EFFECT OF DIFFERENT POPULATION DENSITIES AND NITROGEN LEVELS ON THE YIELD AND YIELD COMPONENTS OF SORGHUM

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Portion of BS thesis conducted by the senior author in ViSCA.

ABSTRACT

Increasing the population density decreased the panicle length, number of grains per panicle, and weight of grains per panicle although it increased the leaf area index. Population density of 200,000 plants/ha gave the highest grain yield of 2.07 t/ha, followed by 300,000 plants/ha at 2.01 t/ha, and 100,000 plants/ha at 1.72 t/ha. Application of N fertilizer affected to a certain extent the morphological characteristic and yield of the plant. It increased plant height, leaf area index, panicle length, number of grains per panicle, weight of grains per panicle, and stover and grain yields. Although grain yield increased with increasing rates of N from 30 to 200 kg/ha, its magnitude was not big enough to show significant differences. Plots treated with the highest level of N (200 kg/ha) gave the highest grain yield of 2.32 t/ha while the control (0 kg/ha) gave the lowest yield of 1.32 t/ha.

Ann. Trop. Res. 3:258-265.

KEY WORDS: Sorghum. *Sorghum bicolor.* Cosor 3 variety. Population density. Leaf area index. Interplant/Intra-plant competition. Fertilizer levels. Agronomic characteristics. Yield and yield components.

INTRODUCTION

Sorghum *(Sorghum bicolor* (L) Moench) is generally used as a source of carbohydrates and is valued for its high protein content as well as utilized as base material for fermentation in the brewing industry (PCARR, 1975). It is a good substitute for rice and corn in some food preparations as well as in feed rations. However, sorghum production is still insufficient to meet the demand of medium and large-scale commercial livestock feed millers. One way of solving this shortage is to increase its yield per unit area.

Several studies on sorghum

have shown that grain yield per unit area is increased by increasing the rate of nitrogen application at certain levels (Escalada *et al.*, 1975, Molina *et al.*, 1972, and Borulkar *et al.*, 1979) which confirm with the result of this study. Some investigators also observed that grain yield is increased by increasing population density (Molina *et al*, 1972). However, in this study yield increased only up to 200,000 plants/ha but no further increase was noted with the increase of population density up to 300,000 plants/ha.

MATERIALS AND METHODS

A split plot design arranged in randomized complete block with three replications was used. Population density was designated as the mainplot and the rates of N as the subplots.

The treatment were as follows:
Population density (main plot):

D_1 = 100,000 plants/ha
D_2 = 200,000 plants/ha
D_3 = 300,000 plants/ha

Nitrogen levels in kg/ha N, P_2O_5, and K_2O (subplot):

T_1 = 0-30-30 kg/ha
T_2 = 30-30-30 kg/ha
T_3 = 60-30-30 kg/ha
T_4 = 100-30-30 kg/ha
T_5 = 200-30-30 kg/ha

Each plot had 4 rows spaced at 0.75 m apart. Every subplot had an area of 3 m x 5 m. To facilitate management, 1 - m alleyways were made between replications. Before planting, soil samples were taken from the experimental area and sent to the Bureau of Soils, Tacloban City for nutrient and pH analysis.

Cosor 3 variety was planted immediately after the land was thoroughly prepared. More than enough seeds were drilled in furrows followed by thinning 2 weeks after germination to meet the desired plant population.

The fertilizers used were urea (46-0-0), solophos (0-20-0), and muriate of potash (0-0-60). These were applied using the band method of application. All of the amounts of potassium (K_2O) and phosphorus (P_2O_5) and one-half of the total amount of N were applied at planting time and the other half of N was sidedressed five weeks after planting. Spraying of insecticide (Thiodan) and fungicide (Benlate) was done one month after planting to protect against insect and disease damage. The experimental area was kept weed-free within 30 days from planting until the leaves of the crop closed in-between rows.

Harvesting was done when 90% of the panicles in each plot were fully ripened. The panicle were dried and threshed and the grains cleaned.

RESULTS AND DISCUSSION

Soil Analysis.

Analysis of the soil samples taken before planting showed the following results: soil pH = 5.9; organic matter = 1.4%; Olsen's phosphorus = 46.9 ppm; and extractable potassium = 751.2 ppm. The data on organic matter content (1.4%) of the soil indicated an inherent amount of nitrogen at 700 ppm or 1400 kg/ha in the soil. This result shows that the experimental area was not deficient in nitrogen.

Plant Height (cm) at Maturity.

Highly significant differences in plant height were observed among nitrogen treatments. However, the main effects of population densities and interactions between population densities and nitrogen levels were not significant.

In general, the plants grew taller as the amount of nitrogen was increased from 0 to 200 kg/ha. However, plant height was not significantly increased with application rates beyond 60 kg/ha N (Tables 1 and 2). The average plant height (134.94 cm) at population density of 100,000 plants/ha was much shorter than at 200,000 plants/ha and 300,000 plants/ha at 142.68 cm (Table 2). However, plants in the highest population density (300,000 plants/ha) were thinner compared to the plant in the low population density. The increasing height at higher population was most likely due to mutual shading.

Table 1. Agronomic characteristics, yield and yield components of sorghum, as affected by N levels when averaged over population densities.[1]

Parameters	Fertilizer levels				
	0-30-30	30-30-30	60-30-30	100-30-30	200-30-30
Plant height (cm)	114.29 c	137.26 b	146.35 ab	147.71 ab	150.97 a
No. of days from planting to maturity	95.33 a	93.66 b	92.56 b	91.11 c	91.11 c
Leaf area index	0.99 c	1.46 bc	1.66 b	2.08 ab	2.37 a
Panicle length (cm)	15.62 d	19.11 c	22.88 b	24.58 ab	25.65 a
No. of grains/ panicle	380 c	748 b	1196 a	1306 a	1448 a
Wt. of grains/ panicle (g)	10.33 c	17.59 b	25.86 a	28.81 a	30.22 a
Wt. of 1000 seeds (g)	27.28 a	23.54 b	21.91 b	21.31 b	20.83 b
Stover yield (t/ha)	6.11 b	7.32 ab	7.96 ab	8.50 ab	9.35 a
Grain yield (t/ha)	1.31 b	1.93 a	1.99 a	2.11 a	2.32 a

[1]Means followed by a common letter are not significantly different at 5% level using DMRT.

Table 2. Agronomic characteristics, yield and yield components of sorghum as affected by different population densities and nitrogen levels. [1]

TREATMENTS	Plant height	No. of days from planting to maturity	Leaf area index	Panicle length (cm)	No. of grain/ panicle	Wt. of grain/ panicle (g)	Wt. of 1000 seeds (g)	Stover Yield (t/ha)	Grain Yield (t/ha)
D_1 = 100,000 plants/ha									
T_1 = (0-30-30)	103.65 c	95.33 a	.51 b	17.17 d	526 c	13.43 c	25.60 a	4.56 b	1.04 b
T_2 = (30-30-30)	133.01 b	93.33 b	.97 ab	21.13 c	954 b	22.25 b	23.50 ab	6.28 ab	1.73 a
T_3 = (60-30-30)	143.43 ab	92.67 b	1.14 ab	24.69 b	1327 a	29.05 a	22.00 b	7.61 a	1.75 a
T_4 = (100-30-30)	145.60 a	90.67 c	1.19 a	25.88 ab	1446 a	31.41 a	21.67 b	7.67 a	1.87 a
T_5 = (200-30-30)	149.03 a	90.67 c	1.38 a	26.93 a	1572 a	33.83 a	21.33 b	8.56 a	2.21 a
Mean	134.94	92.53	1.04	23.16	1165	25.99	22.82	6.94	1.72
D_2 = 200,000 plants/ha									
T_1 = (0-30-30)	119.28 b	95.00 a	1.16 c	15.90 d	365 c	10.42 c	28.32 a	7.39 b	1.53 b
T_2 = (30-30-30)	138.60 a	94.33 a	1.33 c	18.59 c	681 b	16.66 b	24.40 b	8.17 ab	2.09 a
T_3 = (60-30-30)	145.81 a	92.33 b	1.62 bc	24.02 a	1277 a	27.09 a	22.00 bc	8.33 ab	2.19 a
T_4 = (100-30-30)	147.20 a	91.33 b	2.23 ab	24.29 a	1238 a	27.39 a	21.43 ab	9.11 ab	2.22 a
T_5 = (200-30-30)	149.80 a	91.33 b	2.31 a	25.54 a	1497 a	30.49 a	10.78 a	10.78 a	2.33 a
Mean	140.14	92.86	1.73	21.67	1012	22.41	23.33	8.76	2.07
D_3 = 300,000 plants/ha									
T_1 = (0-30-30)	119.93 c	95.67 a	1.29 d	13.78 c	250 c	6.84 c	27.90 a	6.39 a	1.35 b
T_2 = (30-30-30)	140.16 b	93.33 b	2.07 c	17.61 b	609 a	13.86 b	22.73 b	7.50 a	1.99 a
T_3 = (60-30-30)	149.81 ab	92.67 bc	2.23 bc	19.92 b	983 a	21.45 a	21.73 b	7.94 a	2.03 a
T_4 = (100-30-30)	150.34 ab	91.33 c	2.83 ab	23.57 a	1236 a	25.54 a	20.83 b	8.72 a	2.25 a
T_5 = (200-30-30)	153.18 a	91.33 c	3.43 a	24.49 a	1276 a	26.33 a	20.67 b	8.72 a	2.41 a
Mean	142.68	92.87	2.37	19.49	871	18.80	22.77	7,85	2.01
Grand Mean	139.26	92.82	1.71	21.42	1016	22.42	22.98	7.85	1.93
C.V. (a) %	5.51	.91	32.33	6.22	15	13.42	8.38	36.37	7.18
C.V. (b) %	4.63	.83	21.54	6.07	17	14.03	7.80	21.08	16.81

[1] Treatment means within a column and within a population density level followed by a common letter are not significantly different at 5% level using DMRT.

Number of Days from Planting to Maturity.

The number of days from planting to maturity of the sorghum crop was significantly affected by N level (Table 1). Plants which received 100-200 kg N/ha were the earliest to mature at 91.11 days, followed by plants fertilized each with 30 and 60 kg N/ha at 93.66 and 92.06 days, respectively. Plants in the control plots (0 kg N/ha) had significantly delayed maturity (95.33 days).

The results corroborated the findings of Molina *et al.* (1977) who observed that maturity of sorghum crop was influenced by N fertilization since sorghum is a nitropositive crop.

No significant interaction between population density and nitrogen level was observed. Likewise, no significant effects were noted among population densities.

Leaf Area Index (LAI).

Leaf area index is another factor which is closely related to grain yield production because the total leaf area at flowering stage greatly affects the amount of photosynthesis (Fagade and Datta, 1971). In rice and in other cereals, Pascual *et al.* (1977) mentioned that leaves store carbohydrates at the ripening period which are translocated mainly to the grains. A positive correlation between LAI and grain yield in sorghum was also noted. In this study, results indicated that LAI taken at maturity (2 weeks before harvest) was significantly affected by population density and nitrogen level (Table 2). Statistical analysis showed no significant interaction between population density and nitrogen levels.

At maturity, LAI significantly increased with an increase in plant density and N levels (Tables 1, 2 and 3). The maximum LAI value (2.37) was obtained in plots with the highest plant density (300,000 plants/ha) and the least in plots with the lowest plant population (Table 3). On the other hand, highest LAI due to N application was observed in plots treated with 200 kg N/ha but this was statistically similar to that of 100 kg N/ha. Similarly, lowest LAI value (0.99) was obtained in the control plots (Table 1).

The active growth exhibited by plants receiving N resulted in an increased leaf size leading to greater leaf area indices of the plants. On the other hand, the increase in LAI with increased population density could be probably explained by the higher number of plants and more number of leaves present per unit area although average leaf size might have been smaller. At low population density, there were fewer plants and therefore fewer leaves although of larger size per unit area.

Panicle Length (cm) at Maturity.

The main effects of population density and nitrogen levels on panicle length at maturity were highly significant. However, no significant interaction was observed between these variables.

Panicle length decreased from 23.16 to 19.87 as plant population was increased from 100,000 plants to 300,000 plants/ha (Tables 2 and 3). At 200,000 plants/ha, the length of panicle was intermediate and not significantly different from the other two. These results could be attributed to interplant competition among plants grown at different populations. At low population

Table 3. Leaf area, yield, and yield components of sorghum as affected by population densities when averaged over N levels.[1]

Population Densities (plant/ha)	Leaf area index	Panicle length (cm)	No. of grains panicle	Weight of grains/g panicle	Grains yield (t/ha)
D_1 (100,000)	1.04 b	23.16 a	1165 a	25.99 a	1.72 b
D_2 (200,000)	1.73 ab	21.67 ab	1012 ab	22.41 ab	2.07 a
D_3 (300,000)	2.37 a	19.87 b	871 b	18.80 b	2.01 ab

[1] Means followed by a common letter are not significantly different at 5% level using DMRT.

density, lesser degree of competition is expected between plants for light, water, space, and nutrients essential for growth and development leading to production of longer panicles. On the other hand, plants at higher population density suffered greater degree of competition for those factors resulting in the formation of shorter and smaller panicles.

Plants treated with N developed significantly longer panicles compared with the control (Table 1). Shortest panicle were obtained from plants which received no N. Although plants treated with 200 kg N/ha produced the longest panicles, no significant differences were observed between them and those which received 100 kg N/ha.

Number of Grains Per Panicle.

Results revealed that number of grains per panicle was affected by population density and N level. The number of grains per panicle increased from 380 to 1448 as N level was increased from 0 to 200 kg/ha. However, no significant differences were observed beyond 60 kg/ha N (Tables 1 and 2).

The production of more grains per panicle at low population was probably due to lesser degree of competition between plants. In contrast, fewer grains were formed per panicle from plants under high population density as a result of greater competition of sorghum plants due to overshading and overcrowding. Furthermore, shorter and smaller panicles were developed under high population density. Although no correlation analysis was done, the size of the panicles was likely associated with number of grains per panicle.

No significant interaction between population density and nitrogen fertilizer level was observed.

Weight (g) of Grains Per Panicle.

The different population densities and nitrogen levels highly influenced the weight of grains per panicle. This result closely conformed with that of the number of grains per panicle as well as length of panicle. Table 2 shows that there was a corresponding increase in total weight of grains per panicle as the number of grains per panicle increased.

Results further showed that N levels significantly increased the weight of grains per panicle. However, N application from 60 to 200 kg N/ha did not significantly increase the weight of grains per panicle (Table 1). Heaviest grain weight per panicle was observed in high N level (200 kg N/ha), while the lowest grain weight was observed in the control (no N treatment). Plants applied with N up to 200 kg/ha produced well-filled grains resulting in higher weight of grains per panicle.

Low population density (100,000 plants/ha) resulted in the formation of heavier grains per panicle compared to high populations of 200,000 and 300,000 plants/ha (Table 3). It was observed (Table 3) that plants with a population density of 100,000 per hectare produced longer panicles, hence greater number of grains per panicle compared to those with 200,000 and 300,000 plants/ha. This condition consequently caused an increase in weight of grains per panicle of the former.

No significant interaction between population density and nitrogen fertilizer level was observed.

Weight (g) of 1000 Seeds.

Results revealed that weight of 1000 seeds was highly influenced by N application but not by population density.

Plants with more grains per panicle had lower weight per 1000 seeds (Tables 1 and 2). This may be traced to intracompetition among grains within a panicle. The more grains that developed within a panicle, the lesser the amount of photosynthates that accumulated per grain due to greater degree of competition among the grains. The control plants produced fewer grains but heavier weight(s) per grain, hence the weight of 1000 seeds was heavier compared to plants applied with 200 kg/ha. Nevertheless, the size of the panicle obviously compensated for the low weight of 1000 seeds per panicle. Gupta (1975) observed in rice that as the number of grains per head increased, the weight of the individual grains decreased.

Fresh Weight (t/ha) of Stover.

Highest stover yield (8.67 t/ha) was obtained from a plant density of 200,000 plants/ha followed by 300,000 plants/ha (7.85 t/ha) and by 100,000 plants/ha (6.94 t/ha) (Table 2). This trend was attributed to the fact that plants with a population of 200,000/ha had grown normally and vigorously compared to those in population of 300,000/ha. In the latter, most plants did not grow normally as manifested by the development of very small and thin stalks and narrow chlorotic leaves which eventually died at the later stage. Although plants at population of 100,000/ha also grew normally and even vigorously, they produced the lowest stover yield. The size of plants was not compensated by lower population density.

Production of stover was influenced by N level (Table 1). The increase in stover production can be attributed to the over-all improve-' ment in growth and development of the plants treated with N.

Grain Yield (t/ha).

Highly significant differences in grain yield were observed among N treatments and population density. On the other hand, statistical analysis showed no significant interaction between these two factors.

The population of 200,000 plants/ha produced the highest grain yield at 2.07 t/ha, followed by 300,000 plants/ha at 2.01 t/ha. The lowest grain yield was obtained at a population of 100,000 plants/ha (Table 3) although it has the highest values on panicle length, number of grains per panicle, and weight of grains per panicle. The highest population density of 300,000 plants/ha gave a lower yield than at 200,000 plants/ha because more plants in the former did not grow normally and did not develop normal size panicles due to several competition.

Nitrogen application greatly increased grain yield regardless of population density. However, no significant differences were observed with applications beyond 30 kg N/ha (Table 1). This suggests that sorghum responded favorably only at a lower level of nitrogen (30 kg N/ha) under ViSCA conditions. This may be explained by the results of soil analysis which indicate that nitrogen was not deficient in the experimental area.

Overall, grain yield was favored by LAI up to 2.37, tall plants up to a certain extent, long panicles, high number of grains per panicle, and high weight of grains per panicle.

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