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FLOOD TOLERANCE OF WINTER CROPS IN SOUTHERN QUEENSLAND

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SUMMARY

Four major winter crops of the grain belt of southern Queensland—wheat, barley, canary seed and linseed—were subjected to flooding for up to 16 days at various growth stages. The effect of flooding duration was predominant over depth of flooding. Suggested maximum durations of flooding are given for each crop.

I. INTRODUCTION

A problem of some magnitude in the grain-growing belt of southern Queensland is that of uncontrolled flooding during the spring and summer periods of high rainfall. Controlled water-spreading has been suggested as a solution to this problem and its use is currently under investigation.

The average annual rainfall in the area is 26 in. and its incidence is extremely variable. Although summer rainfall is predominant, falls producing run-off may occur throughout the growing period of winter crops and it is envisaged that the major use of water-spreading will be on winter cropland. Information on the tolerance of major winter crops to flooding at various growth stages is desirable in order to facilitate the planning and design of detention schemes, criteria on which to base water release rates and selection of crops for treated areas.

The water disposal problem reaches a peak in the lower reaches of defined watercourses and at the junction of extensive undulating areas with low-gradient plain country. Most of the soils in these areas fall within the Waco clay gilgai complex described by Thompson and Beckmann (1959). This soil is a very dark brown soil, grading into a mottled grey-brown deep subsoil below about

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3 ft. It exhibits gross interconnected cracking when dry and in this condition water access is rapid (Swartz 1966). Percolation through wet soil layers is very slow and base infiltration rates as low as 0.02 in. per hour have been recorded (W. Roche, unpublished data). Land use on this soil type is chiefly winter grain monocrop farming with some summer grain rotation. Wheat, barley, canary seed and linseed account for a high percentage of the total grain production.

Dickson, Langley, and Fisher (1940), Fisher and Burnett (1953) and other workers furnish evidence of improved yields resulting from crop inundation. Zingg and Hauser (1959) refer to mortality under flooding but give no details. Rhoades (1963), investigating a range of grass species, found that, in general, the greater the depth and duration of flooding, the more rapidly individuals of a given species succumbed. It is reasonable to expect that various grain crops at various growth stages will react differently to a range of flooding treatments.

II. METHODS, MATERIALS AND SEASONAL CONDITIONS

The investigation was conducted during the 1961 winter growing season on a Waco soil. Plots 8 ft x 28 in. of wheat, barley, canary seed and linseed were sown at a series of planting dates to produce plots at a range of growth stages during a common flooding period. Planting was carried out with a hand-operated seed drill in 7-in. rows. Plots comprised four rows, the inner two of which were used for survival counts.

Plot layout was in blocks of four containing one plot of each crop studied. A series of three blocks with staggered planting dates was located on the same contour level, and similar series were located at regular vertical intervals. The lower three of these series were confined within an earth structure capable of holding water on plots at a range of depths up to 9 in. A series of control plots was located above the water level.

Each complete bay repesented a flood duration treatment and four of these were randomly located on the experimental area. Growth stage treatments were placed at random in each series of blocks. Location of crop plots within blocks was constant throughout the trial. Randomization of flood depth treatments was not possible, the more deeply flooded plots of necessity being vertically below the shallow plots. Individual treatments were not replicated.

Flood water was applied from an adjacent creek. The flood bays were initially filled to capacity and were refilled at 2-day intervals. Flood durations shown in the tables of results include the period of supersaturation following removal of free water. The depths given are the averages recorded during the flooding period. Treatments subjected to a greater depth of flooding were subjected also to a range of flood durations of a higher order.

Flooding treatments were as follows:

Flood depth treatment (av. in in.)	Flood durations (days)			
$\frac{3}{4}$	1·3	3·1	4·3	7·2
$2\frac{1}{2}$	2·6	5·2	8·0	13·4
$5\frac{1}{2}$	4·2	6·2	8·4	16·0

Flooding of all plots was commenced on November 24 and continued for up to 16 days. The planting dates for the four crops which brought them to the predetermined growth stages at the time of flooding were as follows:

	Mature	Flowering	Late Vegetative	Seedling
Wheat	July 12	Aug. 14	Aug. 21	Nov. 12
Barley	Aug. 1	Aug. 14	Sept. 5	Nov. 14
Canary	Aug. 1	Aug. 14	Sept. 5	Nov. 15
	Late Flowering	Early Flowering	8-leaf Vegetative	Seedling
Linseed	Aug. 1	Aug. 28	Oct. 18	Nov. 14

Where necessary, plots were irrigated at planting with sufficient water to ensure establishment.

Survival assessment for wheat, barley and canary seed at seedling, late vegetative and flowering growth stages, and linseed at all growth stages, was conducted using a measured number of 50 plants per plot. These were pegged prior to flooding. Survival determinations were made 2 weeks after removal of the last flood water by a direct count of surviving plants. At the mature stage of graminaceous crops, difficulty was experienced in determining individual plants. Field experience had indicated that the major loss at this stage results from destruction of individual tillers. Assessment at this stage was therefore based on a count of harvestable heads before and after flooding. These were similarly expressed as a survival percentage. Plots with less than 50 measurable plants at preflooding recording have been excluded from the results.

A close examination was made of plants affected prior to final recording with a view to determining any visible cause of failure.

III. RESULTS

Prior to the commencement of the trial the soil on all plots was wet by fallow rainfall to a depth of 4 ft. This corresponds with the average depth of heavy black soil and is the approximate lower limit of crop root growth in the area. A moisture content of this order was maintained on unplanted areas throughout the trial and existed on plots flooded at the seedling stage when treated. Late-vegetative plots, having supported crops for 6 weeks, contained void space in the surface 18 in. but were wet at depth. Cracking to a depth greater than 3 ft existed at flooding on all plots treated in the reproductive growth stages.

All soil void space was open at the surface at flooding and water entry to its maximum depth was observed in the early stages of water application. Moisture conditions on all treatments at flooding closely paralleled estimated average field conditions for the treatments.

Total rainfall during the growing period was 10·23 in., which exceeds the average by 15%. The excess over average fell during the first 2 months of the growing period. No damage or crop loss due to frost or other factors was recorded between the plant counts.

Survival percentages in relation to flood duration in days are presented in Figures 1-4. Depth and growth stage treatments are shown as separate regression lines on each graph.

No clear-cut differences in reaction to flooding between different growth stages and different flood depths were recorded for wheat (Figure 1). Pre-flowering growth stages did, however, show a sharp rise in mortality after 7 days' inundation which was not recorded at growth stages after flowering.

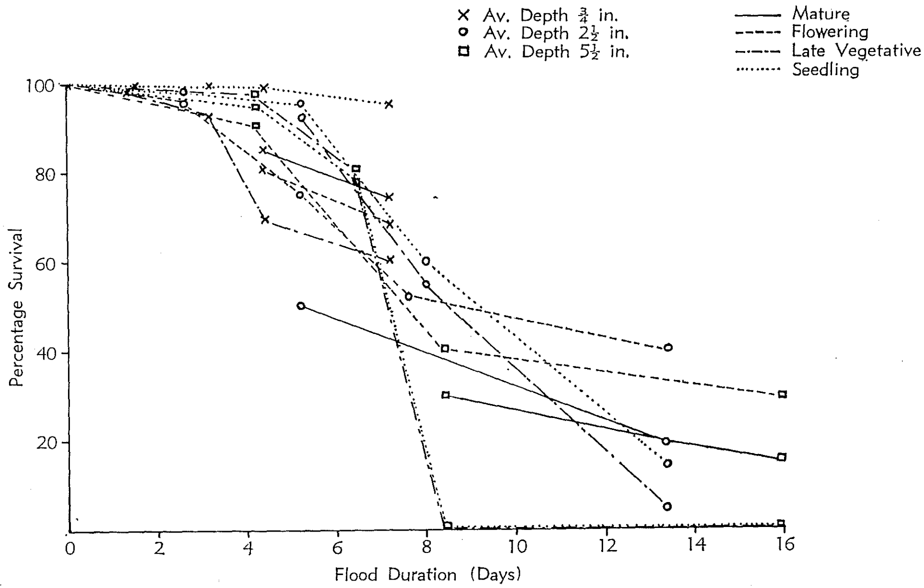

Fig. 1.—Effect of flooding on survival of wheat.

Barley proved to be substantially more tolerant than wheat at growth stages following flowering (Figure 2). A sharp increase in mortality occurred after approximately 5 days of flooding at the vegetative growth stages; 8½ days of flooding was necessary to give a similar increase after flowering.

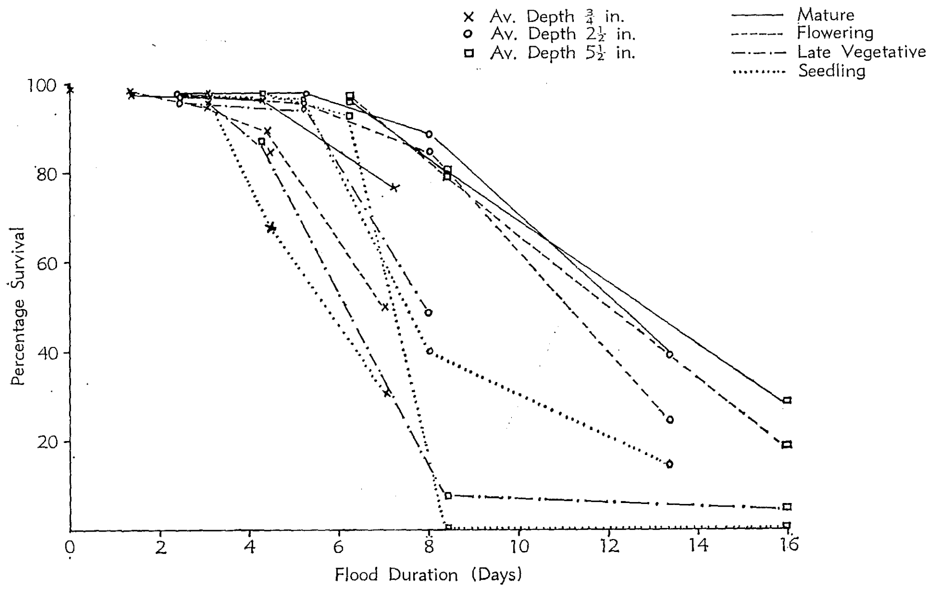

Fig. 2.—Effect of flooding on survival of barley.

A sharp increase in mortality during the vegetative growth stages was recorded for canary seed after 3 days' duration of flooding (Figure 3). During the reproductive stages, flooding caused less than 10% crop loss after 16 days' inundation.

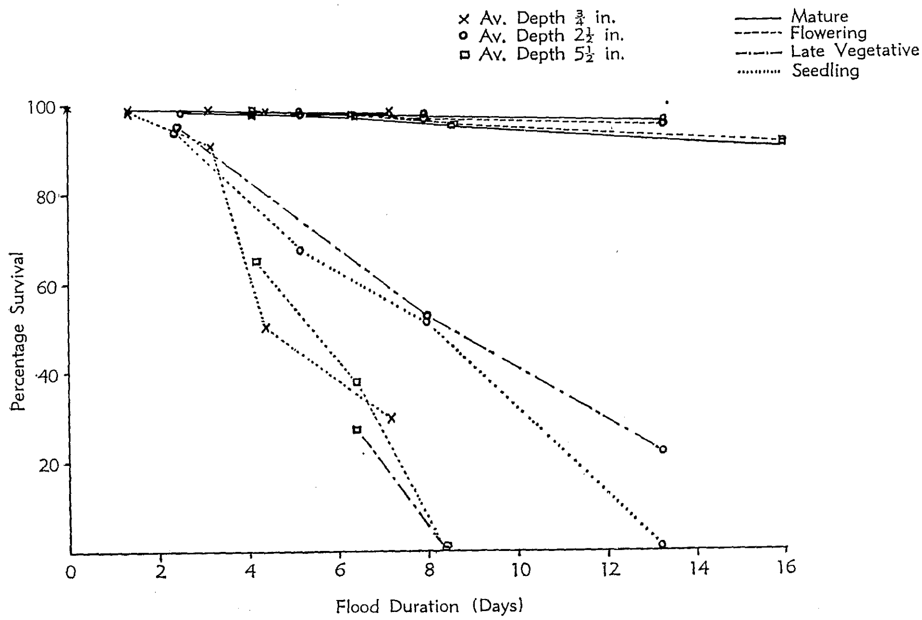

Fig. 3.—Effect of flooding on survival of canary seed.

Linseed displayed a high degree of flood tolerance except at the seedling growth stage (Figure 4). Flooding at later vegetative stages and during flowering caused a maximum of 25% mortality after 16 days' inundation.

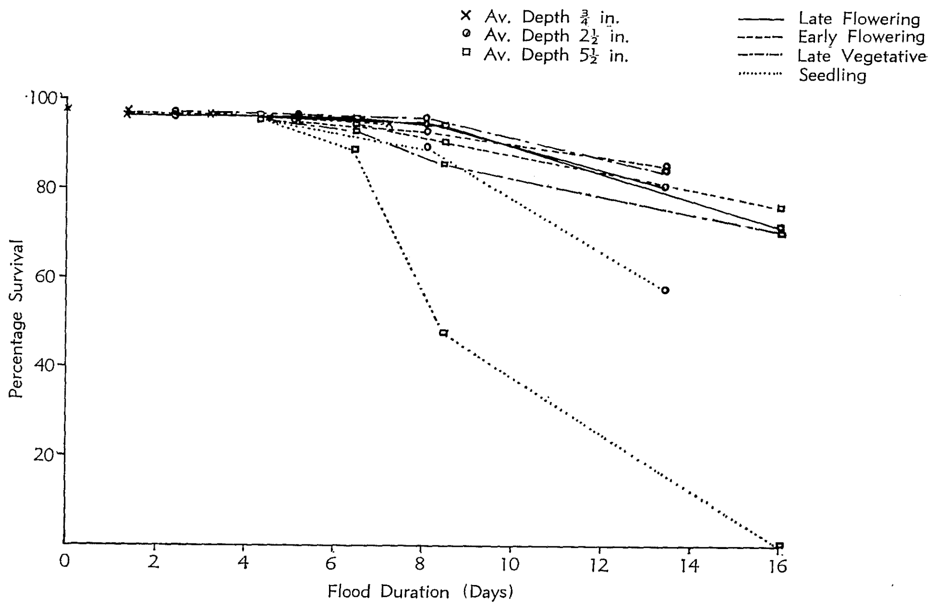

Fig. 4.—Effect of flooding on survival of linseed.

IV. DISCUSSION

In general, the crops studied proved most susceptible to flooding at the seedling stage and wheat, barley and canary seed were susceptible also in the later vegetative stages. Characteristically these crops showed a period of relative tolerance, followed by a very rapid onset of mortality sometimes approaching complete loss. Examination of affected plants showed that most serious damage appeared to be on the lower stem, while root damage was not extensive. Due to the wetness of the plots prior to flooding, water penetration was slow and in most cases the full root zone was not saturated at the time of plant mortality. It was therefore concluded that the aerial portions of the plants at these stages had succumbed before water had advanced sufficiently to cause deterioration of the root system.

Graminaceous species affected at the flowering stage showed little malfunction of aerial structures. Examination of the root system revealed that rotting of the major upper root structures had frequently caused almost complete severing of the below-ground portions of the plant. It was not possible to determine if the bacterial attack was parasitic, or saprophytic following root malfunction due to flood-induced soil disorders. It is possible that if a surface seal existed under field conditions, less rapid saturation of the root zone may prolong crop resistance to flooding. At this growth stage the structural nature of stem tissue appears to render it less susceptible to bacterial attack than earlier in growth. A similar comparison of the effects on root tissue is not possible, however, due to differential wetting of the root environment.

Losses recorded at maturity were due to structural failure of individual stems. Canary seeed was almost unaffected by this loss, whereas wheat and barley recorded an increased severity with increasing depth and duration of flooding.

Linseed in the flowering stages continued to be chiefly affected in the aerial structures, bacterial attack of the lower stem regions being most prevalent.

The effect of flood duration on plant mortality was predominant over flood depth for all situations studied. Negligible loss of any crop at any growth stage was recorded from 2 days' inundation. Suggested maximum durations of flooding to prevent significant plant loss are as follows:—

(*a*) Wheat ..	Vegetative growth stages ..	3 days
	Reproductive growth stages	3 days
(*b*) Barley ..	Vegetative growth stages ..	3 days
	Reproductive growth stages	6 days
(*c*) Canary seed ..	Vegetative growth stages ..	2 days
	Reproductive growth stages	not affected by 16 days
(*d*) Linseed ..	Seedling growth stage ..	6 days
	Post-flowering stages ..	9 days

The results of the investigation have provided a guide to the survival performance of the four crops under standard conditions of flooding. The design of the experiment did not allow an assessment of subsequent yield. Information is therefore necessary on the yield performance of crops within the flood duration necessary to cause severe crop mortality established in this investigation.

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