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MODIFICATION OF THE CRACKING PATTERN ON A BLACK EARTH OF THE DARLING DOWNS, QUEENSLAND

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SUMMARY

A technique involving missed row planting was applied to field wheat crops in an attempt to improve the water intake capacity of the natural pattern of cracking. Where moisture storage at planting was high, the cracking pattern at harvest differed markedly from that occurring under block planting. Gross cracks in excess of the largest occurring normally occupied up to 20% of the original width of the bare area, and extended almost the entire length of areas treated. The cracking pattern in adjacent areas was substantially modified, the effect decreasing with distance from the major cracks. Where moisture storage at planting was low, no satisfactory pattern of cracking could be induced. An assessment was made of factors leading to the development of large induced cracks and of factors which may affect their ultimate size.

I. INTRODUCTION

The agricultural system on the Darling Downs grain belt in south-eastern Queensland is based on conservation of moisture during fallow periods for the use of subsequent crops, as the average rainfall during the growing period of winter crops is insufficient to produce satisfactory yields without supplementary soil storage.

The heavy clay soils have a high capacity to store moisture—up to 2 in. available water per foot depth of root zone. Waring, Fox, and Teakle (1958) established that this capacity is rarely utilized and that crops regularly suffer moisture stress. An average moisture storage efficiency of 17% of rainfall over a 6-month summer fallow was recorded by these workers over a 5-year period.

The problem of run-off and subsequent water flow erosion is also extremely important in the area. This is largely the result of low rate of infiltration through wet surface soil.

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Development of interconnected void space on drying is an inherent soil characteristic in the area, and previous work by the author (Swartz 1966) indicates the high effectiveness of water entry through a void system compared with entry through the soil mass.

Two factors serve to reduce the effectiveness of this cracking in water entry, namely closing of the cracks at the surface due to swelling of the surface layers on wetting, and plugging of the cracks at the surface with dry soil material through cultivation.

Increasing size of individual cracks open at the surface tends to counteract the above influences. It may also decrease the effectiveness of soil plugs in the manner described by Stirk (1954) and increase the probability of plug failure due to loss of shear strength.

Rapid transfer of water to lower profile depths places it in a position remote from the effects of direct evaporation and also reduces run-off. Potential benefits are such that work on techniques to promote and maintain an open void space for as long as possible is justified.

Johnson (1963) studied production of increased crack sizes on a reddish chestnut clay loam in the United States of America. Although this soil is not prone to regular production of wide surface cracks, he was able to induce them in a predetermined pattern by selective removal of crop in the early growth stages. Cracks produced were up to twice the normal size and did not vary significantly over a wide range of bare strip spacings.

Development of an interconnected crack network in the soil is dependent upon the drying cycle in the soil and is therefore related to water content prior to the onset of drying. Planting is carried out on the Darling Downs over a wide range of moisture storage and a study of the technique at high and low moisture storage levels at planting was made initially.

II. METHODS

In the 1963 winter growing season a trial area was laid out on a Waco clay soil of 2% slope. At planting, the soil was at field capacity to a depth of approximately 5 ft. This corresponds with average maximum root depth of wheat on this soil. The higher than average moisture conditions at planting were due to above-average fallow rainfall. Wheat was contour-planted on the area in 7-in. rows. A crack-inducing treatment of missing one row every 12 ft was applied to selected plots. Four paired plots were laid out. One of each pair was treated and the other fully block-planted as a control. Plots were 72 ft wide and covered approximately 1 ac each.

In the subsequent 2 years, plots were laid out on similar soil and slope conditions but with wetting front depths at planting of less than 1 ft 6 in.

Assessment of cracking was carried out with a 60-ft line transect laid at right-angles to the direction of plant rows. Crack width was measured at the base of the dry surface mulch approximately $\frac{1}{2}$ in. from the soil surface. Cracks below

0·3 in. were not recorded. Measurements were made perpendicular to the axis of the crack at the point of intersection with the transect. Occurrence of cracks in relation to the non-planted areas in treated plots was also measured. Four random transects were recorded per plot. All crack measurements were made immediately after harvest.

Yield determinations were conducted on plots at harvest.

III. RESULTS

In the initial investigation with 5 ft of wet soil at planting, minor cracking became evident in the surface layers throughout the area in the mid-vegetative growth stages. In control plots, as crop growth progressed, this cracking enlarged into the typical random crack network. A continuous crack developed along the axis of the bare area in treated plots and rapidly increased in size as crop development proceeded. Figure 1 shows a typical linear induced crack in a treated plot at crop maturity.

Fig. 1.—Induced linear cracking in a wheat crop at maturity.

Average crack recordings per 60 ft transect are shown in Table 1. A 25% reduction in total number of cracks was recorded, the fall being significant ($P<0 \cdot 5$). The total crack width recorded also fell, but the difference did not approach significance. A slightly increased average crack width resulted.

TABLE 1

AVERAGE TOTAL CRACKING PER 60-FT TRANSECT IN PLOTS WET TO 5 FT AT PLANTING

Plots	No. of Cracks	Total Width (in.)	Average Width (in.)	Percentage Transect As Cracks
Treated	26·5	44·3	1·66	6
Control	35·0	50·8	1·40	7
Necessary difference for significance (5%)	6·8	15·5	—	—

Average crack size distribution in treated and untreated plots is presented in Figure 2. Treatment resulted in a marked reduction in cracks between 1·0 and 1·5 in. wide and production of a number of cracks greater than 3·0 in., a size not recorded in control plots. Almost without fail, large cracks were recorded in bare areas.

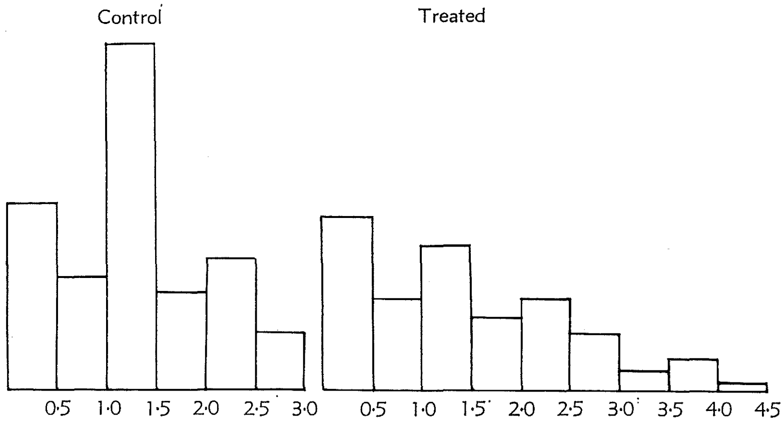

Fig. 2.—Average size distribution of cracks per 60-ft transect.

Treated plots were further investigated to assess the effect of large induced cracks on the remainder of the plot. Average crack interception in a 60-ft transect on bare and cropped areas is presented in Table 2. It is noted that 35% of the total width of cracking was derived from 20% of the cracks. These large cracks were 2·3 times as large as those in the cropped area and 2·1 times as large as those in the control area.

TABLE 2

AVERAGE DISTRIBUTION OF CRACKING ON A 60-FT TRANSECT OF TREATED PLOTS WET TO 5 FT AT PLANTING

Plots	No. of Cracks	Total Width (in.)	Average Width (in.)	Percentage Total Transect Length	Percentage Total Transect Length as Cracks
Bare	5·0	15·3	3·0	9·5	22
Crop	21·5	28·5	1·3	90·5	4

Distribution of cracking on treated plots in relation to the major cracks on bare areas is presented in Table 3. Recovery of total cracking width towards control level increases with distance from the major crack over the interval recorded. This relationship is a tension/distance function and in a homogenous situation should approach linearity. For this trial $r = \cdot 78$, and on the assumption that the relationship is linear, normal cracking would be recovered 8 ft from the major induced crack.

TABLE 3

INFLUENCE OF INDUCED CRACKS ON ADJACENT CRACKING IN TREATED PLOTS WET TO 5 FT AT PLANTING

Distance from Induced Crack (ft)	No. of Cracks		Crack Width (in.) in 60 ft		Crack Size (in.)	
	Total	Percentage of Control Cracks	Total	Percentage of Control Cracks	Average	Percentage of Control Cracks
2	15	43	16·5	32·4	1·10	78
2–3	16	46	28·0	55·0	1·75	125
3–4	28	80	39·0	76·8	1·48	106
4–5	27	77	40·0	78·7	1·39	99
5–6	24	70	32·8	65·0	1·33	95

In trials conducted in following years with a shallow depth of wet soil at planting and approaching the minimum necessary to establish an effective stand, a void system open at the surface failed to develop.

No significant yield variation was recorded in any of the trials conducted despite up to 25% of the area remaining unplanted.

IV. DISCUSSION

Under wet conditions, developing void space has been successfully modified. Under dry conditions, the desired cracking cannot be induced where substantial cracking does not normally occur at the surface. Average wet soil depth at planting on this soil is approximately 2 ft 10 in. (Swartz, unpublished data). With this level of storage, extensive cracking normally occurs and an attempt to modify the resulting void development appears justified.

Fox (1963) stated that in a wet condition the black earth is structureless. Cracking develops because of a three-dimensional contraction phase in drying. Void space in a soil drying uniformly will therefore be at random. Observations on soil drying under evaporation confirm this. A similar random pattern was observed on soil drying under a block-planted crop stand. Under these conditions, overlapping of the root systems took place, with water use in all vertical zones in the early growth stages.

In treated plots, minor cracking occurred in the cropped area before obvious water use in the bare area. This resulted in vertical zones of differential wetting. These zones apparently acted as planes of weakness due either to the existence of wetter soil in the zone or to discontinuities in the root complex. As tension developed on drying, void space occurred preferentially along the plane of weakness, producing the characteristic gross crack.

These cracks relieved tension for a distance on either side and reduced total cracking in this zone. The distance over which a crack relieved tension is undoubtedly limited, and crack size is probably at its peak when the maximum distance is reached. Results of the investigation suggest that, under the experimental conditions, a normal level of cracking would have re-established approximately 8 ft from the induced crack. A distance of over 16 ft between bare areas will probably be needed to achieve maximum crack size.

Conversely, it may be possible to induce a greater percentage of cracks of a higher order, but smaller than the maximum, by reducing the space between bare areas. This reduction could be continued to the point where overall crack size and distribution approach control level. Recordings on control plots suggest that this is between 4 and 6 ft. However, due to the interconnected nature of a soil void system, the ability of a small number of cracks to allow entry of large volumes of water, and the superior durability of larger cracks, it is thought desirable to aim at maximum crack size in the field.

Although in the early growth stages preferential water use was noted in treated plots, all available water in bare areas had been used at harvest. Previous investigations (Swartz, unpublished data) suggest that this may not be so for all bare strip widths. Where complete drill widths were left unplanted on a similar soil, two major parallel cracks developed along the axis of the strip. A "wet core" remained between them at harvest. The distance from the edge of the crop at which these cracks developed probably represented the lateral movement of the crop root system at the time of crack development. The continuous void did not then allow exploitation of the wet core later in growth. This distance varied between 12 and 15 in. It is therefore likely that complete exploitation of soil moisture will result provided the bare area does not exceed 24 in. in width.

The mechanism of crack development suggests that variation in width of bare strip below 24 in. will not substantially affect the cracking pattern provided it varies sufficiently from the normal plant spacing to produce the necessary discontinuity.

The alteration of contour cracking only has been studied. Cracking and crop zones of low impedence to water flow with any other orientation are considered undesirable on sloping land. They may, however, be acceptable on flat land. Tension on drying in a structureless soil mass develops equally in all directions. Alteration in the relief of aggregate tension in any direction will not affect aggregate release of tension perpendicular to it. Similar crack-inducing treatment perpendicular to contour treatment will similarly affect void development. A full treatment of this nature should lead to a maximum proportion of large size cracks within the total cracking.

The indications from the trial are that (*a*) the inherent cracking pattern on a Waco soil wet to deeper than approximately 2 ft 6 in. may be successfully manipulated to produce a higher proportion of large voids in the total void space; (*b*) in block planted wheat in 7-in. rows, one missed row is sufficient to produce the desired effect; (*c*) bare strips greater than 2 ft wide will probably result in wet cores of unused water; and (*d*) a spacing between bare strips of about 16 ft will probably produce the maximum crack sizes on a Waco soil.

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