

METHODS OF INCREASING GRAIN SORGHUM PRODUCTION IN THE MARKHAM VALLEY

G. D. HILL*

ABSTRACT

Fertilizers are not in current general use for production of grain sorghum in the Markham Valley. On former native grassland yield of grain sorghum (cv. Texas 626) was increased from 1,237 lb per acre to 3,046 lb per acre by the application of 71 lb of nitrogen as ammonium sulphate ($P < 0.001$). Responses to phosphorus and potassium were not significant.

Doubling the seeding rate of the same cultivar from 7 to 14 lb per acre sown in rows 2 ft apart increased yield 16 per cent from 2,671 lb per acre to 3,092 lb per acre. This yield response was equivalent to that obtained from the application of an extra 23.5 lb of nitrogen per acre.

At the maximum level of fertilizer applied, yield was still increasing. Economic increases in yield of grain could be expected from the application of nitrogenous fertilizers. The effect of seeding rate change requires further study to determine possible effects of changes of sowing geometry.

INTRODUCTION

Growing of grain sorghum in Papua New Guinea as a cash crop could be of considerable importance in the development of increased local production of pork and poultry products. Springhall (1969) obtained good weight gains from pigs from rations compounded from sorghum and soy beans. Hill (1969a) has shown that good yields of soy beans are possible in the lowlands provided precautions are taken to maintain seed viability prior to sowing.

The lowlands of the Markham Valley have attractions for growing both of these crops, firstly because the generally flat terrain would allow use of large agricultural machines for broadacre sowings, and secondly because alternatives to the cultivation of peanuts are required.

At the time this trial was laid down, little sorghum was grown in the Markham Valley. Fertilizer was not generally used and farm yields from hybrid seed were not impressive (Hill 1969b).

Although soils of the Markham Valley are thought to be adequate with regard to phos-

phorus and potassium requirement, it is almost certain that under native grasslands nitrogen would be limiting for plant growth.

Sowing rates used in Papua New Guinea have generally followed Australian recommendations and no information is available as to suitable sowing rates for the New Guinea lowland environment. Also in accordance with the observations of Downes (1968), hybrids derived from American parents do not tiller in the lowlands. It was therefore thought possible that an increase in sowing rate might give increased yields of grain because of the presence of a greater number of heads.

Two experiments were conducted to determine response to major elements and the effect of sowing rate on yield at Wawin, about 40 miles north-west of Lae in the Markham Valley.

MATERIALS AND METHODS

Both experiments were sown on a commercial property. The soil was a silty brown to black clay loam with a well-defined crumb structure. Prior to sowing the experiments, the land had not been cropped and was under native grasses dominated by *Imperata cylindrica*.

* Formerly Agronomist, Department of Agriculture, Stock and Fisheries, Buba, via Lae. Present address: Department of Agronomy, University of Western Australia, Nedlands, W.A. 6009.

Experiment 1

A confounded 3³ factorial design was used with nitrogen, phosphorus and potassium at three levels. There were three blocks of nine plots (total 27).

The application rates of the fertilizers used were:

Ammonium sulphate

N₀=0 cwt per acre

N₁=1 cwt per acre

N₂=3 cwt per acre

Superphosphate

P₀=0 cwt per acre

P₁=1 cwt per acre

P₂=2 cwt per acre

Potassium sulphate

K₀=0 cwt per acre

K₁=0.5 cwt per acre

K₂=2 cwt per acre

Plots within blocks were 10 ft x 43.5 ft. There were no spaces between plots within blocks. Spaces of 10 ft were left around all blocks. The experiment occupied an area of 90 ft x 157.5 ft.

Each plot comprised five rows 2 ft apart of Texas 626 sown at 7 lb per acre.

Fertilizers were broadcast onto the plots following sowing and precautions were taken to ensure that no fertilizer was walked from plot to plot.

The control plot received a dressing of gypsum equal in sulphur content to that applied to the N₁P₁K₁ plot to ensure that sulphur was not limiting yield. Sulphur had previously been reported deficient in several areas in the Markham Valley (Southern 1967) and yield responses to sulphur have been obtained from peanuts lower down the valley (Hill 1970).

The experiment was sown on 9th January, 1969. At harvest the central 40 ft of the three inside rows of each plot were harvested by cutting off the heads below the panicle, and they were weighed green in the field and bagged. Individual bags were then dried for 48 hours in a forced-draught oven at 50 degrees C to facilitate threshing and for determination of dry grain yields.

The experiment was harvested on 10th April, 1969.

Experiment 2

A randomized blocks design was used with four replicates. Plot size was as in Experiment 1. Spaces of 10 ft were left between blocks and the area occupied by the trial was 90 ft x 97 ft.

To obtain differences in sowing rate, distance between rows was held constant at 2 ft and distance between seeds within the row varied. Distance between seeds within the row and the equivalent sowing rate are shown in Table 1.

Table 1.—Distance between seeds and sowing rate cv. Texas 626

Distance Between Seeds (in)	Sowing Rate (lb/acre)
1.5	14.0
3.0	7.0
6.0	3.5
9.0	2.3

The variety used was Texas 626. All plots received a basal fertilizer dressing of 6 cwt per acre of a mixture of equal parts by weight of ammonium sulphate, potassium chloride and superphosphate. Harvesting procedures were the same as those used in Experiment 1. The experiment was sown on 10th January, 1969 and harvested on 10th April, 1969.

RESULTS AND DISCUSSION

Progress of Trials

Both experiments were remarkably free of attack by insects and plant pathogens. This was probably due to good separation from other sorghum growing on the property.

Although the growing period of the experiments coincided with the wet season in the Markham Valley (November to April), rainfall was erratic. Reasonable rain fell in January followed by a relatively dry February and good rain fell again in March. An adjacent dryland rice trial made very poor growth. The sorghum, presumably because of its greater drought resistance, grew well.

Response to nitrogen could be seen from early in the experiment. Plots treated with nitrogen were greener, flowered earlier, and produced bigger grain heads.

In the sowing rate trial, plants at 6 in and 9 in spacings were larger and produced bigger grain heads than those spaced at 1.5 in and 3 in. Tillering was not observed in any treatment of either experiment.

Experiment 1

Analysis of variance on the yield of green heads showed that there were no significant interactions and only nitrogen gave a significant fertilizer response ($P < 0.001$).

During drying some of the bags from individual plots were bulked by accident. Actual grain yields from all plots are therefore not available. Yield of dry grain for the bulked bags was estimated by a regression based on the available values. The equation was:—

$$Y = -0.650 + 0.559X$$

($t = 7.894^{**}$)

where Y = yield of dry grain in kg per plot
 X = yield of wet heads in kg per plot

The very highly significant relationship ($P < 0.001$) indicates that estimated yields can be accepted with reasonable confidence. Means for the various fertilizer levels are shown in Table 2.

Table 2.—Response of hybrid sorghum to major elements—yield of grain in lb per acre

Element	Level			Significance
	0	1	2	
Nitrogen	1237	2065	3046	***
Phosphorus	2209	2113	2025	N.S.
Potassium	2265	1881	2201	N.S.

On the soil type concerned the only major element to increase yield was nitrogen, an extra 828 lb of grain per acre being obtained from the application of 1 cwt of ammonium sulphate (23.7 lb nitrogen) and an extra 1,809 lb from 3 cwt (71 lb nitrogen).

Experiment 2

As in Experiment 1, some dried bags were mixed prior to final weighing. A regression was again used to estimate yield of dry grain. The equation was:—

$$Y = -9.799 + 1.166X$$

($t = 4.528^{**}$)

where Y = yield of dry grain in kg per plot
 X = yield of heads in kg per plot

The highly significant linear relationship ($P < 0.01$) again indicates that the estimated results can be accepted with reasonable confidence.

Grain yields were subjected to analysis of variance and overall treatment effect were not significant. Partitioning of the treatment sum of squares by fitting of polynomials indicated that a significant linear treatment effect existed ($P < 0.05$).

The regression was of the form:—

$$Y = 3085.101 - 90.559X$$

($t = 2.646^*$)

where Y = yield of dry grain in lb per acre
 X = distance apart in inches of seeds within the row

Mean treatment yields and those estimated from the regression are shown in Table 3.

Table 3.—Effect of sowing rate on yield of grain in lb per acre

Sowing Rate (lb/acre)	Mean Yield (lb/acre)	Estimated Yield (lb/acre)
2.33	2341	2270
3.50	2471	2542
7.00	2671	2813
14.00	3092	2949

Within the range of sowing rates, tested yield of grain decreased by 91 lb per acre per inch increase in the distance between seeds. It is of interest to note that the yield in Experiment 2 for the 14 lb per acre sowing rate which received 2 cwt of ammonium sulphate was slightly higher than that obtained in Experiment 1 where 3 cwt of ammonium sulphate had been applied with a sowing rate of 7 lb per acre.

It should be remembered that in this experiment the distance between rows was held constant while within-row distance was varied. Further work of interest would be to investigate the effect of decreasing between-row distances, as it has been shown in maize that competition is decreased as equidistant distribution is approached and that denser spacings give higher yields (Downey 1971).

The Production Function

By combining mean yields of nitrogen treatments in Experiment 1 with mean yield at the

same sowing rate (7 lb per acre) in Experiment 2, results are available for four nitrogen levels. By fitting polynomials it is possible to determine the shape of the production function. The data were found to be best fitted by a quadratic equation of the form:—

$$Y = 1235.792 + 941.296 X - 112.569 X^2$$

where Y = yield of sorghum grain in lb per acre

X = ammonium sulphate applied in cwt per acre

From the equation it is possible to estimate the change in grain production per cwt of fertilizer or per lb of nitrogen added (Table 4).

Table 4.—Effect of ammonium sulphate on yield of sorghum grain in lb per acre

Fertilizer Application Rate (NH ₄) ₂ SO ₄ cwt/acre	N lb/acre	Yield lb/acre	Increment in Yield for Each Extra cwt of Fertilizer	
			lb/cwt (NH ₄) ₂ SO ₄	lb/lb N
0	0	1240		
1	23.7	2060	820	34.5
2	47.4	2670	610	25.7
3	71.1	3040	370	15.6

In this experiment the point of maximum response to applied nitrogen was not reached at the levels tested. Further work is therefore required to determine this level. It is also of note that at the prices prevailing when the trial was conducted, the maximum rate of application was not at the point required to maximize profit. On economic grounds, profit is maximized when the cost of the last factor added equals the extra return. In 1969 sorghum grain was worth \$52 a ton at the farm gate, while ammonium sulphate cost \$98 per ton. The last cwt of ammonium sulphate therefore cost \$4.90 while the extra 370 lb of grain it produced would have been worth \$8.59. Comparison with the current price of ammonium sulphate and sorghum grain should allow a farmer to make some estimate of his required optimum rate of fertilizer application for profit maximization.

Further Work

These experiments raise almost as many questions as they answer. Doubling the seeding rate at a constant between-row distance in-

creased yield 16 per cent. However, sorghums of tropical origin should be sought for comparison with imported American hybrids to determine the importance for sorghum yield of ability to tiller in a New Guinea lowland environment.

The response to nitrogen was obtained from ammonium sulphate. Other forms of nitrogenous fertilizer require testing. Repeated use of sulphur-free forms of nitrogen could lead to induction of sulphur deficiency.

In this experiment fertilizers were broadcast onto the soil surface after sowing. Soils of the Markham Valley are generally basic, a condition that can lead to the loss of up to 25 per cent of ammonia added as fertilizer, a process which is probably accelerated by high temperatures and non-incorporation (Martin and Skyring 1962). Work is therefore also required on the mode and timing of nitrogen application to maximize yield.

CONCLUSIONS

The experiments showed that significant yield increases in grain sorghum can be expected from the application of nitrogenous fertilizers on former native grasslands in the Markham Valley. On the other hand, responses to phosphorus and potassium were not evident. Yield increased from 1,237 lb of grain per acre with no nitrogen to 3,046 lb of grain with an application of 71 lb of nitrogen (as ammonium sulphate). Considerable increase in grain sorghum production could be expected from commercial use of nitrogenous fertilizers by sorghum growers in the Markham Valley.

Doubling the seeding rate from 7 lb to 14 lb per acre increased yield of grain 16 per cent from 2,671 lb per acre to 3,092 lb which was approximately the same response as could be expected from the addition of an extra cwt of ammonium sulphate. Further work is required on this aspect to determine if at a constant sowing rate yield can be altered by changes in the geometry of seeding.

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