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# Grain Yield of Three Sorghum Varieties as Influenced by Seeding Rate and Cutting Frequency

M.W. Akash and H.M. Saoub
Department of Agricultural Resources and Environment, Faculty of Agriculture, University of Jordan, Amman 11942, Jordan

**Abstract:** The effects of four cutting frequencies (without cut, cut once, cut twice and cut three times) and five seeding rates (20,40,60,80,100 kg $ha^{-1}$) were studied on the productivity of three sorghum varieties (common sudangrass, sugar sudangrass hybrid GII and grazer N2 sudangrass hybrid). Sugar sudangrass hybrid GII and grazer N2 sudangrass hybrid gave higher yield as compared with common sudangrass variety, which was the least productive among the three varieties used. However, common sudangrass attained maximum panicle length (22 cm) and there was no significant difference among these varieties with reference to thousand grains weight. Common sudangrass planted at a seeding rate of 80-100 kg $ha^{-1}$ and cut only once or planted at 100 kg $ha^{-1}$ without cutting treatment showed significantly the highest harvest index (0.443) in contrary to Grazer $N_2$ sudangrass hybrid at a seeding rate of 60 kg $ha^{-1}$ with two cutting treatments, which gave the lowest harvest index (0.06).

**Key words:** Sudangrass, cutting frequency, seeding rate, sorghum varieties

## Introduction

The genus *Sorghum* include several crops: grain sorghum, (*Sorghum bicolor*, L. Moench [formerly *Sorghum vulgare*]); sorgo or sweet sorghum grass sorghum (*Sorghum bicolor*); and sudangrass (*Sorghum bicolor*) [formerly (*Sorghum sudanense*) (piper)], (Fribourg, 1985). Sudangrass is one of the most important grasses utilized for supplemental summer forage, mainly because of its ability of rapid growth and high potential for yield of satisfactory quality (Cullison, 1979; Seo and Kim, 1985).

Under conditions of favourable rainfall or irrigation, narrow row spacing (13 to 25 cm) produce more grains of sorghum than wide spacing of 102 cm (Grimes and Musick, 1960). Robinson *et al.* (1964) obtained similar results, where a linear trend for increased yield occurred as row spacing was reduced from 102 to 25 cm.

The un-clipped sorghum plants produced a higher grain yield when compared to those clipped once (Singh and Colville, 1962). Similarly, there were a reversible relationship between grain yield of western wheat grass (*Agropyron smithi*) and cutting frequency (Everson, 1966).

There was no significant difference in thousand grains weight or kernel size between the lowest (300,000) and the highest (800,000) plant densities per hectare (Soltero, 1992). Generally, kernel weight was slightly affected by the changes within row plant density (Karchi and Rudish, 1966). Superiority in sorghum grain yield was primarily due to the increase in the number of fertile tillers per unit area rather than changes in panicle weight (Brown, *et al.*, 1964). Plant spacing is one of the factors that significantly affect the number of panicles (Joseph, *et al.*, 1980). At the highest plant densities, three grain sorghum hybrids produced approximately one panicle per plant, but under reduced density, the number of panicles per plant increased to a greater extent in early matured hybrid and to a lesser extent in the other two hybrids (Blum, 1970).

Several factors such as biotic factors, weather condition, soil, water supply, fertilization, variety used, cutting frequency and seeding rate influence grain yields of sorghum (Stoskopf, 1981; Litzenberge, 1985). The current study was designed to determine the effects of different seeding rates and cutting frequencies on grain yield of three sorghum varieties grown under irrigation at Jordan Valley.

## Materials and Methods

This experiment was conducted at the University of Jordan Research Station, located in the central region of the Jordan Valley, 32°N latitude, 35°: 30′ longitude and 250 meter below the sea level (Sharaiha and Arabiat, 1987). The experiment was carried out during the period from June to the end of October, 1996. A split-split-plot design with four replicates was used. Three sorghum varieties were the main plots (common sudangrass, Sugar sudangrass hybrid GII and Grazer N2 sudangrass hybrid).

Four cutting frequencies occupied the subplots as follows: without cutting left for grain production (control), cut once then left for grain production, cut twice then left for grain production and cut three times then left for grain production. Five seeding rates (20, 40, 60, 80 and 100 kg $ha^{-1}$) were placed in the sub-sub-plots. The area of each sub-sub-plot was 3.6 $m^2$.

The land was cultivated with a moldboard plough five days before sowing, then harrowed by a chisel plough just before sowing. Mono-super phosphate [Ca $(H_2PO_4)_2$ . $CaSO_4$] was broadcasted by hand at the rate of 85 kg $ha^{-1}$ prior to sowing.

Seeds were sown on 8th of June, 1996, in rows 25 cm apart. The first cut was applied 40 days after sowing (July 18), followed by 30 (August, 17) and 31 days (September, 18) for the second and the third cuts, respectively. Grain was harvested on 25$^{th}$ of October 1996.

The recommended nitrogen fertilizer rate of 150 kg $ha^{-1}$ were added for each sub-plot after each cutting in equal amount (Harb and El-Hattab, 1991).Water was applied by sprinklers after every two days for about 4 hours each time during the growing season. Weed control was done by hand all over the growing season when needed. Paper bags were used to protect the panicles from the attack of birds.

The data were analyzed using the general linear models procedure (GLM) of the SAS system for the split-split-plot design according to the procedure outlined by Steel and Torrie (1980).

## Results and Discussion

There was highly significant effect of cutting frequencies on all studied characters (Table 1). Whereas the effect of varieties was significant for grain yield, panicle length and harvest index. The effect of seeding rates was highly significant for grain yield, panicle length and harvest index and just significant for thousand grains weight.

There was a significant interaction between varieties, cutting frequencies and seeding rates for grain yield, panicle length and harvest index. Meanwhile, the interaction between varieties and cutting frequencies was significant for grain yield, panicle number and panicle length. At the same time, the interaction between varieties and seeding rates significantly affect grain yield and harvest index (Table 1). Grain yield of the grazer $N_2$ sudangrass hybrid which was seeded at a rate of 60 kg $ha^{-1}$ without cutting treatment was significantly superior (11.56 t $ha^{-1}$) to all other combinations (Table 2). Both hybrid varieties yielded more grains than common sudangrass. Meanwhile, seeding rate of 60 or 80

Table 1: Analysis of variance for grain yield, thousand grains weight, panicle number, panicle length and harvest index of three sorghum varieties under different cutting frequencies and seeding rates

| | | Mean square | | | | |
|---|---|---|---|---|---|---|
| SOV | df | Grains yield | Thousand grains weight | Panicle number | Panicle length | Harvest index |
| Replicates | 3 | 4108 | 6.149 | 5.1 | 14.7 | 0.0027 |
| Variety | 2 | 2963801*** | 7.52 | 31.3 | 73.1** | 0.03384*** |
| Error(a) | 6 | 40380 | 2.12 | 20.0 | 5.4 | 0.0046 |
| Cutting frequency | 3 | 4843415*** | 2028.5*** | 621.6*** | 107.7*** | 0.5588*** |
| Variety X Cutting frequency | 6 | 592544*** | 11.16 | 44.9* | 185.7*** | 0.0059 |
| Error(b) | 27 | 14177 | 5.79 | 17.9*** | 6.3 | 0.0046 |
| Seeding rate | 4 | 196091*** | 5.13* | 106.0 | 51.6*** | 0.0337*** |
| Variety X Seeding rate | 8 | 898*** | 3.15 | 2.2 | 7.3 | 0.0030* |
| Variety X Cutting frequency X Seeding rate | 36 | 42264*** | 2.73 | 19.1 | 9.4* | 0.0030*** |
| Error© | 144 | 5597 | 1.88 | 14.5 | 5.346 | 0.0012 |

Significant at 5% probability level (*), Significant at 1% probability level (**), Significant at 0.1% probability level (***).

Table 2: Grain yield (t $ha^{-1}$) of three sorghum varieties as affected by different seeding rates and cutting frequencies

| | | Seeding Rate (kg $ha^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Variety | Cutting Frequency | 20 | 40 | 60 | 80 | 100 | Mean |
| $V_1$ | $C_0$ | 2.97 | 3.00 | 2.47 | 1.29 | 1.62 | |
| | $C_1$ | 1.03 | 1.20 | 1.08 | 1.20 | 1.32 | |
| | $C_2$ | 0.29 | 0.22 | 0.25 | 0.30 | 0.31 | |
| | $C_3$ | 0.27 | 0.24 | 0.23 | 0.25 | 0.29 | |
| Mean | | | | | | | 0.99 |
| $V_2$ | $C_0$ | 5.05 | 5.26 | 8.63 | 9.36 | 10.49 | |
| | $C_1$ | 5.47 | 7.22 | 7.40 | 8.33 | 6.87 | |
| | $C_2$ | 0.76 | 1.14 | 1.25 | 0.90 | 1.06 | |
| | $C_3$ | 0.52 | 0.90 | 1.14 | 1.27 | 1.89 | |
| Mean | | | | | | | 4.25 |
| $V_3$ | $C_0$ | 4.78 | 7.79 | 11.56 | 10.38 | 6.89 | |
| | $C_1$ | 4.62 | 6.73 | 8.97 | 8.06 | 8.50 | |
| | $C_2$ | 0.62 | 0.90 | 1.00 | 1.00 | 0.99 | |
| | $C_3$ | 0.33 | 0.53 | 1.48 | 1.26 | 1.59 | |
| Mean | | 2.226 | 2.926 | 3.787 | 3.632 | 3.483 | 4.40 |
| | | Main effect of cutting frequency | | | | | |
| | | $C_0$ | | $C_1$ | $C_2$ | $C_3$ | |
| | | 6.1022 | | 5.1987 | 0.7303 | 0.8121 | |

LSD (at $P < 0.05$) for Variety = 0.7774, Cutting frequency = 0.4460, Seeding rate = 0.3018, Three way interaction = 1.046

Table 3: Thousand grains weight (g) of three sorghum varieties as affected by different seeding rates and cutting frequencies

| Seeding rate (kg $ha^{-1}$) | Cutting frequency | | | | |
|---|---|---|---|---|---|
| | C0 | C1 | C2 | C3 | Mean |
| 20 | 13.8 | 16.0 | 4.5 | 4.3 | 9.65 |
| 40 | 13.0 | 15.3 | 4.6 | 4.7 | 9.40 |
| 60 | 14.0 | 14.4 | 4.0 | 4.5 | 9.22 |
| 80 | 13.7 | 14.7 | 3.8 | 4.0 | 9.66 |
| 100 | 11.8 | 15.5 | 3.7 | 4.2 | 8.79 |
| Mean | 13.26 | 15.16 | 4.12 | 4.35 | |
| Main effect of Variety | | $V_1$ | $V_2$ | | $V_3$ |
| | | 9.58 | 9.02 | | 9.08 |

LSD (at $P < 0.05$) for Variety = 0.564, Cutting frequency = 0.901 Seeding rate = 0.553, two way interaction = 1.106

$V_1$ = Common Sudangrass. $V_2$ = Sugar Sudangrass Hybrid GII.
$V_3$ = Grazer N2 Sudangrass Hybrid

$C_0$ = Left for grain production (control). $C_1$ = Cut once then left for grain production. $C_2$ = Cut twice then left for grain production. $C_3$ = Cut three times then left for grain production.

kg $ha^{-1}$ gave the maximum grain yield over the remaining seeding rates (Table 2).

This significant superiority of 60 and 80 kg $ha^{-1}$ seeding rate might be related to the optimum plant density that can efficiently use the available growth factors (Stickler and Laude, 1960; Karchi and Rudich, 1966). A significant increase in grains yield was

Table 4: Number of panicles $m^{-2}$ of three sorghum varieties as affected by different seeding rates and cutting frequencies

| | Varieties | | | |
|---|---|---|---|---|
| Cutting frequency | $V_1$ | $V_2$ | $V_3$ | Mean |
| $C_0$ | 20 | 115 | 124 | 86 |
| $C_1$ | 18 | 146 | 111 | 92 |
| $C_2$ | 19 | 119 | 110 | 83 |
| $C_3$ | 12 | 77 | 77 | 55 |
| Mean | 17 | 144 | 105 | |

LSD (at $P < 0.05$) for Variety = 12.85, Cutting frequency = 8.90 two way interaction = 15.42

| Seeding Rate (kg $ha^{-1}$) | $V_1$ | $V_2$ | $V_3$ | Mean |
|---|---|---|---|---|
| 20 | 16 | 53 | 48 | 39 |
| 40 | 15 | 81 | 74 | 57 |
| 60 | 16 | 133 | 122 | 90 |
| 80 | 19 | 154 | 139 | 104 |
| 100 | 20 | 151 | 144 | 105 |
| Mean | 17 | 114 | 105 | |

LSD (at $P < 0.05$) for Variety = 12.85. Seeding rate = 11.40 two way interaction = 19.74

Table 5: Panicle Length (cm) of three sorghum varieties as affected by different seeding rates and cutting frequencies

| | | Seeding Rate(kg $ha^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| Varieties | Cutting frequency | 20 | 40 | 60 | 80 | 100 | Mean |
| $V_1$ | $C_0$ | 30.5 | 26.4 | 30.8 | 30.6 | 26.3 | |
| | $C_1$ | 20.4 | 21.1 | 19.4 | 20.1 | 17.6 | |
| | $C_2$ | 21.8 | 22.0 | 20.3 | 19.8 | 18.8 | |
| | $C_3$ | 20.0 | 19.8 | 19.5 | 18.3 | 16.5 | |
| Mean | | | | | | | 21.98 |
| $V_2$ | $C_0$ | 20.7 | 20.9 | 20.2 | 18.1 | 16.0 | |
| | $C_1$ | 22.5 | 21.9 | 21.5 | 19.8 | 20.6 | |
| | $C_2$ | 20.4 | 21.8 | 24.0 | 21.8 | 21.8 | |
| | $C_3$ | 18.5 | 20.3 | 19.5 | 19.6 | 21.0 | |
| Mean | | | | | | | 20.5 |
| $V_3$ | $C_0$ | 23.2 | 22.1 | 18.2 | 18.1 | 17.6 | |
| | $C_1$ | 22.5 | 20.0 | 22.9 | 21.0 | 20.5 | |
| | $C_2$ | 22.8 | 21.8 | 22.4 | 17.3 | 16.3 | |
| | $C_3$ | 19.1 | 19.0 | 20.0 | 19.3 | 20.1 | |
| Mean | | 21.86 | 21.40 | 21.54 | 20.29 | 19.36 | 20.19 |
| Main effect of cutting frequency | | | $C_0$ | | $C_1$ | $C_2$ | $C_3$ |
| | | | 22.63 | | 20.83 | 20.74 | 19.36 |

LSD (at $P < 0.05$) for Variety = 0.849, Cutting frequency = 0.983 Seeding rate = 0.927, Three way interaction = 1.046

$V_1$ = Common Sudangrass. $V_2$ = Sugar Sudangrass Hybrid GII.
$V_3$ = Grazer N2 Sudangrass Hybrid.

$C_0$ = Left for grain production (control). $C_1$ = Cut once then left for grain production. $C_2$ = Cut twice then left for grain production. $C_3$ = Cut three times then left for grain production.

Table 6: Harvest index of three sorghum varieties as affected by different seeding rates and cutting frequencies

| Variety | Cutting frequency | Seeding rate (kg ha$^{-1}$) 20 | 40 | 60 | 80 | 100 | Mean |
|---|---|---|---|---|---|---|---|
| | $C_0$ | 0.334 | 0.355 | 0.366 | 0.354 | 0.429 | |
| $V_1$ | $C_1$ | 0.314 | 0.388 | 0.378 | 0.443 | 0.433 | |
| | $C_2$ | 0.145 | 0.139 | 0.181 | 0.220 | 0.228 | |
| | $C_3$ | 0.250 | 0.240 | 0.275 | 0.269 | 0.329 | |
| Mean | | | | | | | 0.303 |
| | $C_0$ | 0.267 | 0.240 | 0.244 | 0.310 | 0.339 | |
| $V_2$ | $C_1$ | 0.256 | 0.252 | 0.204 | 0.247 | 0.254 | |
| | $C_2$ | 0.082 | 0.087 | 0.078 | 0.073 | 0.082 | |
| | $C_3$ | 0.107 | 0.120 | 0.134 | 0.182 | 0.229 | |
| Mean | | | | | | | 0.189 |
| | $C_0$ | 0.259 | 0.262 | 0.340 | 0.306 | 0.298 | |
| $V_3$ | $C_1$ | 0.243 | 0.273 | 0.278 | 0.284 | 0.263 | |
| | $C_2$ | 0.066 | 0.068 | 0.060 | 0.077 | 0.079 | |
| | $C_3$ | 0.082 | 0.092 | 0.130 | 0.150 | 0.230 | |
| Mean | | 0.200 | 0.209 | 0.222 | 0.243 | 0.266 | 0.192 |
| Main effect of cutting frequency | | | $C_0$ | $C_1$ | $C_2$ | $C_3$ | |
| | | | 0.314 | 0.301 | 0.110 | 0.188 | |

LSD (at $P < 0.05$) for Variety = 0.0332
Cutting frequency = 0.0438, Seeding rate = 0.0196
Three way interaction = 0.0493
$V_1$ = Common Sudangrass. $V_2$ = Sugar Sudangrass Hybrid GII.
$V_3$ = Grazer N2 Sudangrass Hybrid.
$C_0$ = Left for grain production (control). $C_1$ = Cut once then left for grain production. $C_2$ = Cut twice then left for grain production.
$C_3$ = Cut three times then left for grain production.

obtained as a result of increasing plant population under favourable soil and rainfall conditions (M'Khaitir and Vanderlip, 1992).

As for the cutting frequency, maximum grain yield was obtained from the zero cut treatment over one, two and three cut treatments (Table 2). The significant reduction in grain yield for all varieties and seeding rates which were cut two or three times and then left for grain production might be due to the very low seed set after fertilization process. This was indirectly related to exhausted plants (low level of reserved carbohydrates) after cutting (Everson, 1966).

The highest thousand grain weight (16 g) was obtained from plants seeded at a rate of 20 kg ha$^{-1}$ when cut once (Table 3). In general, as the seeding rate was increased from 20 to 100 kg ha$^{-1}$, thousand seed weight was decreased from 9.65 to 8.79 g (Table 3).

These results are in agreement with those reported by other researchers (Karchi and Rudich, 1966; M'Khaitir and Vanderlip, 1992). This negative effect can be attributed to the fact that high seeding rates will increase grain yield but this will be on the expense of grain size.

As for the number of panicles per square meter, there was a significant interaction between varieties and cutting frequencies and between varieties and seeding rates (Table 4). On one hand, Sugar sudangrass hybrid GII cut only once gave the highest number of panicle 146 panicles per square meter). On the other hand common sudangrass variety gave the lowest panicle number at any cutting frequency used (Table 4). This is related to the low population density obtained by common sudangrass as a result of low germination and percent emergence. For the second interaction, the combination of sugar sudangrass hybrid GII and seeding rate of 80 or 100 kg ha$^{-1}$ was the superior (Table 4). However, there were no significant differences between this treatment and those obtained by Grazer $N_2$ sudangrass hybrid at the same seeding rates (Table 4). In general, increasing the seeding rate from 20 to 100 kg ha$^{-1}$ resulted in a significant increase in panicle number from 39 to 105 panicles m$^{-2}$. Similar results were obtained by other researchers (Stickler *et al.*, 1961; Burnside *et al.*, 1964; Blum, 1970), but contradictory to M'Khaitir and Vanderlip, (1992).

Maximum panicle length (about 31 cm) was obtained by growing common sudangrass at a seeding rate of 20, 60 or 80 kg ha$^{-1}$ under zero cutting treatment (Table 5). On the other hand, the shortest panicle length was obtained by growing sugar sudangrass hybrid GII at a seeding rate 100 kg ha$^{-1}$ with zero cut treatment (Table 5). Common sudangrass was the superior variety and there were reversible effects between panicle length and both cutting frequency and seeding rate, which indicated that panicle length is an important parameter in seed production process (Long panicle means more branches carrying more grains per panicle). But at the same time, common sudangrass variety gave the lowest grains yield, mainly due to its low population density. However, Elmi (1992) recorded that the seeding rate has no significant effect on the corn spike length.

Common sudangrass planted at a seeding rate of 80 kg ha$^{-1}$ with one cutting treatment showed significantly the highest harvest index (0.443). However, this was non significant with harvest index values obtained from the same variety planted at a seeding rate of 100 kg ha$^{-1}$ cut once (0.433) or without cutting (0.429). On contrary grazer $N_2$ sudangrass hybrid at a seeding rate of 60 kg ha$^{-1}$ with two cutting treatments, gave the lowest harvest index (Table 6). The reversible relationships between harvest index and both cutting frequencies and seeding rates indicated that grain yield was affected reversibly by increasing both cutting frequency and seeding rate. However, Naser, (1995) recorded that the seeding rate has no significant effect on the sudangrass harvest index.

Increasing number of harvests will decrease the grains yield, however, it can be safely recommended to cut the crop twice then plants will be left for grain production. In this case growers can ensure some green forage and grain production.

Under the Jordan valley conditions, the optimum seeding rate for maximum grain production was 60 kg ha$^{-1}$ for both hybrid varieties.

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