | | | |
| $F_1$'s | | | | | | |
| CK-60 × Fa357 | 335 a | 6,654 a | 6.50 a | 0.5128 c | 269 c | 197 a |
| CK-60 × Common | 318 b | 6,549 a | 3.89 c | 0.6293 a | 418 a | 272 a |
| CK-60 × Lahoma | 306 b | 6,484 a | 6.58 a | 0.5722 b | 395 a | 279 a |
| CK-60 × Piper | 274 c | 6,166 b | 5.33 b | 0.4867 c | 302 b | 208 a |
| CK-60 × Sweet sudan | 260 c | 6,137 b | 6.61 a | 0.4143 d | 228 d | 166 a |
| CK-60 × Roma | 258 c | 5,433 d | 1.25 e | 0.6307 a | 196 e | 162 a |
| CK-60 × Greenleaf | 209 d | 5,839 c | 1.92 d | 0.6037 a | 266 c | 198 a |
| $\bar{X}$ | 280 | 6,180 | 4.58 | 0.550 | 296 | 211 |
| C.V. (%) | 4.60 | 3.80 | 15.89 | 6.40 | 17.72 | 14.29 |
| Male parents | | | | | | |
| Lahoma | 294 a | 6,549 a | 3.29 f | 0.5601 b | 250 c | 191 b |
| Sweet sudan | 262 b | 4,716 c | 6.11 d | 0.4133 d | 313 ab | 210 b |
| Roma | 248 b | 5,173 b | 3.22 f | 0.6091 a | 274 bc | 184 b |
| Fa357 | 210 c | 3,415 d | 9.83 b | 0.4539 c | 196 d | 139 c |
| Piper | 206 c | 3,258 d | 8.42 c | 0.4339 cd | 331 a | 247 a |
| Common | 195 c | 3,403 d | 21.92 a | 0.4419 c | 341 a | 270 a |
| Greenleaf | 165 d | 2,877 e | 4.47 e | 0.4487 c | 257 c | 202 b |
| $\bar{X}$ | 226 | 4,199 | 8.18 | 0.4801 | 280 | 207 |
| C.V. (%) | 5.25 | 7.25 | 12.56 | 6.26 | 16.32 | 20.62 |

[1] Means within $F_1$'s and means within male parents were compared using Duncan's multiple range test. Means within each group followed by the same letter do not differ significantly at the 0.05 probability level.

Leaf area and height were positively correlated (P = 0.01) with GF, DF and CP yields (table 6). Correlations among other traits and yields were low and in many cases nonsignificant. Torres-Cardona et al. (8) compared three-way hybrids, single crosses and their parents during a 1-year period at Isabela and also found significant positive correlations between leaf area and height and GF, DF and CP yields. Thus, the association of height and leaf area with yields, appears to be consistent

and these two traits might become important selection criteria in the improvement of forages.

Midparent heterosis was manifested for GF, DF, and CP yields, tillers/plant, height and leaf area (table 7). In DM and CP contents average midparent heterosis for the seven crosses was −2.3 and −11.3%, respectively. Corresponding estimates were 2.1% for leaf/stem ratio and 14.4 and 16.7% for HCN-p at 45 and 60 days. High parent heterosis was estimated to be lower than midparent heterosis. In only one trait (leaf stem ratio), did average high parent exceeded average midparent heterosis. High parent heterosis was not observed for DM and CP contents or for tillers/plant.

$F_1$ hybrid CK-60 × Common exhibited the greatest hybrid vigor or heterosis. It produced 146 and 125% more DF than the midparent and high parent, respectively. The $F_1$ hybrids CK-60 × Fa357 and CK-60 × Piper also exhibited appreciable hybrid vigor in terms of yields. Most of the $F_1$ hybrids also showed heterosis in height and leaf area. Parents

TABLE 6.—*Simple correlation coefficients between leaf and height and green forage, dry forage, and crude protein yields of $F_1$ forage sorghum hybrids and their parents across three harvests at Isabela, Puerto Rico*

| Yield | Leaf area | Height |
|---|---|---|
| Green forage | 0.71**[1] | 0.81** |
| Dry forage | 0.69** | 0.80** |
| Crude protein | 0.60** | 0.71** |

[1] Significantly different from zero at P = 0.01 (134 d.f.).

Piper and Sweet sudan had significantly more CP content than their respective hybrids. Hybrid CK-60 × Roma showed the least heterosis in most of the traits studied.

Most of the forage sorghum hybrids tested performed up to expectations, verifying earlier reports (5, 8) on their potential for forage production in the tropics. Excellent DF yields were obtained 60 days after planting. At least three 60-day interval harvests with excellent CP content and yield seem to be possible.

## RESUMEN

En la finca experimental de Isabela de la Estacion de Investigaciones en Agricultura Tropical, ARS-USDA, Mayagüez, Puerto Rico, se cruzó la línea androestéril de sorgo (*Sorghum bicolor* (L.) Moench) A CK-60, con el sorgo forrajero "Roma" y seis variedades de yerba sudán ("Greenleaf", "Common", "Sweet sudan", Florida (Fa), "357", "Piper" y "Lahoma"). Los siete híbridos $F_1$, y los siete progenitores masculinos se evaluaron en términos de rendimiento de forraje verde (GF), forraje seco (DF), materia seca (DM),

TABLE 7.—*Percent increase or decrease of $F_1$ hybrids over or under mean of midparent and high parent values across three harvests at Isabela, Puerto Rico*

| Trait | CK60 × Common | | CK60 × Piper | | CK60 × Fa357 | | CK60 × Greenleaf | | CK60 × Sweet Sudan | | CK60 × Lahoma | | CK60 × Roma | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Midparent | High parent | Midparent | High parent | Midparent | High parent | Midparent | High parent | Midparent | High parent | Midparent | High parent | Midparent | High parent |
| CF yield | 151**[1] | 128** | 103** | 83** | 115** | 70** | 73** | 48** | 63** | 18** | 59** | 12** | 12[NS] | −19** |
| DM % | −2[NS2] | −2[NS] | −1[NS] | −1[NS] | −3[NS] | −3[NS] | 4[NS] | 6** | −1[NS] | −1[NS] | 6[NS] | 10** | −9** | −9** |
| DF yield | 146** | 125** | 103** | 83** | 107** | 64** | 80** | 57** | 61** | 17** | 72** | 23** | 1[NS] | −26** |
| CP % | −13[NS] | −9[NS] | −18** | −13** | −6[NS] | 0[NS] | −12[NS] | −3[NS] | −16** | −14** | −10[NS] | −3[NS] | −4[NS] | 0[NS] |
| CP yield | 15** | 104** | 68** | 60** | 100** | 68** | 60** | 51** | 58** | 2[NS] | 37** | 17** | 1[NS] | −25** |
| Tillers/plant | −66** | −82** | 14[NS] | −36** | 22[NS] | −33** | −32[NS] | −58** | 92** | 13[NS] | 229** | 137** | −31[NS] | −44** |
| Height | 100** | 64** | 65** | 33** | 102** | 62** | 43** | 26** | 35** | 0[NS] | 46** | 4[NS] | 39** | 5[NS] |
| Leaf area | 92** | 95** | 84** | 90** | 94** | 96** | 85** | 106** | 50** | 31** | 30** | −1[NS] | 26** | 6** |
| Leaf/stem ratio | 21** | 42** | −6[NS] | 13** | −2[NS] | 13** | 16** | 35** | −18** | 0[NS] | −1[NS] | 3[NS] | 5[NS] | 4[NS] |
| HCN-p 45 days | 43** | 23** | 4[NS] | −6[NS] | 22[NS] | 44** | 5[NS] | 6[NS] | −17** | −19** | 68** | 85** | −24** | −21** |
| HCN-p 60 days | 24** | 1[NS] | 1[NS] | −14** | 31** | 50** | 7[NS] | 1[NS] | −12[NS] | −15** | 71** | 79** | −5[NS] | −5[NS] |

[1] Significant at the 0.01 probability level.
[2] Not significant.

proteína bruta (CP), ahijamiento, altura, proporción hoja:tallo y potencial de ácido cianhídrico (HCN-p) a los 45 y 60 días. Se llevaron a cabo tres cortes a intervalo de 60 días. Se estudió el efecto de la heterosis en todos los caracteres.

La producción de GF, DF y CP fue más alta en el segundo corte. En todos los cortes los híbridos fueron los mejores productores de DF. Fueron superiores a los progenitores masculinos en casi todos los caracteres, excepto HCN-p, a los 45 y 60 días, contenido de DM y CP y ahijamiento. Al combinarse los datos de los tres cortes, se notaron diferencias significativas entre genotipos en todos los caracteres estudiados. Se obtuvieron diferencias significativas entre los progenitores masculinos en todos los caracteres, excepto en rendimiento de DM y CP y entre los híbridos $F_1$ excepto en rendimiento de DM y concentración de HCN-p a los 60 días. Los híbridos $F_1$ de CK-60 × Fa357, CK-60 × Common y CK-60 × Lahoma fueron los mejores productores en términos de GF, DF y CP. El híbrido $F_1$ CK-60 y Common presentó la mayor heterosis; produjo de 146 a 125% más DF que el promedio de los padres y que el padre con la mayor heterosis, respectivamente. Los valores de HCN-p fueron menores a los 60 días que a los 45.

Los resultados indican que los híbridos que registraron las mayores producciones de DF y CP tienen un magnífico potencial como forrajeras en los trópicos. Producciones de alrededor de 20 toneladas de DF y 2 toneladas de CP bruta en solo 180 días son excelentes, especialmente cuando el forraje puede cosecharse a intervalo corto (60 días) con un bajo potencial de ácido cianhídrico.

## LITERATURE CITED

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