FERTILIZATION OF RICE IN THE EASTERN TRANSVAAL LOWVELD*

(Met opsomming in Afrikaans)

E. WOLF, J. H. VISSER, Optichem Fertilizers (Pty.) Limited, and F. H. LE ROUX,
Bonsakor, Nelspruit.

Abstract

Rice of the indica type has been grown under irrigation in the Transvaal Lowveld and several long grain varieties have been used in 3 x 3 x 3 factorial trials. It has been found, with phosphorus nutrition kept at a constant level, that high nitrogen and high potassium levels produce significantly higher crops than lower levels of nitrogen and potassium and that three split applications of nitrogen are superior to two or a single application at planting.

Introduction

Rice is undoubtedly one of the most important foods of all times. As early as 5 000 years B.C. the Chinese ceremoniously prepared their daily rice dishes according to traditional rules. Over the years rice gained in popularity and today provides staple food for more than half of the world's population. The area under rice is rapidly approaching 300 million acres and the average production of unshelled 'rough' rice has exceeded 300 million short tons. Traditional rice growing countries are Japan, China and India, but the highest yields so far have been harvested in Australia during the last decade, viz more than 12 000 lb per acre, thus taking the lead from Japan, Spain and Italy.

Rice can be grown in many ways and under various conditions. It is still sown by hand as 7 000 years ago in Asia; it is drilled mechanically in most of the Western countries and it is sown by aeroplane in the United States.

Temperature and moisture restrict the success of rice growing mainly to the tropics and subtropics. Optimum growth takes place at 90°F and the temperature should never drop below 70°F. Water requirements vary between eight and 35 inches a month according to variety and growing stage. Rice is rather sensitive to duration and intensity of light.

Little information is available on the fertilizer requirements of so-called 'upland' rice, ie rice grown under irrigation, similar to wheat, in contrast to 'paddy' conditions, or submerged culture. Because of the completely different conditions under which 'upland' rice is cultivated, very limited value can be attached to fertilizer trials carried out on flooded fields.

Experimental work by Beacher & Wells (1960) and Evatt (1964) showed that rates of nitrogen as great as 135-160 lb N per acre were required to produce maximum yields. Maximum yields from single applications were obtained by Sims (1963) with rates of 60-90 lb N per acre.

Wells (1962) compared single applications of 80 lb N per acre made at 10 day intervals from 15-115 days after seeding. Bluebonnet 50 responded well to applications made at 75 and 85 days after seeding.

Grain yields of Bluebonnet 50 were found to be highest from a 120 lb N single application by Sims, Johnston & Henry (1965) who concluded that rate of nitrogen application appeared to have a significant effect on rice yields. Applying all the nitrogen at 48 days after emergence resulted in the lowest yields, while split applications (1/3 at 14; 1/3 at 48; and 1/3 at 66 days after emergence) resulted in highest yields.

The preceding studies emphasize the value of applying nitrogen at or near the stage of panicle initiation. Nitrogen applied early in the growing season, especially if it is a high application, stimulates the plant to excessive vegetative development and the danger of lodging becomes real.

Because of increased consumption, the Republic of South Africa has to import increasing quantities of rice annually. In order to produce rice locally, it was decided to grow it under irrigation as a summer cash crop.

The effective fertilization of rice under sprinkle irrigation on heavy soil presents specific problems. The nutrition of the rice plant becomes a critical factor in increasing productivity and hence the economic cultivation of this crop. Soil analysis reveals deficiencies or unbalanced available plant nutrients, thus making corrective application of fertilizer a delicate matter.

Rice growing in the Transvaal Lowveld started promisingly and a couple of early and medium-early varieties of the 'long grain' group of 'upland' rice have been used, viz

Belle Patna,
Blue Belle, and
Bluebonnet 50.

The soil of this area, where sugarcane dominates all other crops, was classified by Maud and Van der Meden (1966) as a deep dark brown coloured clay, derived from basalt and belonging to the Kiora series.

TABLE 1 *Chemical characteristics of the Kiora series*

Depth in inches	Exchangeable cations me %					% Base saturation	pH 1:2.5 (H_2O)
	K	Na	Ca	Mg	CEC		
0–10	0.23	1.09	18.00	8.72	38.04	75	6.6
10–22	0.18	1.61	19.50	9.67	37.50	83	6.7
>22	0.15	2.22	27.00	10.51	36.36	100	7.5

From experimental results obtained under comparable conditions overseas an N:P:K ratio of roughly 3:2:1 with optional N dressing at a later stage was selected, but this resulted in rather vigorous early growth and later lodging.

It was obvious that overseas experience could not be applied and that nutrient requirements would have to be established under local conditions.

In order to establish optimum rates of nutrients under Transvaal Lowveld conditions, a fertilizer trial with different rates of nitrogen and potassium

---

* This paper was read by E Wolf at the Annual General Meeting of the Fertilizer Society of South Africa, Allemanskraal, May 1969.

applications linked with the timing of nitrogen application, was conducted.

The composition of soil samples taken at a depth of 0-6" from the experimental site prior to fertilizer application, are shown in Table 2.

TABLE 2 Soil analyses at experimental site

Sample number	Organic material %	pH		Available plant nutrients ppm			
		KCl	H_2O	P	K	Ca	Mg
1	5.2	5.0	6.0	10.0	280	1 280	550
2	3.2	4.8	5.9	12.5	180	1 800	560
3	3.4	4.9	6.0	7.5	180	1 800	600
4	2.7	5.0	6.1	10.0	280	1 280	510
5	3.0	4.9	6.1	5.0	280	1 280	500
6	3.2	5.0	6.0	10.0	180	1 820	550

Materials and Methods

The cultivar Bluebonnet 50 was seeded in seven inch drills at a rate of 100 lb per acre on the 2nd of October 1967 in a dry soil, and immediately irrigated at the rate of 1½ inches (40 mm) and at weekly intervals throughout the growing season.

Weed control was effected by two post-emergence applications of 'Stam F-34' at the rate of ½ gall per acre per application when the first grass weeds reached the three to nine leaf stage. The second application was made ten days later at the same rate. A slight infestation of the parasitic witchweed **(Striga lutea)** became apparent fairly late in the growing season, and coincided with ear emergence

A basic dressing of 46 lb P per acre, as well as differential potassium dressings and part of the nitrogen were applied to all experimental plots prior to seeding, and disced in.

Nitrogen topdressings were based on the date of emergence. The experimental treatments were as follows

1 Rate of nitrogen applications

N_1 : 30 lb N/acre
N_2 : 45 lb N/acre
N_3 : 60 lb N/acre

2 Rate of potassium applications

K_0 : No K applied
K_1 : 30 lb K/acre
K_2 : 60 lb K/acre

3 Timing of nitrogen applications

T_0 : All N applied prior to seeding
T_1 : 30 lb N per acre prior to seeding and 15 and 30 lb N/acre topdressed at 45 days after amergence
T_2 : 30 lb N/acre prior to seeding and two topdressings of 7½ and 15 lb N/acre respectively at 45 and 60 days after emergence.

Plots were laid out in a 3 x 3 x 3 confounded factorial design with one replication.

Results

All plots were harvested on the 8th March, 1968. The yields obtained are shown in Table 3.

TABLE 3 Grain yields of Bluebonnet 50 (12% moisture) in lb/acre

Nitrogen effect	Potassium effect	Timing effect
N_1 : 3 060 N_2 : 3 400 N_3 : 4 250	K_0 : 2 990 K_1 : 3 370 K_2 : 4 790	T_0 : 3 530 T_1 : 3 580 T_2 : 4 130
LSD (P=0.05) 328	294	413
Coefficient of Variation 9.8%		

Leaf samples were taken on all plots on the 22nd January 1968. At this time the plants were in the boot stage, and only the flag leaf (top leaf on haulm) were sampled, air dried and subsequently analysed. These analyses are given in Table 4.

TABLE 4 Chemical composition of flag leaves, in percentage on an oven dry basis

Treatment	% Element				
	N	P	K	Ca	Mg
N_1	1.70	0.15	1.35	0.29	0.19
N_2	1.89	0.15	1.42	0.29	0.15
N_3	1.89	0.16	1.47	0.25	0.12
K_0	1.75	0.15	1.36	0.33	0.15
K_1	1.88	0.15	1.44	0.29	0.14
K_2	1.91	0.16	1.47	0.23	0.13
T_0	1.87	0.15	1.43	0.27	0.14
T_1	1.82	0.15	1.39	0.29	0.14
T_2	1.83	0.15	1.45	0.28	0.14

In addition micro-element determinations were carried out on a few selected samples. These results are presented in Table 5.

TABLE 5 Micro-element content of flag leaves

Treatment	Cl %	Cu ppm	Fe ppm	Mn ppm	Zn ppm	B ppm	Mo ppm
N_1K_0	0.72	5	198	130	2	9	0.10
N_2K_1	0.80	3	280	121	8	18	0.09

Discussions and conclusions

From the results it is evident that the addition of nitrogen results in an increased grain production (Fig. 1). This effect is also notable in the nitrogen content of the leaves. An increased vegetative growth and nutritional status contribute much to this increased yield.

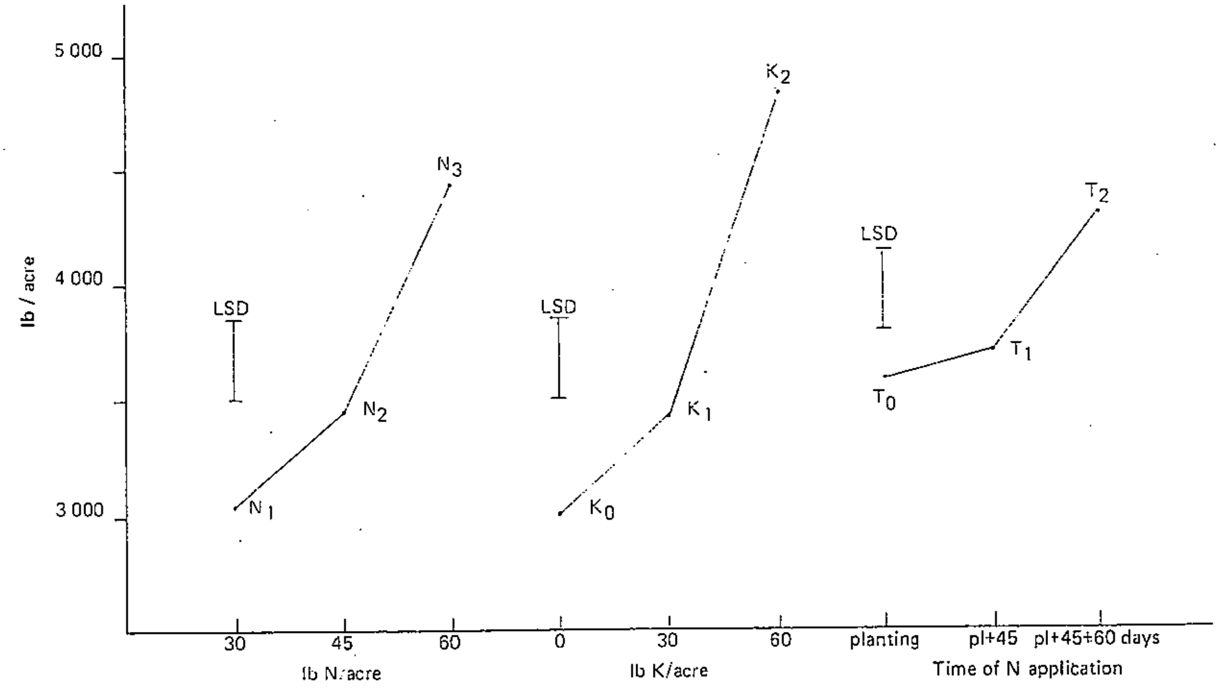

Fig 1 Treatment effects in lb rice (at 12% moisture)

The rather remarkable response obtained as a result of increased potassium applications, particularly in view of the rather high potassium content of the soil, is exhibited not only in the grain yield (Fig. 1), but also in the chemical composition of the leaves. From the almost linear response obtained, it can be expected to continue beyond the highest level of potassium application, viz 60 lb K per acre.

This reaction to potassium application demonstrates the well-known antagonism between Ca and Mg and K. The relatively high Ca and Mg content of the soil impairs the uptake of K from the soil solution (Scheffer-Welte, 1955; Prevot, 1959).

The optimum relationship between K and Ca in the leaves of gramineous crops can, according to Scheffer-Welte (1955), be considered as 5-6:1. In this experiment the following values were obtained

K_0	4.3:1
K_1	4.9:1
K_2	6.4:1

The values obtained for K_1 and K_2 (30 and 60 lb K per acre respectively) come close to the considered optimum, while that of K_0 (no potassium applied) is below this optimum value.

The time of application of nitrogen to the rice crop appears to be of great importance (Fig. 1). A late application favours high yields (Sims et al, 1965). Too late an application can, however, decrease yields, especially if this application is made after flower initiation has taken place, ie after the plant has entered the reproductive phase. Micro-elements determined in the leaves clearly show that they are to a large extent influenced by the nutritional status of the plant. From Table 4 it is apparent that the higher levels of N and K application result in an increased content of iron, zinc and boron. The elements chlorine, copper, manganese and molybdenum contained in the plant material do not seem to be greatly influenced by the application of N and K.

As to the specific contents of the various micro-elements in the rice plant, a few facts of interest emerge from this study. The copper and zinc contents of the plants appear to be rather low. Chapman (1966) presents evidence which indicates that a copper content of about 15 ppm appears to be the optimum for gramineous crops (wheat and oats). A copper content of less than 5 ppm is considered to be very low. In the case of zinc 30 ppm could be considered optimum for maize, while a content of less than 20 ppm exhibited deficiency symptoms in oats according to Chapman (1966). These facts are substantiated by leaf analysis data for other crops grown in this area, and it can be safely assumed that the copper and zinc status of this particular crop is low to very low.

The boron content is markedly increased by the application of N and K. Scheffer (1955) points out that an increase in calcium content is always accompanied by a simultaneous increase in boron. This fact is borne out by the results obtained in this study. Under conditions of low calcium content, the boron content of the material is also low. (From Tables 4 and 5 it can be seen that high calcium content is lower at high levels of N and K). This fact should be kept in mind when application of high levels of N and K are anticipated.

Upland rice can be successfully grown under Transvaal Lowveld conditions.

A yield of 5 000 lb of rough rice per acre should not be regarded as optimum as increased nitrogen and potassium applications increase production significantly above this figure.

Splitting the nitrogen dressing into three applications is superior to one or two applications.

Opsomming

BEMESTING VAN RYS IN DIE TRANSVAALSE LAEVELD

Rys kan met sukses onder besproeiing in die Transvaalse Laeveld verbou word. Die optimale produksiepeil is met 5 000 lb rowwe rys per akker nog nie bereik nie omdat verhoogde stikstof asook kalium-toedienings betekenisvolle hoë opbrengs lewer as laer peile

Die opdeel van stikstof-toediening in drie applikasies is beter as een of twee toedienings.

Acknowledgement

The authors wish to thank Mr D J Coetzee, Komatidraai Boerdery (Edms) Beperk, Komatipoort and his staff for their assistance and uninterrupted support during the rather complex experimental work. This contributed greatly to the success of the series of experiments.

References

BEACHER, R. L. & WELLS, J. P. 1960. Rice fertilizer studies, 1952-1958. Ark. Agr. Sta. Bull. 620.

CHAPMAN, H. D., 1966. Diagnostic criteria for plants and soils. Univ. of Cal., Div. of Agr. Science.

EVATT, N. S., 1964. The timing of nitrogenous fertilizer applications on rice. Int. Rice Res. Inst. Symp. on the mineral nutrition of the rice plant.

KÜRTEN, P., 1954. Reis, Anbau und Düngung ausserhalb Ostasiens Schriftenreihe über tropische und subtropische Kulturpflanzen, Ruhr-Stickstoff A. G., Bochum.

MAUD, R. R. & VAN DER MEDEN, E. A., 1966. Some characteristics of the soils of the sugarcane growing areas around Malelane-Komatipoort, Eastern Transvaal. Proc. S.A. Sugar Tech. Assoc. March 1966.

PREVOT, P., 1959. Bases du diagnostic foliare, ses résultats et sa généralisation. Bull. Agr. Congo Belge et du Ruanda-Urundi, Vol. 50(6) 1475-1502.

SCHEFFER, F. & WELTE, E., 1955. Pflanzenernährung. F. Enke Verlag — Stuttgart.

SIMS, J. L., 1963. Nitrogen fertility studies in rice fields and reservoirs. The Rice Journal 66(7), 86-87.

SIMS, J. L., JOHNSTON, T. H. & HENRY, S. E., 1965. Effect of rates and timing of nitrogen fertilization on performance of rice varieties 1957-1962. Univ. of Arkansas Agr. Expt. Sta., Report series 142.