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POTASSIUM STATUS OF SOME DARLING DOWNS (QUEENSLAND) SOILS

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SUMMARY

Soil potassium values of the 11 soil types examined are generally high when compared with critical values cited in the literature for grain crops.

Potassium levels in the young plant and in the straw are satisfactory in comparison with critical values in the literature.

Potassium level of the wheat grain (cv. Mendos) is lower than would be expected from soil and plant levels.

I. INTRODUCTION

The Darling Downs, an area of rich agricultural land in south-eastern Queensland, stretching from the Great Dividing Range in the east to west of the Condamine River, has been described by Hart (1967).

A broad survey of the soils and land use on the Darling Downs has been made (Skerman and Allen 1952), while soils of part of the region have been more intensively mapped and described by Thompson and Beckmann (1959), Beckmann and Thompson (1960) and Reeve, Thompson, and Beckmann (1960).

During the 1965-66 summer crop season, there were reports of suspected potassium deficiency symptoms in maize from two different areas on the Downs. A response to potassium had been recorded earlier (J. K. Leslie and M. J. Whitehouse, unpublished data). As a result of these reports, it was considered desirable to have further information on the potassium status of the various soil types and on the potassium levels of the crops grown on them. Advantage was taken of an opportunity to do this with respect to wheat planted at 55 sites during the 1966 winter crop season.

II. MATERIALS AND METHODS

Soils.—Exchangeable potassium was determined on 0–6 in. soil samples taken from 55 sites. The soils were of various types and had different cropping histories, including length of fallow and age of cultivation. The soil samples were taken just prior to planting the sites to wheat. The age of cultivation of the sites ranged from 3 years to 75 years. The sites occurred in an area bounded by Toowoomba in the east, Dalby in the north-west, and Brookstead in the south-west. The area takes in part of the eastern Downs and the southern part of the open Downs, as described by Hart (1967).

Using the soil classification of Thompson and Beckmann (1959) and Beckmann and Thompson (1960), as nearly as possible, the soils examined comprised the following types:—

Cecilvale	12	Norillee	1
Waco	10	Condamine	1
Anchorfield	9	Oakview Sandy Loam	1
Mywybilla	7	Red Brown Earth	3
Irongate	4	Still to be identified (probably Waco type)	2
Irving–Purrawunda	3		
Beauaraba–Purrawunda	2		

As it has been shown by some workers (Attoe 1947; Reitemeier 1951; Scott and Hanway 1960; Leverington, Sedl, and Burge 1962) that drying, including air-drying, of soils can result in reversion of "fixed" potassium to an "exchangeable" form, the samples were placed in plastic bags in the field to maintain field moisture, and brought back to the laboratory, where they were extracted with a neutral 1N ammonium acetate solution, using the method of Pratt (1965, p. 1026). An Eel flame photometer was used to measure the potassium content; the standard potassium solutions used to obtain the calibration curve were prepared in a neutral 1N ammonium acetate solution.

Plant Material.—

(*a*) Young plants: The wheat plants (cv. Mendos) were sampled from the sites at about 6–10 weeks after emergence, and the whole aboveground portions of the plants were analysed for potassium. The plant samples were taken from plots fertilized with 195 lb urea and 360 lb superphosphate per acre at planting.

(*b*) Straw: Straw samples (i.e. the whole aboveground portion of the plants, minus the ears) taken at harvest from four different fertilizer treatments on three of the sites were analysed for potassium content.

(*c*) Grain: Grain samples from selected fertilizer treatments at selected sites were analysed for potassium content.

Potassium in all cases was extracted from the ground plant tissue by digesting in 25 ml 0·1N HNO_3 at 100°C for 10–15 min, then filtering and leaching with several aliquots of hot distilled water and making to volume. The potassium level was measured with an Eel flame photometer.

III. RESULTS AND DISCUSSION

(a) Soil Potassium

The exchangeable potassium ranged from 0·32 to 2·16 m-equiv. % (corrected to oven-dry weight basis).

The 10 soils lowest in exchangeable potassium (range 0·32 to 0·77 m-equiv. %) comprised the following types: Cecilvale (7 of the 12); Beauaraba–Purrawunda (1 of the 2); and the 2 unidentified samples. The 10 soils with the highest exchangeable potassium (range 1·70 to 2·16 m-equiv. %) comprised the following types: Mywybilla (6 of the 7); Irongate (1 of the 4); Waco (2 of the 10); and the 1 Norillee sample.

Barber *et al.* (1961), in greenhouse experiments with millet, obtained maximum yield when the exchangeable potassium in the field moist soil was about 0·25 m-equiv. % or greater. Hanway *et al.* (1962), in field experiments with maize, obtained no significant yield increases where the exchangeable potassium exceeded 0·2 m-equiv. % in the 0–6 in. field moist samples, except on an organic soil which had about 0·25 m-equiv. % potassium. Holford (1966), using sugar-cane as the test crop on Fijian soils, obtained significant responses to potassium fertilizer when the soil potassium was less than 0·13 m-equiv. % (50 p.p.m.), while no responses were obtained where the soil potassium was greater than 0·38 m-equiv. % (150 p.p.m.).

In work also based largely on sugar-cane, von Stieglitz (1953) considered levels of 0·2 m-equiv. % potassium, or better, as a level of sufficiency, with certain modifications after consideration of other factors.

I. Vimpany (Anon. 1966) has provisionally adopted values of 0·15 m-equiv. % for exchangeable potassium, using an 0·025N barium chloride extract with a wetting agent (personal communication), and 0·4 m-equiv. % for "available" non-exchangeable potassium, as being the threshold values below which deficiency is likely to occur.

However, Hogg (1957), in an assessment of New Zealand soils, found that in North Island soils the critical soil potassium level was 0·44 m-equiv. % when using a neutral 1N ammonium acetate extraction procedure, apparently similar to the one used in this present investigation.

Thus, different workers have given values ranging from 0·15 to 0·44 m-equiv. % as the critical levels for exchangeable soil potassium. Of the soils examined in this investigation, only two have levels of exchangeable potassium less than 0·4 m-equiv. %, these being 0·32 and 0·38 m-equiv. %, in each case on a Cecilvale soil type.

The Queensland Bureau of Sugar Experiment Stations has shown that, with respect to coastal soils used for growing sugar-cane, the exchangeable potassium in the soil reaches a maximum in early or mid summer, and that potassium is released during fallow periods (Kerr and von Stieglitz 1938). The Bureau has standardized its soil sampling procedure to sample only in the May–October period, and it considers it preferable to sample blocks at the harvest of a crop, or while still under crop, rather than following a fallow period (Sedl 1967). In this present investigation, the samples were taken during late May and June, but the length of fallow varied from a couple of weeks (i.e. from a just harvested summer crop) through the "normal" fallow (i.e. fallowed through the summer from the preceding winter crop), to the "long" fallow (i.e. fallowed through the preceding winter and summer, from an earlier summer crop).

Table 1 sets out the exchangeable potassium levels for sites of the same soil type, on the same property, but having different fallow lengths, and Table 2 sets out the mean exchangeable potassium levels for all of each of four soil types in each of three fallow categories. These results suggest that there is not much change in exchangeable potassium in these soils during fallowing—at least not in the heavy grey soils of the Cecilvale type or in the Black Earths.

TABLE 1

EXCHANGEABLE POTASSIUM FOR SITES OF SAME SOIL TYPE, ON SAME PROPERTY, BUT OF DIFFERENT FALLOW LENGTHS

Site No.	Soil Type	Exchangeable K (m-equiv. %)		
		Normal Fallow	Long Fallow	Double Cropped
7, 30, 45	Cecilvale	0·77	0·76	0·80
34, 49	Mywybilla	. .	1·92	1·78
10, 11, 47	Waco type	0·65	. .	1·03
		0·73	. .	. .
22, 38	Irving–Purrawunda	0·89	0·86	. .
24, 51	Waco	1·69	. .	1·72
25, 40	Waco	1·67	1·50	. .
26, 27, 41	Anchorfield . .	1·24	1·40	. .
		1·15	. .	. .
28, 42	Anchorfield . .	1·35	1·38	. .

TABLE 2

MEAN EXCHANGEABLE POTASSIUM FOR EACH OF FOUR SOIL TYPES FOR EACH OF THREE FALLOW CATEGORIES

Soil Type	Mean Exchangeable K (m-equiv. %)		
	Normal Fallow	Long Fallow	Double Cropped
Cecilvale	0·65	0·61	1·06
Mywybilla	1·77	1·97	1·77
Waco (including 2 Intermediate) . .	1·18	1·42	1·44
Anchorfield	1·31	1·39	1·55

(b) Plant Potassium

Young plants.—The young plant samples taken at 6–10 weeks after emergence had potassium contents ranging from 2·7 to 4·8%.

In pot experiments with millet, using soil previously air-dried, Barber *et al.* (1961) plotted exchangeable potassium in the air-dried soil against percentage potassium in the plant, sampled 5 weeks after planting, and obtained a linear relationship. They also presented data on the field moist exchangeable potassium, as measured using a neutral 1N ammonium acetate extract, similar to the method used on the soils in this present investigation. The results of this present experiment show a spread of points similar to the corresponding section of the plot of Barber and associates and the results are shown in Figure 1.

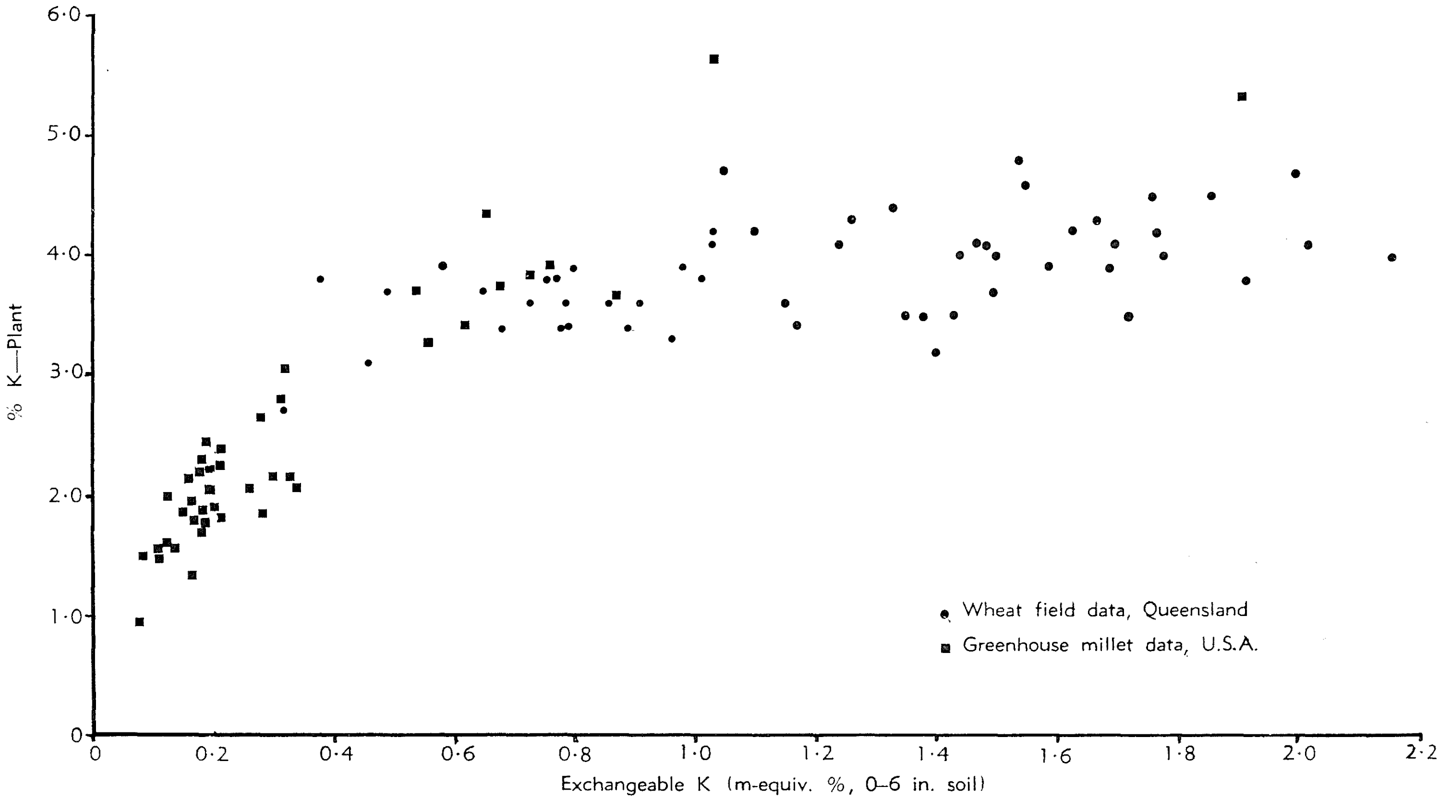

Fig. 1.—Comparison between soil potassium/plant potassium relationship for Queensland wheat and United States (North Central) millet.

Hanway *et al.* (1962), as a result of field experiments with maize, obtained a curvilinear relationship between soil potassium and plant potassium; the results of this present investigation approximate the asymptotic section of the plot of Hanway *et al.*

The results of experiments by Acharya and Jadav (1957) with wheat indicated that a level of 2·5% potassium (3·0% K_2O) in the dry matter of the aboveground part of the plant sampled at 2 months was sufficient to meet the potassium requirements for a high crop yield. No site had a plant potassium content as low as this, although on the Cecilvale site having the lowest exchangeable soil potassium the plant potassium was 2·7% K.

Straw at harvest.—The straw samples taken at harvest from three sites (including the two sites having the lowest exchangeable soil potassium) had potassium contents ranging from 0·86 to 1·80% potassium (moisture-free) (Table 3). Wagner (1915) gave a level of 0·56% potassium in the straw at harvest as being low, while Munter (1919) (cited in Goodall and Gregory 1947, p. 112) considered that potassium was inadequate where the ratio K:N in straw at harvest was less than 1·66 (i.e. $K_2O:N<2:1$). The results in Table 3 would therefore indicate a satisfactory potassium nutrition at these sites.

TABLE 3

POTASSIUM CONTENT AND K:N RATIO IN STRAW AT HARVEST

Site, Soil Type and Exchangeable K (m-equiv. %)	% K (Moisture-free)				K:N Ratio			
	Treatment*				Treatment*			
	a	b	c	d	a	b	c	d
Cecilvale (0·38)	1·41	1·41	1·72	1·71	3·3	3·4	3·1	2·8
Unidentified Waco Type (0·65)	1·51	1·59	1·80	1·66	3·9	4·2	3·7	3·9
Cecilvale (0·32)	0·92	0·86	1·14	1·10	2·6	2·8	2·3	1·9

*Treatment—a = Control (no fertilizer) c = 190 lb urea/ac
b = 360 lb superphosphate/ac d = 190 lb urea + 360 lb superphosphate/ac

Grain.—The potassium content determined in 54 grain samples from selected treatments of 15 sites ranged from 0·28 to 0·49% potassium (moisture-free).

It was shown from a survey of world wheat in 1958 (Wright 1959) that the average potassium content of New Zealand wheat was 0·36%, while a world average was 0·41%. Russell (1962, p. 536) stated that a 30 bus wheat crop having a dry weight of 1,530 lb removes 7·7 lb of potassium per acre in the grain, i.e. an average of 0·50% potassium in grain.

No data are available on critical potassium levels in grain, perhaps because the straw potassium content varies more markedly with increased potassium supply than does grain potassium content (Goodall and Gregory 1947). But it does appear the potassium level in some of these grain samples is lower than would be expected, especially in view of the rest of the results. This could be a characteristic of this cultivar.

(c) General

From a consideration of the literature, the potassium status of the soils examined appears adequate to supply the requirements for a high-yielding wheat crop. The soil potassium values are high when compared with "critical" soil values cited in the literature, although some Cecilvale soils might be approaching marginal status. An examination of potassium levels in the young plant, and in the straw at harvest, shows that these levels are satisfactory in comparison with critical values obtained by other authors. Despite these satisfactory potassium levels, it does appear that the potassium level of the grain is lower than would be expected. This could be a characteristic of the variety (Mendos).

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