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Effect of Seeding Rate and Nitrogen Fertilization on the Carbohydrate Reserves, Stand Reduction, and Yield of Sorghum-Sudangrass Hybrid

Wang Beom Han* and Dong Am Kim

播種量과 窒素施肥水準이 수단그라스系 雜種의 貯藏炭水化物 含量, 株數低下 및 乾物收量에 미치는 影響

韓旺範* · 金東岩

摘 要

본 시험은 수단그라스계 잡종의 수량, 그루터기의 저장탄수화물 및 주수저하에 미치는 파종량과 질소시비수준의 영향을 구명하기 위하여 1983년 서울대학교 농과대학 부속실험목장의 사초시험포장에서 실시되었으며 얻어진 결과를 요약하면 다음과 같다.

1. 파종량은 사초수량에 미치지 못하였으나 질소시비수준에 의한 사초수량의 차이는 고도의 유의성이 인정되었다. 높은 질소시비 수준에서 최대 건물수량이 생산되었다.
2. 1회 예취시 파종량과 질소시비수준은 공히 저장탄수화물 수준에 영향을 주었다(P<.05). 2회 예취시는 2처리 공히 저장탄수화물 수준에 영향을 미치지 못하였다.
3. 1회 예취시 파종량만이 주수저하에 영향을 주었다. 그러나 총고사율은 파종량과 질소시비수준에 의해 영향을 받았다(P<.05). 높은 파종량은 그루터기의 높은 고사율을 유발하였다.
4. 본 시험결과에 의하면 수단그라스계 잡종을 여름철 사초로 이용할 경우 최대수량을 얻기 위해 ha당 40kg의 파종량과 300kg의 질소시용이 가장 바람직하다고 생각된다.

Ⅰ. INTRODUCTION

In recent years, a great deal of new interest has been generated in the area of summer forage management. For that reason, sorghums have been introduced as a possible alternative summer forage crop to cool season pasture plants.

This supplemental forage help maintain a high level of production during the summer months when unfavorable climatic conditions often bring about a decrease in quality and production of perennial herbage.

Sorghum-sudangrass hybrid is one of the most important grasses utilized for supplemental summer forage(Kim et al., 1981; Seo, 1982). Specific information is lacking as to what seeding rate needs to be sown and how much nitrogen fertilizer needs to be applied in order to obtain high yields of quality forage and sustain this production over the summer period under Korean condition(Yun, 1981 ; Lim, 1983).

Until data are available on such problems, definite management decisions on supplemental summer forages can not be recommended with assurance.

The present study was initiated, therefore, to determine the effect of seeding and nitrogen fertiliz ation levels on the yield and performance of sorg-

서울大 農生科大(College of Agric. & Life Sciences, Seoul Nat'l Univ., Suwon 441-744, Korea)

* 미국 코넬대학교 농업생명과학대학(Cornell University, USA)

hum-sudangrass hybrid as a summer forage crop.

Ⅱ. MATERIALS AND METHODS

The experiment was carried out to investigate the influences of seeding rates and nitrogen fertilization levels on sorghum-sudangrass hybrid performance in 1983 on the Experimental Livestock Farm, College of Agriculture, Seoul National University in Suwon.

For the test, a split plot design with three replications was used with 3 seeding rates{20(S2), 40(S4) and 80(S8) kg/ha} as mainplots and 3 nitrogen fertilization levels{0(N0), 150(N15), and 300 (N30) kg/ha} as subplots. The soil was a silty clay loam with 2.7% organic matter, and had a pH of 5.5, a C.E.C. of 12.5me/100g, and a 0.19% of nitrogen of soil(Table 1). Each experimental subplot consisted of 2 m by 3.3 m area.

The cultivar used was Pioneer 988 which was recommended one in Korea. Seeds were planted on May 11 by hand broadcasting. Split applicaions of nitrogen one third prior to planting and one third after the first harvest and one third after the second harvest was achieved. Nitrogen, in the form of urea, was applied broadcast at seeding time at 3 levels: 0, 50, and 100kg of nitrogen per hectare. Phosphorus and potassium, as fused phosphate and potassium chloride, were broadcasted uniformly on all plots at the rates of 100 and 50kg per hectare, respectively. And additional 100kg/ha of potassium was applied evenly after the first and second cuts.

Table 1. Chemical soil properties of the experimental field.

pH	OM (%)	P_2O_5 (ppm)	N	Exchangeable(me/100g)			CEC (me/100g)
				Ca	Mg	K	
5.5	2.7	42	0.19	5.0	0.8	0.28	12.5

3kg/ha of simazine{2-chloro-4, 6-bis(etylamino) -S-triazine} was diluted in 1500 l/ha of water and applied with a sprayer operated at 4kg/cm^2 pressure on May 12. For the control of leaf blight, 1.5kg/ha of Benlate{methyl-1-(butylcarbamoyl)-2-bensymidazol carbamate} was diluted in 1500 l/ha of water and applied with the same sprayer on June 13.

Army worm(*Mythimana separata* Walker) was detected on June 22. As a pesticide, 1.8 l/ha of trichlorofon(dimenthyl-2, 2, 2-trichloro-1-hydroxyethyl phosphonate) was diluted in 1500 l/ha of water and applied on the same day.

The first and second cuts were conducted at the heading stage to insure good regrowth: those were July 22 and September 6, respectively.

The middle 3.3m^2 of the center area were harvested for forage and weed yields: the stubbles in the out side area served as samples to analyze the reserved carbohydrates contents by Anthrone methods.

Major weed species in the experimental plots were annual grasses (*Digitaria spp., Echinochloa macrocorvi, Setaria spp.*) and broadleaf weeds (*Amaranthus spp., Chenopodium spp.*).

Percent stand reduction was computed from stand in 1m^2 at harvest. Drought conditions occurred through the early vegetative stage from the time the seed were sown until the time the plants were 100cm tall.

Ⅲ. RESULTS AND DISCUSSION

1. Forage yield

The average yields in tons of dry matter per hectare of sorghum-sudangrass hybrid are shown in Table 3. At first harvest, the yields of dry matter (DM) were 2.70, 4.60, and 5.23 ton/ha for S2, S4

Table 2. Environmental conditions during growing season of sorghum-sudangrass hybrid at Suwon in 1983.

	Decade \ Month	May	June	July	August	September
Temperature (℃)	First	14.9	20.1	22.5	27.3	22.8
	Second	18.1	21.1	22.4	26.7	21.8
	Third	19.5	22.3	25.5	23.5	19.4
	Mean	17.5	21.2	23.6	25.8	21.4
Precipitation (mm)	First	35.5	0.0	68.9	57.1	115.4
	Second	12.9	27.7	149.9	0.8	16.0
	Third	7.2	4.4	64.0	79.6	30.1
	Total	55.6	32.1	282.8	137.5	161.5
Duration of sunshine(hr.)	First	8.5	11.0	3.2	6.5	3.6
	Second	8.1	8.2	5.0	9.3	7.2
	Third	7.9	5.9	1.7	3.2	6.1
	Mean	8.1	8.4	3.2	6.2	5.7

*: Data originated from Suwon Agriculture Meteorological Station.

and S8 plots, respectively, and at second harvest, the yields of DM were 3.20, 4.37, and 5.45 ton/ha for S2, S4, and S8 plots, respectively.

In this experiment, the DM yield of the first harvest was a little less than that of the second harvest. This result occurred since the drought conditions prevailed during the first growing season (Table 2). At both harvest, there was no significant difference in yields among three seeding rates{20kg/ha (S2), 40kg/ha(S4), and 80kg/ha(S8)}. Similar results were reported by a number of researchers(Grimes and Musick, 1960; Stickler and Laude, 1960; Burger and Campbell, 1961; Stickler and Wearden, 1965; Ali-Khan, 1973).

Burger and Campbell(1961) suggested that the tillering habit of sudangrass would compensate for a comparatively low initial population. Similar results were reported by Stickler and Laude(1960) that less tillering and finer stems were noted at the higher plant population. In this experiments, it could be explained that the more tillering and thicker stems at the low plant population and high mortality at the high plant density were both able to compensate the forage yields. However, there was a general trend towards higher yields in high populations. But very little or no advantage could be gained by increasing seeding rate.

Whereas there was a significant difference($P<.01$) in forage yield among three nitrogen fertilization levels{0kg/ha(N0), 150kg/ha(N15), and 300kg/ha(N30)}. At first harvest, the yields of dry matter were 2.84, 4.10 and 5.59 ton/ha, in the order of increasing fertilization level. At second harvest, the yields of dry matter were 2.60, 4.31, and 6.11 ton/ha for N0, N15, and N30 plots, respectively.

For dry matter yield, high nitrogen plots(N30) were definitely superior to zero nitrogen plots (N0), with medium nitrogen plots(N15) generally intermediate at any seeding rates. Based on this experiment, the yield of N30 plots exceed that of N0 plots by 115%. This observation was consistent with the reports of others(Jung et al., 1964; Griffith et al., 1964 and 1965; Hart and Burton, 1965; Sumner et al., 1965; Tweedy et al., 1971; Harms and Tucker, 1973; Escalada and Plucknett, 1977) and suggested that the forage yield was increased

Table 3. Effect of seeding rates and nitrogen fertilization levels on the dry matter yield of sorghum-sudangrass hybrid.

Seeding rate	N rate	Dry matter yield 1st cut	2nd cut	Total
kg/ha		metric tons/ha		
20	0	1.73	1.95	3.68
	150	3.01	3.20	6.21
	300	3.37	4.45	7.82
	Mean	2.70	3.20	5.90
40	0	2.89	2.18	5.07
	150	3.97	3.77	7.74
	300	6.92	7.16	14.09
	Mean	4.60	4.37	8.97
80	0	3.89	3.67	7.56
	150	5.34	5.95	11.29
	300	6.47	6.73	13.20
	Mean	5.23	5.45	10.68
	Main plot	NS[a]	NS	NS
LSD(0.05)	Sub plot	1.690(0.01)	1.867(0.01)	2.920(0.01)
Between	Sub plot for same main plot	2.927(0.01)	3.234(0.01)	5.058(0.01)
	Sub plot for different main plot	5.168(0.01)	4.518	7.370

[a]: not significant.

due to nitrogen fertilization.

Yield increases from N fertilization were small for the first harvest, probably due to residual available N percentage in the soil. By the second harvest, large increases were obtained from N application. This result well agreed with that of Harms and Tucker's(1973). Maximum yields were obtained at the 300kg/ha of N level for the first and second harvestings.

There was no increased yield resulting from increased rates of seeding in this experiment. Therefore it appears that little is to be gained, in the form of increased yield, by increased seeding rate over 20kg/ha. In support of this results, Hart and Burton(1965) reported that there were no significant differences among total annual yields of the different planting rates at any nitrogen rate. It is suggested that the desirable planting rates of sorghum-sudangrass hybrids are 22 to 35kg/ha of seed for broadcast planting. And higher seeding rates are needed for humid and irrigated areas(Anon, 1978).

Since the water is one of the limiting factors for growth, desirable planting rates depend on the available soil moisture during the growing season. It depends on locations but the precipitation in Korea usually occur during summer. So it can be suggested that the desirable seeding rate and nitrogen fertilization level of sorghum-sudangrass hybrids are 40kg/ha of seed and 300kg/ha of N for broadcasting (Table 3).

2. Carbohydrate reserves

Table 4 shows the total water soluble carbohydrate contents of stubble of sorghum-sudangrass hybrid grown in 1983. The samples were collected at the first and second harvests. At first harvest,

Table 4. Effect of seeding rates and nitrogen fertilization levels on the total water soluble carbohydrate (TSC) contents of stubble of sorghum-sudangrass hybrid.

Seeding rate	N rate	TSC 1st cut	TSC 2nd cut
kg/ha		%	
	0	17.9	13.7
20	150	17.8	11.7
	300	14.2	11.2
	Mean	16.6	12.2
	0	17.7	11.4
40	150	24.5	11.7
	300	14.0	11.6
	Mean	18.7	11.6
	0	10.1	10.8
80	150	12.6	11.4
	300	10.8	12.0
	Mean	11.2	11.4
	Main plot	4.47	NS[a]
LSD(0.05)	Sub plot	3.30	NS
Between	Sub plot for same main plot	5.72	NS
	Sub plot for different main plot	6.42	NS

[a]: not significant.

there was a significant difference in carbohydrate reserves among main plots and subplots. Main plot means were 16.6, 18.7, and 11.2% for S2, S4, and S8 plot, respectively. These results were consistent with the view of White's(1973) that if N is deficient, application of moderate amounts of N can increase plant growth when carbohydrates, water and other nutrients are available and environmental conditions are favorable. Increased plant growth from N application was associated with increased leaf area, chloroplast protein and chlorophyll content which increased photosynthesis. The increased photosynthetic activity can then, theoretically increase carbohydrate reserves. But excess N tends to decreases carbohydrate reserves when other nutrients and environmental factors do not limit plant growth. In this case, N fertilization stimulates the synthesis of amino acids and amide compounds to the detriment of carbohydrate reserves. Similar results were suggested by Jones et al. (1965) that nitrogen had a marked effect on reducing the soluble carbohydrate content of grass. This depression is presumably to be attributed largely to the acceleration in growth rate which accompanies the use of nitrogenous fertilizer. Lechtenberg et al. (1973) reported similar results that the nitrogen fertilization(140kg/ha) reduced the average total carbohydrate concentration from 16.6 to 14.8%.

At second harvest, the carbohydrate reserves were not influenced by seeding rate and N fertilization level. Burton et al. (1959) reported that shading as well as high nitrogen applications decreased the percentage of TAC in the herbage of *Cynodon dactylon*. The shading effect was more pronounced at the lower nitrogen level. At second harvest, the rainy and cloudy day was occurred before the harvesting day. Because of that reason the carbohydrate reserves decreased. At high nitrogen level, this decrease was small. But at low nitrogen level, this decrease was large. Because of that reason, the carbohydrate reserve levels were almost same at any seeding rate and N fertilization level. May (1960) reported that the accumulation of reserves was influenced by many environmental factors, e.g. nutrients, water content and temperature. Therefore more study is needed to investigate the certain interpretation.

3. Original stand and stand reduction

Table 5 shows the number of original stand per hectare. These were counted in the two quadrats of 1m×1m in each plot and computed in terms of stand per hectare. The number of original stand increased with increasing seeding rate.

Table 5. Original stand of sorghum-sudangrass hybrid.

Seeding rate	N rate	No. of plants
kg/ha		plants/ha
	0	240,000
20	150	307,000
	300	297,000
	Mean	281,000
	0	650,000
40	150	593,000
	300	723,000
	Mean	655,000
	0	1,553,000
80	150	1,500,000
	300	1,480,000
	Mean	1,511,000
	Main plot	853,000
LSD(0.05)	Sub plot	NS
Between	Sub plot for same main plot	NS
	Sub plot for different main plot	NS

The mean original stands were 281,000, 655,000, and 1,511,000 plant/ha for S2, S4, and S8 plots, respectively. There was a linear response of original stand count to seeding rate, so there was a significant difference in original stand among seeding rates.

Stand reduction was measured after the first and second harvest(Table 6). According to the value measured after the first cut, the mortality was influenced by seeding rates($P<.01$) during the first growing season. During that season, the plant already thinned enough for growing, so the mortality was not influenced by seeding rate any more after the second cut.

Total mortality was influenced not only by seeding rates but also by nitrogen fertilization levels. White(1973) suggested that high rates of N should not be applied under the combined conditions of drought and high temperatures. Under these conditions, clipping or grazing could deplete carbohydrate reserves below a critical level, and caused stand reduction and poor growth recovery.

Since height and stem diameter are related to lodging, we expected height and/or stem diameter to be correlated with percent stand reduction, however, r values were non significant (0.16 and −0.07 for height and stem diameter, respectively). The primary cause of stand loss was probably greater intraspecific competition at the higher populations(Campbell and White, 1982).

Ⅳ. SUMMARY

This experiment was carried out to determine the effects of seeding rates and nitrogen fertilization levels on the yield, carbohydrate reserves in stubble and stand reduction of sorghum-sudangrass hybrid (*Sorghum bicolor* (L.) Moench) in 1983 on the Experimental Livestock Farm, College of Agriculture,

Table 6. Effect of seeding rates and nitrogen fertilization levels on the percent stand reduction after cutting of sorghum-sudangrass hybrid.

Seeding rate	N rate	Mortality		
		After 1st cut	After 2nd cut	Total
kg/ha		%		
	0	12.87	9.13	22.00
20	150	16.43	14.13	30.56
	300	24.37	17.80	42.17
	Mean	17.89	13.69	31.58
	0	21.80	13.47	35.27
40	150	18.23	18.23	41.50
	300	37.07	22.57	59.64
	Mean	27.38	18.09	45.47
	0	34.03	23.00	57.03
80	150	34.93	24.40	59.33
	300	42.17	27.60	69.77
	Mean	37.04	25.00	62.04
	Main plot	13.449(0.01)	NS	19.968
LSD(0.05)	Sub plot	NS[a]	NS	10.013
Between	Sub plot for same main plot	NS	NS	17.344
	Sub plot for different main plot	NS	NS	24.310

[a]: not significant.

Seoul National University in Suwon.

The results of this experiment are summarized as follows:

1. There was no significant difference in forage yield among three seeding rates(20, 40, and 80kg/ha), but there was a significant difference($P<.01$) in forage yield among three N fertilization levels(0, 150, and 300kg/ha). High nitrogen plot showed the highest dry matter yield.

2. Carbohydrate reserves were influenced not only by seeding rates, but also by nitrogen fertilization levels at first cut($P<.05$). At second harvest, no treatments affect the carbohydrate reserves.

3. Only the seeding rates affect the stand reduction at first harvest. But the mortality was influenced by seeding rates and N fertilization levels($P<.05$). The high seeding rates caused the high mortality.

4. According to the results obtained from this study, it is suggested that the seeding rate of 40 kg/ha and nitrogen fertilization of 300kg/ha would be recommendable for maximum forage yield and good performance where sorghum-sudangrass hybrids are broadcasted for summer forage production.

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