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Effects of Soil Fertility on Comparative Yields and Nutritional Characteristics of Corn and Sorghum Cultivars

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ABSTRACT

A field experiment was conducted on plots with different soil fertility to compare yields and nutritional characteristics of KU Hybrid-8501 sorghum, KU-439 sorghum, KU Hybrid-2602 corn and Suwan-1 corn.

Sorghum reached maximum grain yields at much lower soil fertility than corn and gave higher grain yields as well as being superior in sustaining fertility of low-fertility soils. At high fertility levels, corn gave much higher grain yields than sorghum which outran slight, if any, nutritional advantages of sorghum.

There was no significant difference in grain yields of the two corn cultivars at all fertility levels though KU Hybrid-2602 gave higher stover yields than Suwan-1. KU-8501 sorghum gave higher grain and stover yields than KU-439 sorghum at low fertility levels. Differences in soil fertility depletion between cultivars of each kind of crop were found to be slight, if any.

In views of grain yields and sustaining N, P and K status of soils, sorghum cropping was superior to corn cropping on low-fertility soils. On high-fertility soils, the reverse was observed. For medium-fertility soils corn and sorghum were comparable. At all fertility levels, the two corn cultivars were comparable. KU-8501 sorghum was superior to KU-439 sorghum at low soil fertility levels.

INTRODUCTION

For Thai farmers, when choice has to be made between corn and sorghum, sorghum is usually recommended for low-fertility soils whereas corn is recommended for soils with medium or high fertility. There are however no appropriate data to support these recommendations. Moreover, plant yields and yield components have been traditionally used as criterion in crop selection. With these criterion, differences in fertilizer responses of different cultivars of corn and sorghum have been reported (Senanarong *et al.*, 1971a, b; Boonampol *et al.* 1978; Suwanarit *et al.*, 1984). This suggests variations in nutritional characteristics of different crop cultivars which may, in turn, render differences in depletion of nutrients in soil. Data on comparative yields and nutritional characteristics are therefore needed in order that well-supported recommentations may be made.

This paper presents results of a field experiment to compare yields and nutritional characteristics of different recommended cultivars of corn and sorghum grown on soils with different fertility so that well supported recommendation may be made on selection of kind and cultivar of crop to be grown.

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MATERIALS AND METHODS

Experimental site and soil

A field experiment was conducted, starting from August 10, 1985, in long-term N-P Fertilizer treated plots located in E_{11} Block of the National Corn and Sorghum Research Center, Pakchong, Nakorn Ratchasima, Thailand.

The soil has been classified as Loei series, Reddish Brown Lateritic great group with clay loam texture and CEC of 19.0 me/100 g. Chemical properties of soil of each main plot are shown in Table 1.

Design and treatment

A split plot in randomized block design with 3 replications was employed. Each main plot, measuring 7.5 m × 15 m, consisted of four subplots of 3.75 m × 7 m. Experimental variables are shown in Table 2. The corn and sorghum cultivars under study have been recommended for Thailand conditions. Differences in yield responses to soil fertility of these corn cultivars have been reported (Suwanarit *et al.*, 1984).

Cultural practices

Plants were grown on flat soil. Plant rows were arranged along the longer sides of plots. Plant spacings used were those that had been found most favorable, i.e., 0.75 m between rows and 0.25 m between hills of one plant for corn (Sarakul and Iamsupasit, 1977a; Suwanarit *et al.*, 1984) and 0.60 m between rows and 0.125 m between hills of one plant for sorghum (Chungmanoch *et al.*, 1975; Faungfupong *et al.*, 1976; Senanarong *et al.*, 1976; Sarakul and Iamsupasit, 1977b). Five rows of plants in the case of corn and six rows in the case of sorghum were grown in each subplot. However, only plants within the central areas of 2.25 m × 5.00 m and 1.80 m × 5.00 m were accounted for in data collection in the cases of corn and sorghum, respectively.

Since 1973, fertilizers used had been ammonium sulfate and either superphosphate or triple superphosphate. Only 10 kg/ha zinc sulfate had been applied as basal fertilizer in some years. Weed control was performed by hoeing at 12 days and 35 days after sowing. For insect control, Furadan 3% (2-3 dihydro-2,

Table 1 Chemical properties of soils prior to experiment

Treatment	pH[1]	% OM[2] (%)	Total N[3] (%)	Available P[4] (ppm)	Available K[5] (ppm)
F_1	6.1	2.3	0.161	13.5	295
F_2	6.0	3.1	0.174	21.5	300
F_3	5.7	3.0	0.154	40.0	300
F_4	5.4	3.0	0.166	44.5	270
F_5	5.1	3.0	0.172	70.5	270
F_6	4.8	3.1	0.177	134.5	280

1/ 1:1, soil : water;
2/ By Walkley and Black's method (Walkley and Black, 1934);
3/ By Kjeldahl method (Bremner, 1965);
4/ By Bray II method (Olsen and Dean, 1965);
5/ Extracted by neutral $\underline{N}$ NH_4OAc

Table 2 Description of experimental variables

Symbol	Description
	Levels of soil fertility (main plots)
F_1	Soil with no application of N-P fertilizer for annual corn growing since 1973, including the present experiment.
F_2	Soil with application of 30-30 kg N-P_2O_5/ha/yr for annual corn growing since 1973, including the present experiment
F_3	As F_2 but the fertilizer rate had been 60-60 kg N-P_2O_5/ha/yr
F_4	As F_2 but the fertilizer rate had been 90-90 kg N-P_2O_5/ha/yr
F_5	As F_2 but the fertilizer rate had been 120-120 kg N-P_2O_5/ha/yr
F_6	As F_2 but the fertilizer rate had been 180-180 kg N-P_2O_5/ha/yr
	Crop cultivars (subplots)
S_1	KU Hybrid-8501 sorghum
S_2	KU-439 sorghum
C_1	KU Hybrid-2602 corn
C_2	Suwan-1 (C_9F_3) corn

dimethy 1-7 benzofuranyl methyl carbamate) at the rate 40 kg/ha was applied at 14 days after sowing. Since rainfalls were not adequate, especially at the early and late stages of plant growth, supplimental irrigation was applied with sprinklers when plants showed sign of wilting. Harvest was done 117 days after sowing when all crops were fully mature and appreciably dry.

Plant analysis

Samples of grain and stover were digested with wet oxidation (Jackson, 1967). Total N was then determined with Kjeldahl distillation (Bremner, 1965). P was determined spectrophotometrically with molybdenum blue method (Olsen and Dean, 1965). K was determined with flame photometry.

RESULTS

Grain yields, stover yields and grain/stover ratios

Differences in responses in grain yields,

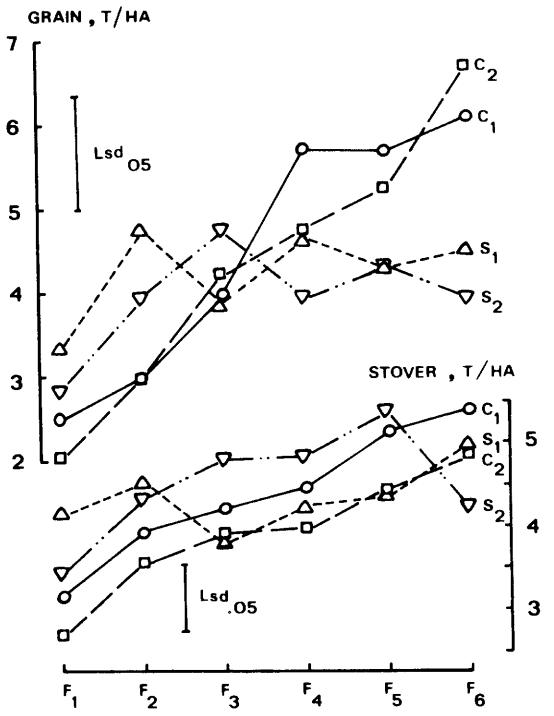


Figure 1 Grain (15% moisture) and dry stover yields of different corn and sorghum cultvars as affected by soil fertility.
% CV : 19.1 for grain, 10.9 for stover.

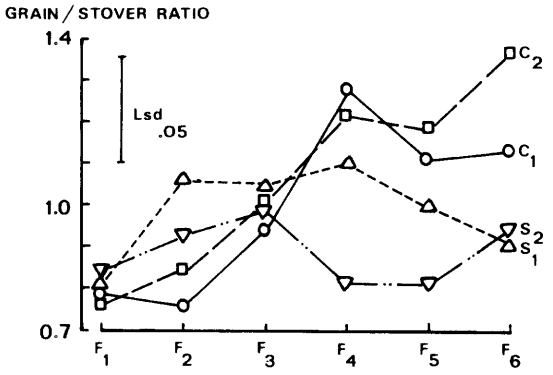


Figure 2 Grain/stover ratios of different corn and sorghum cultivars as affected by soil fertility. % CV = 15.3

stover yields and grain/stover ratios to soil fertility between corn and sorghum were observed (Figures 1 and 2). Differences in stover yield responses were also between sorghum cultivars. As compared to sorghum, corn generally gave lower figures at low fertility levels but either comparable or higher figures at high fertility levels. With low fertility corn gave 30 – 50% lower grain yields than sorghum but with high fertility the reverse was found. Sorghum generally reached maximum yields at much lower fertility levels than corn.

Suwan-1 corn still showed positive response in grain yields at the highest fertility level while KU Hybrid-2602 corn seemed to have reached maximum. This was opposite to finding of others (Suwanarit *et al.*, 1984). With low fertility, KU-8501 tended to give higher yields than KU-439 sorghum but with moderate or high fertility it gave either comparable or lower yields.

Total uptake of N, P and K

Total N-uptake, i.e., quantity of N in grain and stover, generally increased with soil fertility (Figure 3). At all fertility levels, but the highest, all cultivars gave comparable N-uptake. At the highest soil fertility level sorghum gave lower N-uptake than corn.

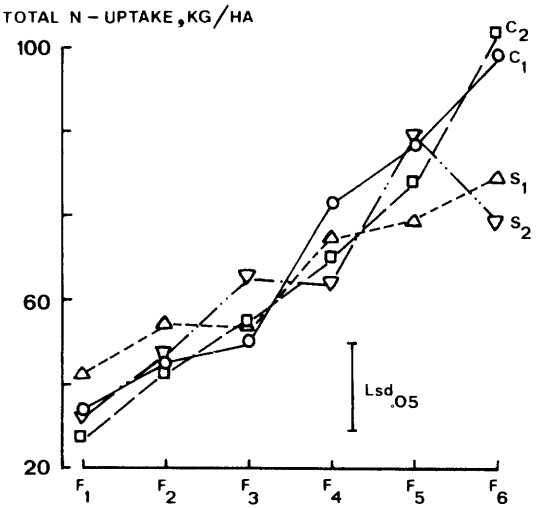


Figure 3 Total N-uptake of different corn and sorghum cultivars as affected by soil fertility. % CV = 16.6

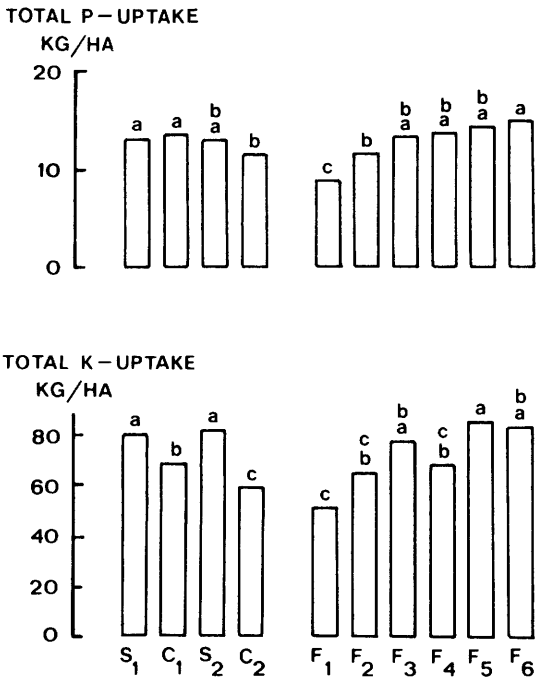


Figure 4 Total P-uptake and K-uptake as affected by crop cultivars and soil fertility. % CV : in the case of P, 15.5 for cultivar, 26.1 for soil fertility; in the case of K, 14.3 for cultivar, 28.5 for soil fertility. Bars with a common letter are not different by $DMRT_{.05}$.

Differences in total P-uptake and K-uptake obtained between corn and sorghum and between cultivars of the same crops did not vary with soil fertility (Figure 4). Suwan-1 corn gave about 1.5 kg/ha (or 12%) lower P-uptake than the other corn and sorghum cultivars. Suwan-1 corn and KU Hybrid-2602 corn gave about 20 kg/ha (or 24%) and 16 kg/ha (or 14%), in respective order, lower K-uptake than the two sorghum cultivars.

Ratios of grain nutrient/stover nutrient

Grain N/stover N ratios, i.e., ratios of quantities of N in grain to quantities of N in stover, grain P/stover P, and grain K/stover K were given in Figures 5 and 6. Differences in these ratios of different crops and/or cultivars generally did not vary with soil fertility though the ratios tended to increase with soil fertility. Corn generally gave higher ratios than sorghum. There were no significant differences between cultivars of corn or sorghum.

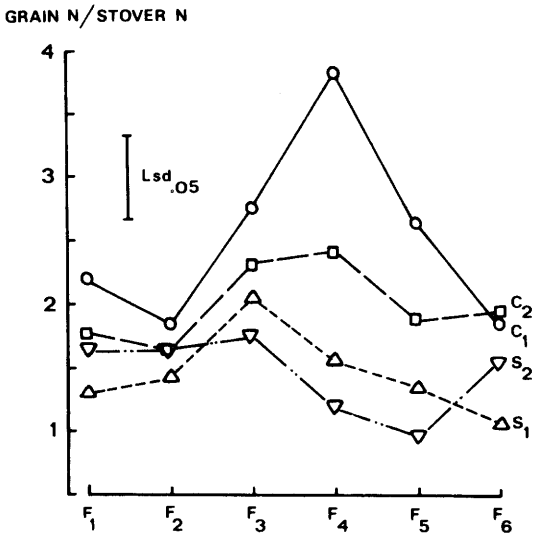


Figure 5 Ratios of total N in grain (grain N) to total N in stover (stover N) of different corn and sorghum cultivars as affected by soil fertility. % CV = 21.2

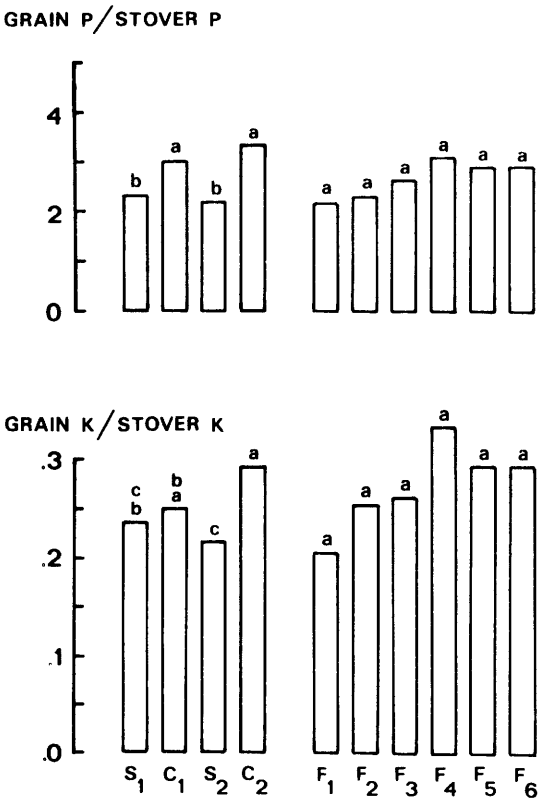


Figure 6 Ratios of total P in grain (grain P) to total P in stover (stover P) and total K in grain (grain K) and total K in stover (stover K) as affected by crop cultivars and soil fertility. % CV : in the case of P, 35.9 for cultivar, 28.6 for soil fertility; in the case of K, 24.4 for cultivar, 32.6 for soil fertility. See Figure 4 for captions.

Nutrient uptake in grain

N-uptake in grain, i.e., quantity of N in grain, of corn and sorghum and different cultivars of the same crops were comparable at low fertility levels (Figure 7). At high fertility levels, corn gave higher figures than sorghum.

Comparative P-uptake and K-uptake were very similar (Figures 7 and 8). Corn generally gave lower figures than sorghum at low fertility levels but gave higher figures at high fertility levels. KU Hybrid-2602 corn gave higher figures than Suwan-1 corn at medium fertility. At low and high fertility

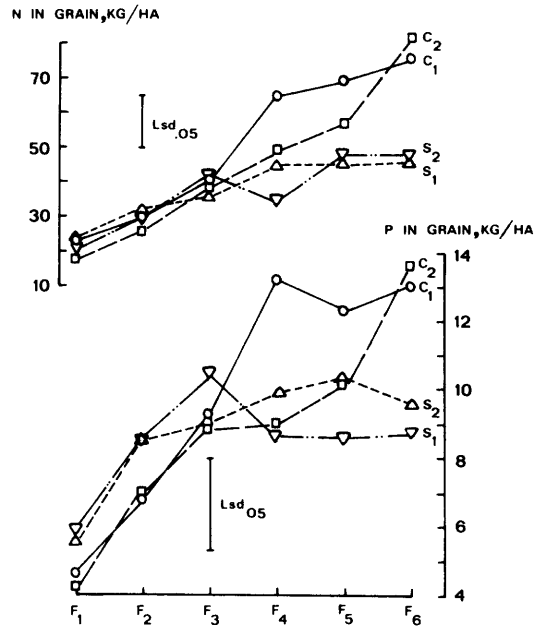


Figure 7 Quantities of N in grain and P in grain of different corn and sorghum cultivars as affected by soil fertility. % CV : 21.4 for N, 18.5 for P.

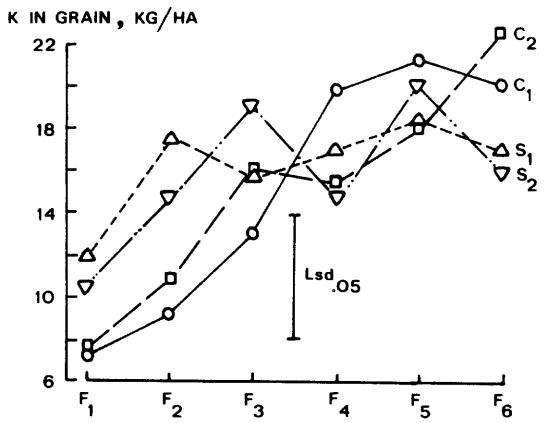


Figure 8 Quantities of K in grain of different corn and sorghum cultivars as affected by soil fertility. % CV = 23.1

levels no differences were found between cultivars of the same crops.

Effectiveness of absorbed nutrients

Quantities of N, P and K absorbed to produce one ton of grain, i.e., total absorbed nutrient divided by weight of grain produced in tons, were used to assess effectiveness of absorbed nutrients in producing grain to different crop and crop cultivars. A lower value

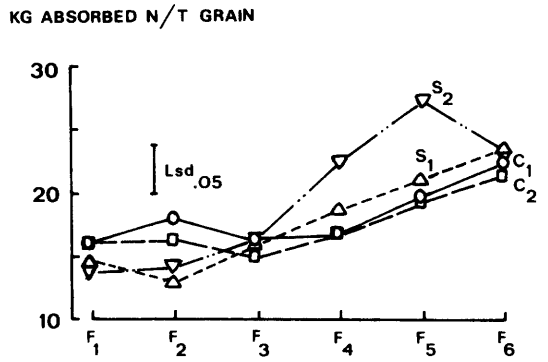


Figure 9 Quantity of N absorbed to produce one ton of grain for different corn and sorghum cultivars as affected by soil fertility. % CV = 13.2

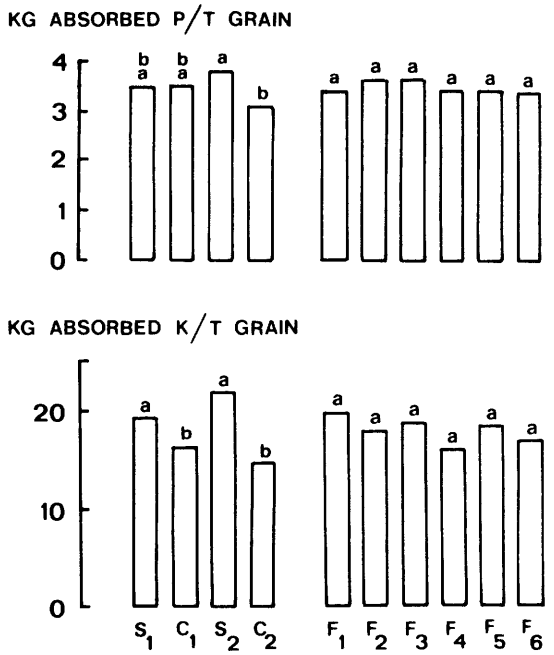


Figure 10 Quantities of P and K absorbed to produce one ton of grain as affected by crop cultivars and soil fertility. % CV : in the case of P, 17.1 for cultivar, 17.5 for soil fertility; in the case of K, 22.3 for cultivar, 23.1 for soil fertility. See Figure 4 for captions.

indicated higher effectiveness of absorbed nutrient.

Generally sorghum gave higher effectiveness of N than corn at low fertility levels but gave lower effectiveness at high fertility levels (Figure 9). Differences in effectiveness of N were also obtained between sorghum cultivars at F_4 and F_5.

Differences in effectiveness of absorbed P and K did not vary with soil fertility (Figure 10). Corn showed either comparable or higher effectiveness when compared to sorghum, depending on corn cultivars.

Losses of N, P and K through one-ton grain export

Quantities of N, P and K in one ton of grain were used to assess rate of nutrient lost through grain export. Amounts of N lost through one-ton grain export increased with

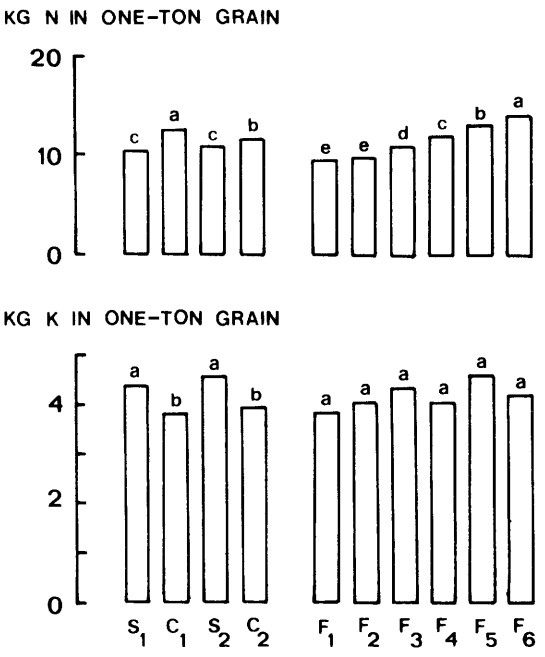


Figure 11 Quantities of N and K in one ton of grain as affected by crop cultivars and soil fertility. % CV : in the case of K, 12.3 for cultivar, 14.9 for soil fertility. See Figure 4 for captions.

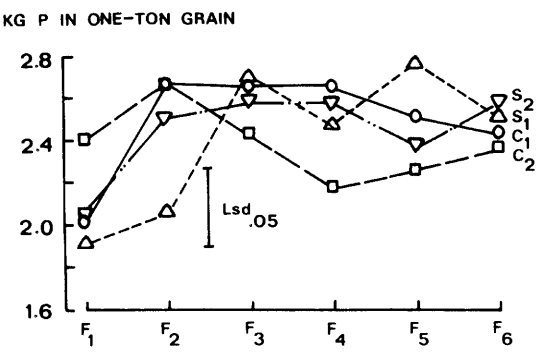


Figure 12 Quantity of P in one ton of grain of different corn and sorghum cultivars as affected by soil fertility. % CV = 9.1

soil fertility (Figure 11). Corn gave higher figures than sorghum. Suwan-1 corn gave lower figures than KU Hybrid-2602 corn. These differences did not vary with soil fertility.

Comparative P-losses varied with soil fertility and cultivars (Figure 12). Suwan-1 corn gave higher figures than the other corn cultivar and sorghum but gave lower figures at medium fertility levels. At low fertility levels, KU-8501 sorghum gave lower figures than the other sorghum cultivar. There was no significant difference among the four cul tivars at high fertility levels.

The loss of K tended to increase with fertility. Differences were found only between corn and sorghum but not between cultivars of the same crops. Corn gave lower figures than sorghum at all fertility levels.

N, P and K concentrations in stover

Concentrations of N, P and K in stover are given in terms of quantities of the elements in one-ton stover as shown in Figures 13 and 14. Sorghum generally gave higher N concentration than corn; the differences were more pronounced at medium soil fertility levels. Sorghum also gave higher P and K concentrations than corn. The two cultivars of corn and sorghum gave comparable P and K concen-

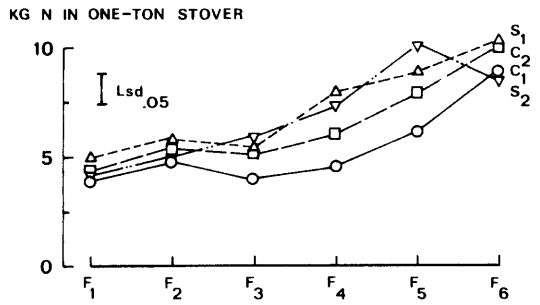
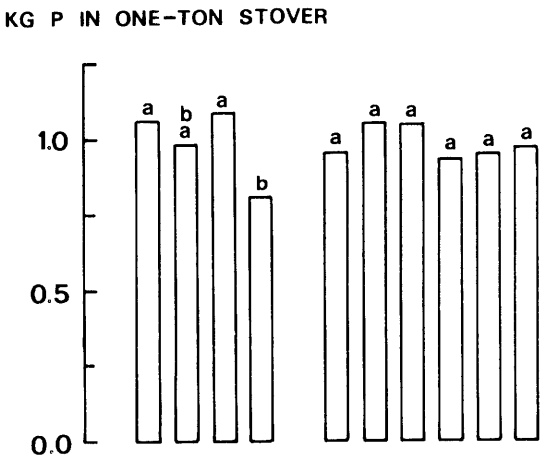


Figure 13 Quantity of N in one ton of stover of different corn and sorghum cultivars as affected by soil fertility. % CV = 13.0



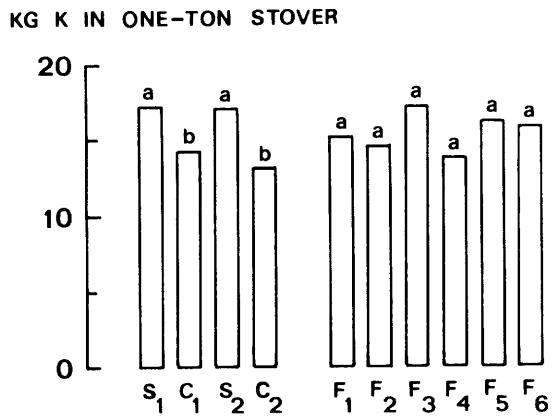


Figure 14 Quantities of P and K in one ton of stover of different corn and sorghum cultivars as affected by soil fertility. % CV : for P = 32.2, for K = 11.9. See Figure 4 for captions.

trations. P and K concentrations were not significantly affected by soil fertility.

DISCUSSION

Results of this study indicated that differences between crops and crop cultivars could be obtained not only in response in plant yields to soil fertility but also in nutritional characteristics.

Differences in total uptake of an element, in ratios of the element in grain to that in stover, and in quantities of the element in grain, which is usually lost from soil through grain harvest, reflect superiority of a crop and/or crop cultivar to others in maintaining soil fertility. As an example from this study, at low fertility levels sorghum took up more K and produced larger amounts of K in grain but had lower grain K/stover K. This indicated that sorghum incorporated more K into stover than corn. Since elements in organic residues are usually regarded as being superior to elements in inorganic forms, growing sorghum on low-fertility soils would be superior to growing corn in maintaining availability of soil K. Data obtained in the present experiment also suggested superiority of sorghum in maintaining N and P status of soils with low fertility if the stover was left to decay in the plot and was not burned out. Concentrations of N, P and K in sorghum stover suggested higher status of these nutrients in soil during decomposition of the residues. Higher stover yield of sorghum as compared to that of corn suggested superiority of sorghum to corn in maintaining organic matter of soil. In views of these advantages and highter grain yield of sorghum, growing sorghum would be superior to growing corn on soils with low fertility.

At medium soil fertility levels, which were regarded here as the levels at which sorghum had just reached maximum grain

yield, corn growing and sorghum growing would be equally recommendable.

At high fertility levels, differences in the nutritional characteristics were small, if any, as compared to the advantage in grain yields of corn. Corn is thus recommendable for soils with high fertility.

There were no significant differences in grain yields and grain yield responses to soil fertility of the two corn cultivars. Though the hybrid corn tended to give higher grain yields than Suwan-1 corn, it caused higher losses of N, P, and K through grain harvest. Suwan-1 corn caused lower loss of N through one-ton grain export at all soil fertility, higher loss of P through one-ton grain export at very low fertility level but lower loss at moderate fertility levels. In views of grain yields and nutritional characteristics, the two corn cultivars were therefore essentially comparable.

KU 8501-sorghum gave higher grain and stover yields than KU-483 sorghum at low fertility levels but gave either comparable or lower yields at medium and high fertility levels. It also reached maximum yields at lower fertility levels. Nutritional characteristics of the two cultivars were mostly comparable. KU-8501 sorghum was thus superior to KU-439 sorghum.

CONCLUSIONS

Sorghum reached maximum grain yield at much lower soil fertility level than corn. With low soil fertility, sorghum gave higher grain yield than corn as well as being superior to corn in sustaining soil fertility. With high soil fertility, corn gave much higher grain yield than sorghum which outran slight nutritional advantages of sorghum. Considering with both grain yields and nutritional characteristics, the two corn cultivars were essentially comparable at all soil fertility levels. KU-8501 sorghum was superior to KU-439 sorghum at low fertility levels but was comparable at medium and high fertility levels.

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