IRRIGATION CHARACTERISTICS OF SOILS IN THE MAREEBA-DIMBULAH AREA OF NORTH QUEENSLAND

4. INFILTRATION AND RELATED DATA FOR NICOTINE SAND

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SUMMARY

The soil moisture and infiltration characteristics of Nicotine Sand were investigated using techniques described previously. Two dyes (Rhodamine and Fluoresceine) were found useful in defining the "wetted profiles".

The results are discussed in terms of the irrigation amounts, frequencies and techniques suitable for this soil type. It is concluded that frequent light applications using spray irrigation would be required. This soil is of low irrigation potential and its development for tobacco growing would require further investigation.

I. INTRODUCTION

The soil type classified as Nicotine Sand (Type 23) was first described by officers of the Queensland Department of Agriculture and Stock (now Department of Primary Industries) in a soil survey of that portion of the Mareeba-Dimbulah Irrigation Area known as the Right Bank Granite Creek area. Some tobacco was grown on this soil type under natural rainfall conditions about 1930, but the farms were subsequently abandoned. Information on the reaction of this soil to irrigation was required before water could be made available for its development. This paper describes preliminary studies on the irrigation characteristics of Nicotine Sand.

II. SOIL DESCRIPTION

Nicotine Sand occupies some 1,100 ac in the Right Bank Granite Creek area. It occurs in patches immediately north of Mount Uncle and also in one complete area of nearly 1,000 ac north of Nicotine Creek in the Chewko region. In the Left Bank Granite Creek area it occupies more than 1,000 ac and is often associated with soils of greater agricultural potential.

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The tree vegetation consists mainly of broadleaved tea-tree (*Melaleuca nervosa*), bloodwood (*Eucalyptus intermedia*) and pandanus (*Pandanus* spp.). Black wattle (*Acacia aulacocarpa* var. *macrocarpa*) is common around and on deserted cultivations. Numerous grasses and herbs make up the ground cover, which is usually fairly sparse (Figure 1). The topography varies in slope from 2·5 to 8·0 per cent.

Fig. 1.—Vegetation on Nicotine Sand. Black wattle in left foreground; tea-tree in right foreground.

This loose sand is classified by van Wijk (1962) as a ground-water podzol. On the surface it resembles a white beach sand but at depth may be coloured ashy-grey or yellowish brown. A field description of the profile in the area investigated is:—

PROFILE DESCRIPTION (Figure 2)

Horizon	Depth (in)	
A1	0–10	grey sand
A2	10–24	white/light yellowish brown sand
A3	42–48	coarse sandy clay compact
	48–	decomposing granite

Fig. 2.—Soil profile, Nicotine Sand.

The depth to the clay layer and the thickness of this layer vary. A water-table builds up over this compact layer during the "wet" season.

III. METHODS

Investigations on Nicotine Sand were confined to an area of 1 square chain on the representative virgin site already described.

For the infiltration studies, unbuffered ring infiltrometers were used, the method being the same as that outlined by Ward (1961). Eight trials (6 tests run simultaneously constitute a trial) were conducted between March 10 and July 26, 1960.

For the gravimetric determination of soil moisture, a tube sampler was used to collect samples to a depth of 3 ft in 4-in. increments. Antecedent soil moisture was determined at six positions in close proximity to each trial. The rings were covered to prevent evaporation and samples were taken down the wetted profile within each ring at 24 hr. These samples were used to determine the field capacity figures reported and also the fraction of the applied water retained directly beneath each ring, using the method of Marshall and Stirk (1950).

The methods used in the soil moisture studies were those outlined by Keefer and Ward (1961).

IV. RESULTS

(a) Infiltration Studies

The results of the infiltration studies are presented in Table 1. The trials on March 10 and 29, April 27 and May 6 were run for periods ranging from 70 to 105 min, with an average application of 48 in. Antecedent soil moistures indicated that the soil was saturated below 18 in. during the first two trials but the water-table had receded below 36 in. by the time the May trial was run. Consequently, in all these trials something like 90 per cent. of the large amount applied penetrated to the ground-water zone. It was not feasible to calculate the fraction retained below the ring under these circumstances. For the trials run on the above dates, the corrected values given in Table 1 were calculated, using the mean correction factor for the remaining four trials (11·9 per cent.). In the trials run on June 7 and 27, July 13 and 26, the aim was to apply approximately 12 in. in each individual test, which took from 20 to 35 min. In correcting these results for lateral spread, the corresponding mean fraction retained for each trial was used.

TABLE 1

INFILTRATION DATA, NICOTINE SAND

Date	Antecedent Soil Moisture at 0–12 in. (%)	Rate During Period (in./hr)								Total Amount Applied (in.)	Mean Fraction Retained (%)
		0–5 min		0–10 min		0–20 min		0–30 min			
		1*	2†	1*	2†	1*	2†	1*	2†		
26.vii.60 ..	1·0	34·8	4·5	33·0	4·3	31·5	4·1	24·5	3·2	13·2	13·1
7.vi.60 ..	1·1	26·4	3·0	25·8	2·9	26·0	2·9	22·2	2·5	12·2	11·3
13.vii.60 ..	1·3	33·6	4·2	32·4	4·0	30·9	3·8	22·0	2·7	13·0	12·5
6.v.60 ..	1·4	42·0	4·9	40·2	4·7	38·7	4·6	37·4	4·4	45·6	..
27.vi.60 ..	1·5	27·6	2·9	25·8	2·7	25·5	2·7	25·4	2·7	12·6	10·7
20.iv.60 ..	1·9	38·4	4·5	36·6	4·3	35·7	4·2	34·6	4·1	53·1	..
29.iii.60 ..	3·4	48·0	5·7	45·6	5·4	39·9	4·7	37·6	4·4	47·1	..
10.iii.60 ..	3·5	52·8	6·2	52·4	6·2	43·5	5·1	36·0	4·2	48·6	..
Mean ..	1·6	37·9	4·5	36·5	4·3	34·0	4·0	30·0	3·5	..	11·9

* Actual mean figures for the particular trials (Intake Rate).

† Corrected figures (Infiltration Rate).

The first series of trials were run to ascertain if there was any marked change in intake rate with time. It was found that there was a slight decrease in rate after the sharp decrease occurring in the first 10 min. The main object of the second series was to determine the water distribution pattern as well as the intake rate.

At a later stage eight tests were run when the soil was dry to 36 in. to study the penetration profiles. Immediately after 12 in. had been applied, pits were dug to expose the wetted profiles. In these tests a number of dyes were used to help define the "wetted profiles". A saturated solution of Indigo Carmine (Haise 1948) was introduced into the soil in three parallel strips spaced equidistantly across the ring, prior to the infiltration test. During the test, water passing the point of contact with the dye became coloured and on exposure a blue wavy line marked the wetted front. Rhodamine B 500 (R. A. Bond, personal communication 1962) and Fluoresceine L.T.S. were both found to be more satisfactory. In both cases the surface of the exposed profile was dusted with a 1 per cent. suspension of the dye in finely powdered kaolinite. Where the soil was wet the powder changed from white into an intense red in the case of the Rhodamine and into a yellowish green in the case of the Fluoresceine (Figures 3 and 4).

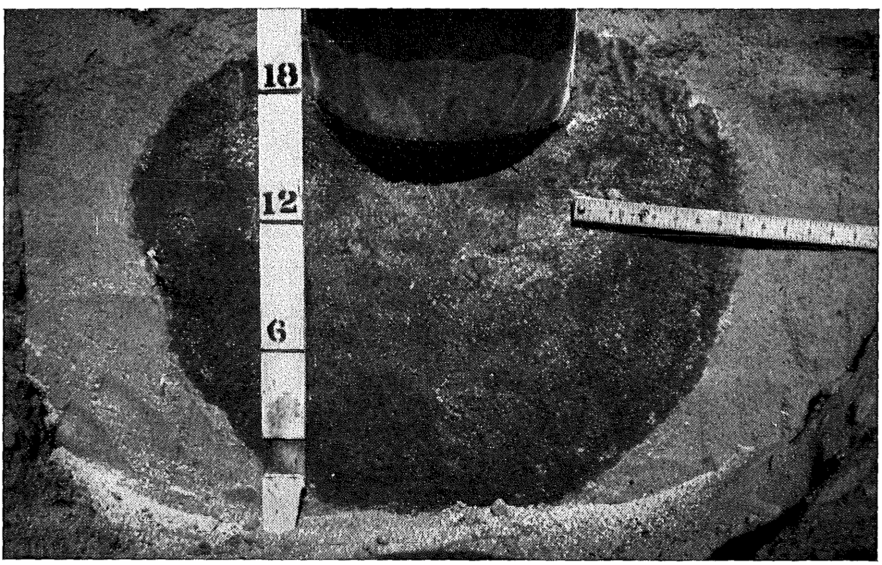

Fig. 3.—"Wetted profile" immediately after 12 in. had been applied. Rhodamine dye was used to help define the wetted portion.

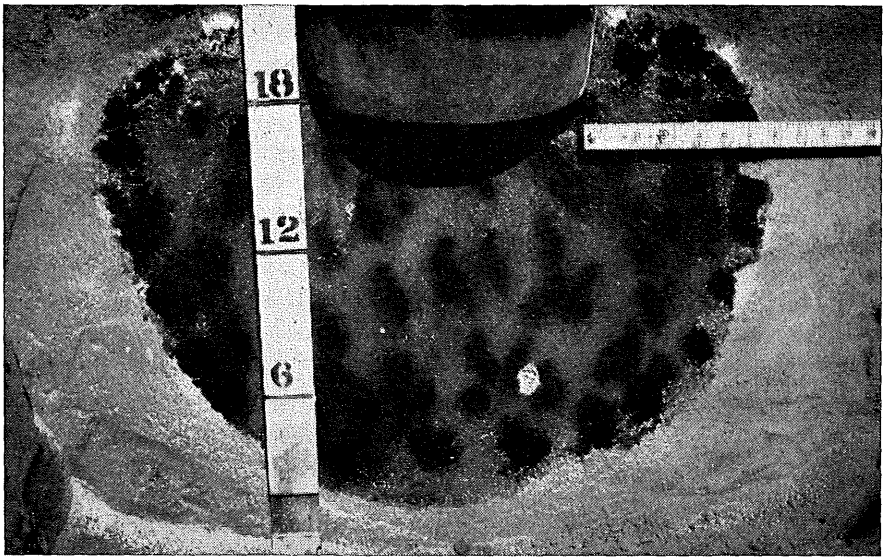

Fig. 4.—"Wetted profile" immediately after 12 in. had been applied. Fluoresceine dye was used to help define the wetted portion.

These tests indicated that immediately after the 12 in. had been applied the water had penetrated to an average depth of 26 in., with a maximum lateral movement of 6–9 in. That is, immediately after these tests had been completed at least 16–25 per cent. of the water applied had been retained directly under the ring. The factors used to obtain the corrected rates in Table 1 were much lower and consequently the infiltration rates reported would be much lower than did actually occur during the infiltration process.

For each trial, the coefficient of variability for the intake rates over the first 20 min was calculated. The mean coefficient of variability for all trials on this soil type was $13 \cdot 7 \pm 4 \cdot 8$ per cent.

(b) Soil Moisture Studies

The results of the soil moisture studies are summarized in Table 2, together with the mechanical analyses. This soil consists of 97 per cent. sand and the mechanical analysis does not change with depth above the sandy clay layer. The proportion of coarse sand to fine sand is reflected in the low field capacity and wilting point. The soil holds approximately $0 \cdot 76$ in. of available water per foot of depth with no significant changes down the profile above the impermeable layer.

TABLE 2

AVAILABLE SOIL MOISTURE AND MECHANICAL ANALYSES, NICOTINE SAND

Soil Depth (in.)	Available Soil Moisture					Mechanical Analyses			
	Field Capacity (%)	Wilting Point (%)	Available Soil Moisture	Bulk Density (g/cc)	Available Soil Moisture (in./ft)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)
0–6	4·4	0·8	3·6	1·60	0·68	77	20	2	1
6–32	5·0	0·7	4·3	1·66	0·85	78	19	2	1

Mean S.D.: Field Capacity 0·43, Wilting Point 0·12, Bulk Density 0·08

V. DISCUSSION

Tisdall (1951) found that the lower the initial soil moisture the higher the infiltration rate but suggested that the longer the time of application, the less effect the antecedent soil moisture would have. A positive rather than a negative correlation with soil moisture is indicated by the results in Table 1. In the previous paper in this series (Keefer and Ward 1963) it was suggested that such an effect could be the result of seasonal changes mainly due to temperature nullifying changes due to antecedent soil moisture. Temperature records were not obtained on the experimental site but temperature records from Parada and Mareeba indicate that this suggestion is further supported by the infiltration results from Nicotine Sand.

This soil has a low available soil moisture level and would require frequent light applications of irrigation water. The amount of available water necessary to ensure economic utilization of a soil is dependent to a large extent upon the climatic conditions which prevail during the irrigation season and the crop being grown. The U.S. Bureau of Reclamation (1947) considers that soils require at least 0·75 in. of available water per foot for economic management in comparatively arid environments. In more humid environments, irrigation may be practicable with reserves of approximately 0·5 in. per ft. Tobacco, which is the only crop likely to be grown on this soil type in the immediate future, would be planted out in the field in early September or late August. From the time of planting until the northern "wet" season begins normally in November or December, the climate could be considered more arid than humid. Although tobacco gives a high gross return, the U.S. standards indicate that the irrigation of this crop on Nicotine Sand, which holds only 0·76 in. of available water per foot, may not be economically sound, particularly while soils of greater irrigation potential are available.

There is a danger of waterlogging if inefficient irrigation practices are employed or if an early "wet" season eventuates. In any case, some form of drainage may be necessary, particularly on the shallow phases. The leaching of nutrients would also be a problem on this soil and the application of fertilizer through the sprays would require investigation.

Finkel and Nir (1960), in reviewing the criteria for choice of irrigation method, state that as a general criterion soils with an infiltration rate above 3 in. per hr are suitable only for spray irrigation. The infiltration results in Table 1 indicate that Nicotine Sand comes into this category and practical experience on this soil supports this conclusion.

VI. ACKNOWLEDGEMENTS

The assistance of Mr. D. K. Ward is acknowledged as well as the use of facilities provided by the Tobacco Industry Trust Account.

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(Received for publication May 7, 1963)