WHEAT INVESTIGATIONS AT BILOELA REGIONAL EXPERIMENT STATION, CENTRAL QUEENSLAND.

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SUMMARY.

A review of climatic conditions has been given to show the relationship between the distribution of rainfall and the production of wheat in the Callide Valley region. Data have been presented to show the total amounts and the percentage chances of receiving specific quantities of rainfall during the fallowing, planting and growing periods for wheat.

Wheat for grain can be sown in most years and reasonable crops expected if sufficient stored water is available. If a minimum of 8 in. of effective fallowing rain has been received and wet soil is present to a depth of 48 in., good crops can be obtained with a planting rain of 1½ in. If only 4-8 in. of effective rain was received during the fallowing period, a planting rain of approximately 2 in. is desirable. In seasons where 4 in. of effective rain has not been received and most stored in the soil, it is not advisable to plant wheat irrespective of the amount of rain at planting time.

The utilisation of conserved moisture and rainfall by wheat during the years 1948-1951 has been studied and tables are presented to show the moisture loss from the soil at different depths during the cropping season. The overall use of water has been shown diagramatically and a ratio of water use to yield of grain has been established for each season of production. It was found that from 5 in. to 6·5 in. of available water could be stored in four feet of soil and that in all seasons the crop utilised most of the stored water as well as small amounts of current rainfall. The total use of water from the top 48 in. of soil was 6·77 in. in 1948, 6·53 in. in 1949, and 5·63 in. in 1951.

The availability of water affected plant behaviour. In 1951 the application of 2 in. of extra water by irrigation at flowering time increased yields by 5 to 12 bus. per acre for certain varieties. In 1950 high moisture conditions prevailed in conjunction with a high nitrogen status in the upper soil during the early growing season; the resultant bulky crop utilised such large volumes of water that the supply was exhausted before maturity was reached and the potential yield of grain was considerably reduced.

The wheat crop required approximately 1·5 in. of water to be readily available at flowering time to assure good grain yields. As roots are well distributed by that stage it is desirable that this water should be stored in the soil below three feet so that it is not utilised by earlier plant development, and this objective can be attained only by effective long-term fallowing.

The demand for and the importance of available nitrogen are high when the crop is in the grain-forming stage and it is considered desirable that a reasonable nitrate supply should be retained in the soil to meet this requirement. Production of nitrate can be fostered by cultural practices and crop rotations and storage may be achieved by holding some nitrate in solution with the water conserved at depth.

The efficiency of production under different seasonal conditions has been indicated by a ratio of water use to grain yield. For each inch of water used under the conditions of the experiments, an average yield of 5·5 bus. of grain per acre was obtained and as it was considered that some water was utilised from below the 48 in. depth of soil and not recorded, the actual figure may more closely approximate 5 bus. of grain for each inch of water used.

Comments have been made on the selection of planting time and the suitability of varieties for grain and hay production. The influence of soil nitrogen supply and frosts upon wheat production in the Callide Valley has been discussed.

I. INTRODUCTION.

The expansion of grain growing in the main agricultural region of Queensland, the Darling Downs, has brought under cultivation most of the suitable land presently available for this purpose. Attention has therefore been directed in recent years to grain production in areas such as the Callide and Dawson Valleys and the marginal agricultural country of the Central Highlands.

In these newer areas of agricultural development, successful farming depends on the full use of the available knowledge of soils, soil moisture control, and soil conservation.

Experiments on crop growing have been conducted at the Regional Experiment Station at Biloela for 29 years. This report deals with the interpretation of the results of investigations related to wheat growing at that centre. In addition to a study of climatological records, the cultural practices, soil moisture relationships, and yields of different varieties of wheat are discussed in terms of the data accumulated at the Station.

II. LOCATION AND DESCRIPTION OF THE AREA.

Biloela is situated 102 miles in a southerly direction from Rockhampton. The Regional Experiment Station is two miles from the town and adjoins the Callide River.

The area is in the 25-30 in. per annum rainfall belt, with a summer precipitation approximately twice as high as that recorded during the winter months. Rainfall is somewhat erratic, with summer storms of high intensity and a dry August to October period when P/E values are unfavourable. Climatic data are shown in Table 1 as means of a 29-year period.

Table 1.

Summary of Climatological Records for 29 Years at Biloela Regional Experiment Station.

—	Jan.	Feb.	Mar.	Apr.	May.	June.
Mean Rainfall (inches)	4·18	4·85	2·78	1·60	1·66	1·71
Mean Evaporation (inches)	9·19	6·93	7·39	6·11	4·71	3·51
Mean P/E Value	·45	·70	·37	·28	·35	·50
Mean Maximum Temperature (°F.) ..	91·6	89·1	87·6	83·0	77·0	71·3
Mean Minimum Temperature (°F.) ..	66·9	66·2	62·7	54·6	47·1	42·8
Number of Frosts	..	..	..	·2	1·7	6·2

—	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Mean Rainfall (inches) ..	1·27	0·61	0·96	2·00	2·88	3·29	27·79
Mean Evaporation (inches)	3·50	4·49	5·91	7·59	8·31	9·42	77·06
Mean P/E Value ..	·36	·13	·16	·26	·34	·35	..
Mean Maximum Temperature (°F.)	70·9	74·7	80·3	85·1	88·8	90·6	82·5
Mean Minimum Temperature (°F.)	40·1	40·6	46·3	54·8	60·5	64·3	53·9
Number of Frosts ..	10·0	7·7	1·4	·1	..	..	27·3

The region consists of alluvial plains approximately 15 miles wide bounded on each side and underlain by a series of Tertiary sediments, mainly clays, shales and sandstones. The basement of Palaeozoic rocks is largely volcanic, with some granite. The alluvial soils are usually fringed with Tertiary sediments on a slightly higher level with a scrub vegetation on grey and grey-brown clay or clay loam soils having a self-mulching surface horizon.

The Experiment Station is located on the alluvial flats, and although sandy loams occur near the stream banks the more extensive areas consist of deep dark-grey to grey-brown clay loams and clays. Soil profiles have resulted from banding in the alluvial flow, the fertility is high, and the structure is normally good. The wilting point of these soils varies from 10 to 17 per cent. in the top 24 in. and from 10 to 14 per cent. at lower depths. The moisture content at the field capacity level is 20-32 per cent. in the first 24 in. and from 18 to 24 per cent. in the deeper layers.

III. ANALYSES OF RAINFALL.

Records from the Experiment Station covering the period 1924-1952 have been examined. Although that period is comparatively short for critical analyses, the general trends are of value.

Mean monthly rainfall records, in groups covering the fallowing, planting and growing periods for wheat, are as follow:—

—	Fallowing Period.					Planting Period.		Growing Period.			
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
Mean rainfall over 29-year period (in.)	3·29	4·18	4·85	2·78	1·60	1·66	1·71	1·27	0·61	0·96	2·00

(1) Fallowing Rains.

The average rainfall during the growing period is inadequate to produce a crop of wheat and it is therefore essential to conserve in the soil the relatively good precipitation of the previous summer months. The average rainfall over the 29 years for the period December to April inclusive totals 16·52 in., but a number of factors significantly influence the amount which may be retained in the soil for later crop use. Many small falls which fail to penetrate below 12 in. are lost by evaporation; the rate of fall and nature of the soil surface may result in poor penetration and retention of moisture from the more common torrential rains of the summer period; and during the summer, weed growth draws considerable amounts of moisture from the soil.

(a) Effective Fallowing Rainfall.

Rainfall for each year has been totalled into effective fallowing falls wherein rain groups yielding more than 2 in. on consecutive days or in rainfall periods separated by up to three days have been tabulated. This grouping would be subject to reduction for runoff water, evapo-transpiration losses, &c. The mean monthly effective fallowing rainfalls are as follows:—

Dec.	Jan.	Feb.	Mar.	Apr.	Total.
2·06	2·74	3·94	1·84	1·10	11·68

Table 2.

PERCENTAGE OF YEARS WHEN MONTHLY FALLOWING RAINS TOTAL SPECIFIC AMOUNTS.

Month.	Mean of 29 Years.	Percentage Chance of Receiving Rain in Specific Amounts.					
		0–2″	2–4″	4–6″	6–8″	8–10″	10–15″
	Inches.						
December	3·29	28	43	25	..	..	4
January	4·18	28	28	14	20	7	3
February	4·85	17	31	17	10	17	7
March	2·78	51	20	15	15	..	..
April	1·60	69	24	4	..	3	..

The reliability of the summer fallowing rains have been examined and the percentage chances of receiving specific amounts of rain in fallowing months are presented in Table 2. A similar calculation has been made with regard to the effective fallowing rains which occurred in rain groups yielding over 2 in., and these data are shown in Table 3.

Table 3.

PERCENTAGE OF YEARS WHEN MONTHLY EFFECTIVE FALLOWING RAINS OCCUR IN SPECIFIC AMOUNTS.

Month.	Mean of 29 years.	Percentage Chance of Effective Rain Groups.				
		2–4″	4–6″	6–8″	8–10″	10–15″
	Inches.					
December	2·06	32	4	4	..	4
January	2·74	14	7	24	..	4
February	3·94	24	7	21	7	7
March	1·84	21	17	4	..	..
April	1·10	10	10	..	..	..

(b) Total Fallowing Rainfall.

The percentage chances of receiving specific amounts of total rain and total effective fallowing rain during the December to April period are shown in Table 4.

Table 4.

PERCENTAGE EXPECTANCY OF TOTAL RAINS AND TOTAL EFFECTIVE FALLOWINGS RAINS IN THE DECEMBER TO APRIL PERIOD.

Amount of Rain Group.	Expectancy of Total Rain.	Expectancy of Total Effective Fallowing Rain.
	%	%
Over 16 in. ..	36	18
12–16 in. ..	46	21
8–12 in. ..	14	29
4–8 in. ..	4	25
Under 4 in. ..	..	7

Effective fallowing rain of more than 12 in. was received in 39 per cent. of years, while more than 8 in. was received in 68 per cent. of years. As shown in Table 3, the greatest amount of rain is received during January and February, while March and April are progressively drier. A distribution of this type is quite suitable for preparing land for wheat. Provided the land is in a

Table 5.

SUMMARY OF WHEAT YIELDS IN RELATION TO EFFECTIVE FALLOWING RAINS AT BILOELA REGIONAL EXPERIMENT STATION DURING A 28-YEAR PERIOD.

Group.	No. of Years.	Yield.	No. of Years.	Planting Rain.	No. of Years.	Growing Rain.	Comments.
Of 28 years where effective fallowing rain exceeded 8″ in Dec.-Apr. period in 19 years	12	Good ; over 25 bus.	11	Over 1½″	4	Over 6″	If over 8″ effective fallowing rain received, a good crop may be grown on planting rain of 1½–2″
					2	4–6″	
					5	2–4″	
			1	1–1½″	1	4–6″	
	3	Fair to good ; 18–25 bus.	2	Over 1½″	1	2–4″	
					1	Less than 2″	
			1	1–1½″	1	Less than 2″	
	2	Fair 12–18 bus.	1	1–1½″	1	2–4″	
			1	Less than 1″	1	Less than 2″	
	2	Nil	2	Nil			
Of 28 years where effective fallowing rain was 4—8″ in Dec.-Apr. period in 8 years	2	Good ; over 25 bus.	2	Over 2″	2	Over 6″	If effective fallowing rainfall is between 4″ and 8″, planting should only be made on over 2″ of rain in May or June.
	3	Fair to good ; 18–25 bus.	3	Over 2″	1	Over 6″	
					1	4–6″	
					1	2–4″	
	1	Fair ; 12–18 bus.	1	Over 2″	1	2–4″	
	1	Poor ; less than 12 bus.	1	1½–2″	1	2–4″	
	1	Nil	1	Nil			
Of 28 years where effective fallowing rain was less than 4″ in 1 year	1	Poor ; less than 12 bus.	1	1–1½″	1	2–4″	Do not plant on less than 4″ of effective fallowing rainfall, irrespective of the amount of planting rain.

14 years good	..	50·0%
6 years fair to good	..	21·5%
3 years fair	..	10·7%
2 years poor	..	7·1%
3 years not planted	..	10·7%

receptive condition for the higher rainfalls of January and February, a large percentage of the effective rain would be conserved, and general cultivation for weed eradication and seedbed preparation could be performed during March and April, when smaller falls of rain are received.

Over 4 in. of effective rain may be received in March in 21 per cent. of years and in April in 10 per cent. of years, and in the same number of years 2–4 in. can be expected. These falls would contribute materially to the moisture stored for later crop use. The records of high rainfall received in March or April generally signify a very late monsoonal influence and relatively dry conditions in the previous months of summer.

(c) Effect of Fallowing Rains on Yield.

In assessing the value of fallowing rains, the records of the Biloela Station have been examined. For most years data on wheat yields are available and for the other years an estimate of production has been made.

Yields have been recorded in four groups, viz.:—

(i.) Good—Over 25 bus. per acre.

(ii.) Fair to good—18–25 bus. per acre.

(iii.) Fair—12–18 bus. per acre.

(iv.) Poor—Under 12 bus. per acre.

Relevant details of rainfall during the planting and growing periods are shown for the respective years, with general conclusions, in Table 5.

(2) Planting Rains for Wheat.

During years when sufficient moisture has been conserved to wet the soil to a depth of 40–48 in., wheat could be sown dry in expectation of germinating rains or could be sown after planting rains are received.

Table 5 shows that planting rains of over 2 in. are required when only 4–8 in. of effective fallowing rain has been received in the summer, whereas a minimum of 1½–2 in. would be necessary if over 8 in. of effective fallowing rain was recorded. A good crop could be produced on 1–1½ in. at planting time if fairly good moisture status was maintained during the growing period.

It will be observed from Table 6 that the chances of planting rains are higher in May and June, but the month of July has been included for comparison even though a planting after the first week of July may result in later crop damage by early storms at the ripening stage.

The percentage chances of receiving certain amounts have also been given for groups of two and three months.

Table 6.

PERCENTAGE OF YEARS WHEN SPECIFIC AMOUNTS OF RAIN (AS A RAIN GROUP) CAN BE EXPECTED.

Amount of Rain Group.	Percentage of Years in Period —					
	May.	June.	July.	May-June.	June-July.	May, June, July.
½ in. or more ..	58·6	76·0	62·0	86·0	86·0	90·0
1 in. or more ..	45·0	58·6	34·5	76·0	76·0	86·0
1½ in. or more ..	38·0	31·0	20·7	58·6	48·3	72·4
2 in. or more ..	31·0	17·2	13·8	41·4	31·0	51·8
3 in. or more ..	10·4	13·8	10·4	20·7	27·6	31·0

The May-June combination is of most importance, and planting then should be possible in three out of four years with assurance of fair to good yields, provided adequate subsoil moisture has been conserved by fallowing over the previous summer.

Observations on the Experiment Station have shown that wheat planting before mid-May is particularly risky, as late frosts in August can cause heavy crop losses. In view of this hazard, the May rainfall has been examined to show the average falls during the first and second halves of the month.

In the first half of May, falls exceeded 3 in. in 6·9 per cent. of years; in 10·3 per cent. of years small falls of ½-1 in. were recorded. It would appear that early May is a period of light isolated showers with occasional heavy falls which may be due to monsoonal influences delayed from the preceding summer. The second half of May is more favoured, with reasonable planting rains (falls over 1½ in.) occurring one year in three. A summary of May rains giving percentage chances of receiving specific amounts is presented in Table 7.

Table 7.

PERCENTAGE CHANCES OF RECEIVING RAIN IN MAY AT BILOELA.

Amount of Rain Recorded.	Percentage Chance in Month.	
	First half of May.	Second half of May.
½ to 1 in. ..	10·3	13·8
1 to 1½ in. ..	..	6·9
1½ to 2 in. ..	..	6·9
2 to 3 in. ..	..	17·3
Over 3 in. ..	6·9	6·9

(3) Rain during the Growing Period.

The period July-September is the driest of the year, the mean annual rainfall for the three months being, respectively, 1·27, 0·61 and 0·96 in. In October, early storms are experienced, and although the amount of rain varies considerably from year to year the mean precipitation is 2·0 in.

The rains in early July are of value in assisting firm establishment of young wheat plants and maintenance of moist topsoil to encourage surface root development. Precipitation in August is of particular importance and even light falls may be utilised if a surface root structure has been developed. However, if crown rooting is not developed, August rains initiate this, so active growth, penetration of the soil and utilisation of future light rains which affect only the top few inches of soil will be possible.

It is considered that the value of light rainfall during the late growing and flowering period has frequently been underestimated in analysing wheat production.

An application of half an inch of water to bare land would penetrate approximately three inches on an average soil of the basin alluvials and therefore could not be conserved, but when falling on a growing wheat crop such a small amount could be effectively used if a surface rooting system had been produced.

The value of rain at flowering time, normally September, is of great significance. In 1951, yields were increased by up to 12½ bus. of grain per acre by a supplementary irrigation of 2 in. of water at flowering. The minimum amount that will cause a response in yield has not been determined, but it is likely that if earlier rain had induced crown rooting, then any rainfall exceeding 0·40 in. would be used to advantage and result in increased yields.

As the occurrence of rains during the growing period is highly important, an examination of the Biloela records has been made.

Rainfall groups have been tabulated into sections yielding 0·20-0·40, 0·40-0·60, 0·60-1·00, 1·00-2·00, and over 2·00 in. for each of the months July to October inclusive; the percentages of years in which specific amounts may be expected are shown in Table 8. Chances for periods of two months and three months are also given.

Table 8.

Percentage of Years when Specific Amounts of Rain (as a Rain Group) can be Expected During the Wheat Growing Season.

Amount of Rain Group.	Percentage Chance in Period.						
	July.	Aug.	Sept.	Oct.	July-Aug.	Aug.-Sept.	July-Aug.-Sept.
0·20–0·40 in. ..	28	34	38	31	41	62	69
0·40–0·60 in. ..	31	24	17	28	48	41	48
0·60–1·00 in. ..	14	24	10	14	31	28	28
1·00–2·00 in. ..	24	14	14	55	31	28	45
> 2·00 in. ..	14	..	10	24	14	10	21

It will be observed that in the period July-August-September more than 0·40 in. may be expected in at least one year in two, and that more than 0·60 in. could be expected in at least one year in three. The incidence of good rain is appreciably higher in July than in August or September, and the occurrence of heavier early summer rainfall in October is obvious.

As well as the number of years, the occurrence of two or more falls each month which would greatly enhance the value of light rainfalls must be considered. An examination of the data showed that in 31 per cent. of years there was more than one rain group in each of the three separate months July, August and September, and in October more than one rain group occurred in 62 per cent. of years.

The percentage of years in which multiple falls have been recorded for separate months and for grouping of months is shown in Table 9.

Table 9.

PERCENTAGE OF YEARS WHEN CERTAIN NUMBER OF RAIN GROUPS WERE RECORDED.

Number of Rain Groups.*	Period.						
	July.	Aug.	Sept.	Oct.	July-Aug.	Aug.-Sept.	July-Aug.-Sept.
1	55	38	38	21	17	28	10
2	21	31	21	45	38	24	31
3	10	..	10	17	24	21	14
4	..	..	..	..	10	14	10
5	..	..	..	..	3·5	3·5	24
6	..	..	..	..	..	..	10

* A rain group is defined as a rainfall period covering consecutive wet days and falls occurring at intervals of less than three days.

From the table it is obvious that reliance upon rains during the growing period is particularly risky. For wheat growing it is essential that sufficient conserved moisture be stored from the previous summer to produce a good crop and it is also necessary that planting rain should be adequate to ensure firm establishment of the young plants and linking of the surface and subsoil moisture to permit root expansion. However, as the percentage chances of receiving at least one fall in the 2-month groupings of July-August and August-September are 93 and 90, respectively, and two falls can be expected in these periods in 76 and 62 per cent. of years, the possibility of establishment and grain-forming rains is not to be disregarded.

IV. SOIL MOISTURE AND RELATIONSHIP TO WHEAT YIELDS.

(1) General Farming and Fallowing Practices.

The programme of operations at Biloela Regional Experiment Station is designed to trap and hold as much moisture as possible in the soil and to provide a suitable environment for nitrate-nitrogen production. It is necessary to avoid over-cultivation, particularly with disc implements, with consequent destruction of soil structure and loss of permeability. Wastage of water must be overcome by limiting runoff and utilisation by weed growth.

If wheat is to follow wheat the stubble is ploughed as soon as soil conditions allow after harvesting, and when wheat is to follow another crop land preparation should commence not later than December. There is a natural sequence in the use of the various implements, aimed at opening the soil in the first instance, retaining a semi-rough condition for as long as possible, and gradually reducing the structure to a fine seedbed for a May or June planting. A typical series of operations is as follows:—

December—Disc plough or sundercut.

January—Harrow to take off roughness.

February—Tandem or offset disc if land is trashy or becomes weedy through prolonged wet weather. Avoid the disc and use the scarifier if this implement can be operated without choking.

March—A scarifier cultivation may be necessary to control weed growth.

April—The combined cultivator drill can be used in preference to the scarifier and after this working the land should be ready for planting.

May-June—Plant wheat after suitable rain with combine with light trailing harrows attached. Rolling to ensure germination is advantageous on certain soil types.

Minor variations are necessary according to seasonal conditions but a total of about six workings of the land can be anticipated.

(2) Data from Experiments.

Wheat varietal trials have been conducted at the Biloela Regional Experiment Station since 1948 and an examination of recorded data on moisture usage and crop yields has been made.

The crop-water relationships for certain years are summarised in the following pages, and tables showing the amounts of water available for crop use at various depths are included.

(a) Year 1948.

Area I.11-14. *Blocks* II, III *and* IV.

Wheat varieties were planted on June 30 on soil wet to a depth of 45-58 in.

Soil samples for moisture determinations were taken on July 1 and at varying intervals during the growing period of the crop. Determinations were made of the amount of available water* in the soil at each sampling at each depth. The water available is shown in Table 10.

Table 10.

UTILISATION OF WATER BY WHEAT CROP, 1948.

Depth of Sample.	6″	12″	18″	24″	30″	36″	48″	Total Water Available.	Effective Rain.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
Total available July 1	·92	·85	1·20	·97	·71	·58	·80	6·03	..
Rain July 3–6	..	..	..	..	..	..	..	..	1·40
Total available July 19	·90	·95	1·20	·97	·87	·53	·80	6·22	..
Aug. 3	·57	·82	1·02	·87	·70	·47	·87	5·34	..
16	·39	·57	·86	·73	·55	·41	·64	4·15	..
30	·22	·45	·53	·37	·30	·25	·75	2·87	..
Sept. 14	·18	·39	·38	·20	·08	·13	·61	1·97	..
30	·05	·32	·40	·16	·0	·0	·39	1·32	..
Nov. 10	·0	·20	·22	·12	·0	·0	·12	·66	..

Water used by crop .. 5·37 in.
Effective rain .. .. 1·40 in.
Total used .. .. 6·77 in.

It will be observed that the rainfall of 1·61 in. in July, of which 1·40 in. was estimated as effective, maintained the crop requirement for 12 days and allowed a small carryover in the 12-in. zone. Moisture loss from the 18-in. level was recorded in early August, and about six weeks after planting water was being drawn off from all depths. The demand on the water resources appears to be high in the 24-30 in. zone 10 weeks after planting, and this would coincide with emergence of the seedheads. The available water at 30 in. and 36 in. was exhausted by late September and the supply at 48 in. was being utilised.

The figures indicate that root penetration in these soils is particularly rapid. There is also a suggestion that roots in the 12-18 in. zone were not particularly active in gathering moisture in the later stages of plant growth in this season.

* Available water in inches has been determined by multiplying depth of soil (inches) by volume weight of soil by available moisture percentage (= measured water percentage — approximate wilting point), divided by 100.

$$\text{Inches of Water Available to Plant} = \frac{\text{Depth x Volume Weight x Available Moisture Percentage}}{100}$$

Wilting Point taken as 12% at 12 in., 13% at 18 in., 14% at 48 in.

Specific Gravity taken as 1·1 at 12 in., 1·2 at 24 in., 1·3 at 48 in.

The mean yield of the 10 varieties of wheat was 35·1 bus. per acre, which shows a relationship to use of water of 1 in. of water to 5·2 bus. of grain.

The use of water is shown diagramatically in Fig. 1.

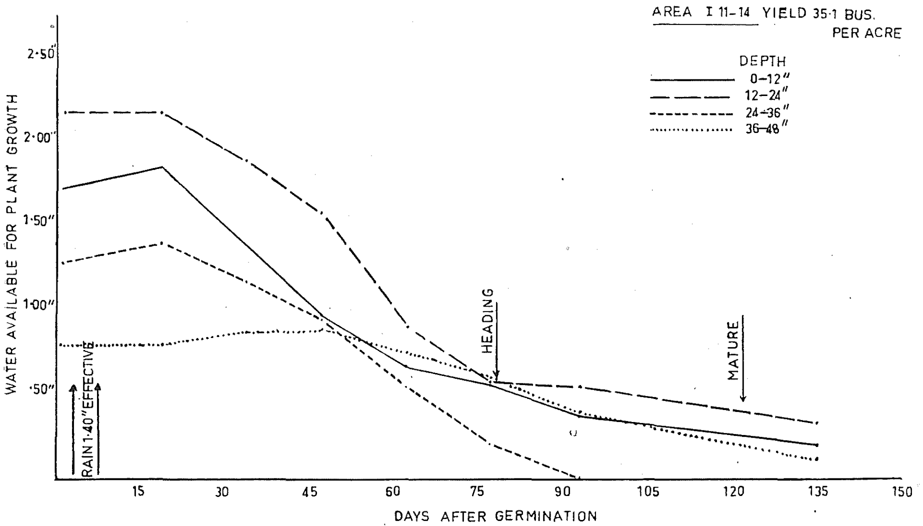

Fig. 1.

Diminution of Available Moisture in Top Four Feet of Soil During Growth of Wheat Crop, 1948.

Area I. 11–14. Block I.

Block I. was sown dry on June 10 and received rainfall totalling 3·48 in. on June 14–15; it has been estimated that 2·00 in. of rain was held in the soil. This crop germinated with approximately 6·72 in. of water stored in the soil and at harvesting time had utilised 6·28 in. plus 1·40 in. of effective rain received in July. The yield of this block was 43·1 bus. per acre, indicating a relationship of 1 in. of water to produce 5·62 bus. of grain.

The early planting evidently favoured this block and a heavy stand of plants was obtained. Results showed that water was being used from the 24 in. and 30 in. zones in eight weeks and that the 36-48 in. zone had been tapped before the crop was 10 weeks old.

(b) Year 1949.

Area J. 11–14.

A wheat varietal trial was sown on June 6 and soil moisture determinations were made during the growing season. The soil was wet to an average depth of 42–48 in. at planting.

The water available for plant growth from planting until early October, when heavy rains were recorded just as the crop was approaching maturity, has been set out for various periods in Table 11.

Table 11.

UTILISATION OF WATER BY WHEAT CROP, 1949.

Depth of Sample.	12″	18″	24″	30″	36″	48″	Total Water Available.	Effective Rain.
	in.	in.	in.	in.	in.	in.	in.	in.
Total available								
June 7 ..	1·64	·89	·77	·62	·66	1·08	5·66	..
July 8	1·58	·95	·78	·68	·72	·97	5·78	..
Rain July 19 ..	..	..	..	..	..	..	..	·60
Aug. 4 ..	·69	·45	·48	·47	·50	1·12	3·71	..
19 ..	·65	·37	·36	·30	·39	·97	3·04	..
Sept. 1 ..	·45	·29	·28	·12	·19	·64	1·97	..
Rain Sept. 11 ..	..	..	..	..	..	..	..	·60
15 ..	·35	·25	·20	·12	·13	·44	1·49	..
Oct. 6	Estimated use in 20 days (all depths) = ·66″					..	·83	..

Water used by crop	4·83 in.
Estimated use of Oct. rain by crop ..	·50 in.
Effective rain July and Sept.	1·20 in.
Total used	6·53 in.

During the first month after planting the use of water was very slight but in the second month the draw-off of water from the top 24 in. was fairly heavy, some two inches of stored water and over half an inch of effective rainfall being used. After two months the crop utilised water from the 30–48 in. zone and September growth was aided by 0·60 in. of effective rain.

Early wheats were approaching maturity by Oct. 6, when a rainy period extending to Oct. 16 yielded 3·81 in. This rain would have been of little value to the crop, and caused some germination in the heads of early-maturing varieties.

The results indicate that successful wheat yields can be obtained if adequate subsoil moisture is available for the crop after a planting rain, even if only light showers are recorded during the growing period. The yield of grain in 1949 from the crop of Puno where the moisture determinations were made was 37·5 bus. per acre, which indicates a ratio of yield to water use of 1 in. of water to 5·74 bus. of grain.

The periods of growth to full heading and maturity were very similar to those recorded in 1948.

The diminution of the available water supply is shown diagramatically in Fig. 2.

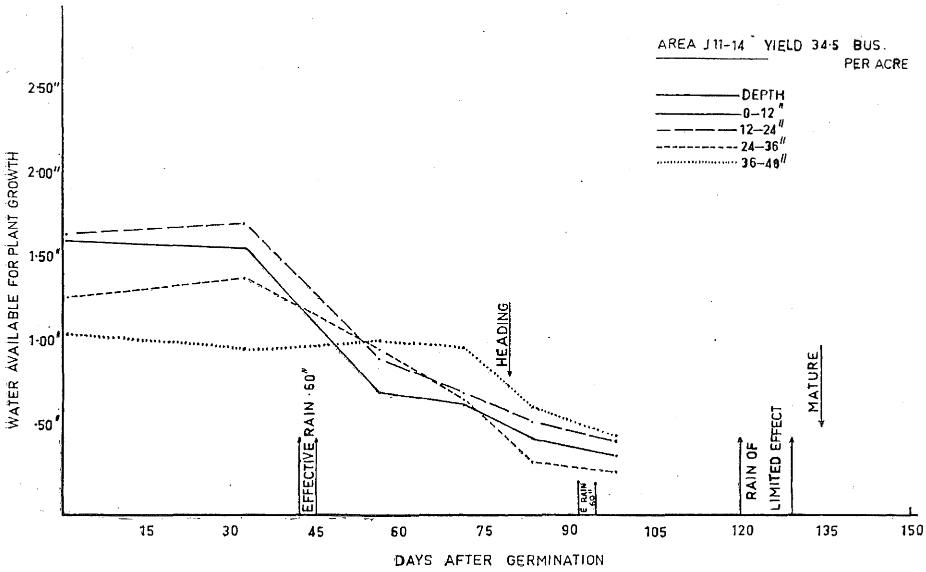

Fig. 2.

Diminution of Available Moisture in Top Four Feet of Soil During Growth of Wheat Crop, 1949.

(c) Year 1950.

Area I. 5–10.

In 1950 insufficient soil moisture determinations were made to allow a calculation of the type presented for previous years. It was an exceptionally wet season, heavy rains in January, February and March being followed by good falls during April, May and June. Stored water was available to a depth of 40 in. at planting on June 2. Over 2 in. of rain had been received during the third week in May and a further 1 in. was registered six days after planting. Light showers totalling 1 in. were received later in June and 2·82 in. spread over 16 days was received in July.

Early growth of the wheat was rapid and inclined to be lush under the high moisture conditions, and tall sappy plants were produced. The August rainfall, with two groups yielding 0·48 and 0·81 in. respectively, was inadequate to maintain the tall crop and by Sept. 5 most of the available moisture in the top 30 in. of soil had been utilised.

It is reasonable to assume that under the conditions of early growth, root concentration was confined to fairly shallow depths while ample moisture was present and that the crop grown under luxury conditions was unsuited to the drier conditions that existed during late August and September. Most varieties came into head at the end of August and the demand for water for head formation while maintaining very tall leafy plants could not be met.

The check in supply of readily available moisture during September appears to have been most significant in reducing the potential grain yield. The nitrate status may have also restricted yield, as leaching of nitrate-nitrogen undoubtedly occurred during the wet period of the summer.

Excessively wet conditions immediately after planting produced leafy succulent plants which evidently utilised a considerably greater amount of moisture and failed to develop a deep active root system. When a period of slight moisture stress occurred in September, coincidental with formation of grain, the physiological resources of the plants were not capable of active production of grain while maintaining the great bulk of other plant material. (In 1950 the mean height of the wheat was 50·7 in., or 19·2 in. higher than the 1949 crop).

Satisfactory yields averaging 36·4 bus. per acre were obtained, but it has been estimated that 10·30 in. of water was utilised, which gives a ratio of 1 in. of water to 3·43 bus. of grain.

The crop was ready for harvesting after mid-October but harvesting was delayed until three weeks later, when many of the varieties had lodged. The loss of grain was reported to vary from 2 bus. to 4 bus. per acre; hence a total yield of 39 bus. per acre may be assumed. The allowance for lost grain would raise the ratio of water use to crop yield to approximately 1 in. of water to 4 bus. of wheat. This rate of efficiency is considerably lower than in previous years and indicates that continuance of flush conditions until maturity would have been necessary to obtain yields proportionate to the quantity of water used.

Under the favourable conditions of early growth the varieties took approximately 10 days longer to come into full head and to reach maturity than in the 1948 and 1949 seasons.

(d) Year 1951.

Area J. 11–14.

This area was prepared for wheat following Poona pea in 1950-51, and soil moisture was present from the January and February rains. Planting rains were not received during May and June. Wheat was dry sown on June 29, and a 2 in. irrigation applied by sprays from July 3 to July 6, but due to very windy conditions an uneven watering was obtained. A further 2 in. of water was applied from July 11 to July 13, which connected up with stored moisture and assured a wet soil to a depth of more than 48 in.

Good germination was reported and the crop grew uniformly during August.

Soil moisture samples taken 13 days after irrigation indicated a high moisture status to 48 in. When the crop germinated, approximately 6·28 in. of water was available in the top 48 in. The rate of utilisation may be followed in Table 12.

Table 12.

UTILISATION OF WATER BY WHEAT CROP, 1951.

Depth of Sample.	6″	12″	18″	24″	30″	36″	48″	Total Water Available.	Effective Rain.
	in.	in.	in.	in.	in.	in.	in.	in.	in.
Water available at germination July 13	..	..	..	..	..	..	..	6·28	..
Available July 26 ..	·81	·72	·82	·75	·63	·65	1·40	5·78	..
Rain Aug. 21	..	..	..	..	..	..	..	..	·60
Available Aug. 24 ..	·51	·59	·60	·59	·62	·84	1·40	5·15	..
Sept. 14	·72		·38	·35	·34	·44	1·17	3·40	..
Rain Sept. 25 ..	..	..	..	..	..	..	..	..	·41
Available Oct. 2 ..	·36		·24	·19	·15	·20	·64	1·78	..
Oct. 26	·07	·20	·26	·17	·16	·22	·58	1·66	..

Water used by crop .. 4·62 in.
Effective rain .. .. 1·01 in.
Total used .. .. .. 5·63 in.

Soil moisture was not being utilised from the 30 in. zone by Aug. 24, about five weeks after germination. However, ample water had been available in the upper levels and considerable use had been made of the water stored to slightly below 24 in. By mid-September the moisture in the upper 24 in. had been almost depleted and the crop was drawing heavily on the 30–48 in. zone. The growing period was particularly dry and only two small falls of 0·60 and 0·41 in. of effective rain were recorded. These showers would have influenced the moisture status of the top 6in. of soil and crown root activity was observed after the first fall. These roots would have utilised the light September fall of 0·41 in.

The moisture studies were made on plots sown to Pusa 4 variety, which came into full head 75-78 days after germination, which is somewhat quicker than usual in this district. (The July planting has indicated that wheat sown late can utilise water with slightly greater efficiency, and that heading and maturity may occur earlier than if sown in May or June.) The quick-maturing varieties appear to utilise water more effectively than long-term varieties, especially in seasons of somewhat limited supply.

The yield of grain from Pusa 4 was 31·7 bus. per acre, which when compared with water used by the crop showed a ratio of 1 in. of water to 5.62 bus. of grain. It is highly probable that during the 1951 season water was used from below the sampling depth of 48 in., and if 1 in. of water was obtained the crop produced 4·8 bus. for each inch of water.

The use of soil moisture during the growing period is illustrated in Fig. 3.

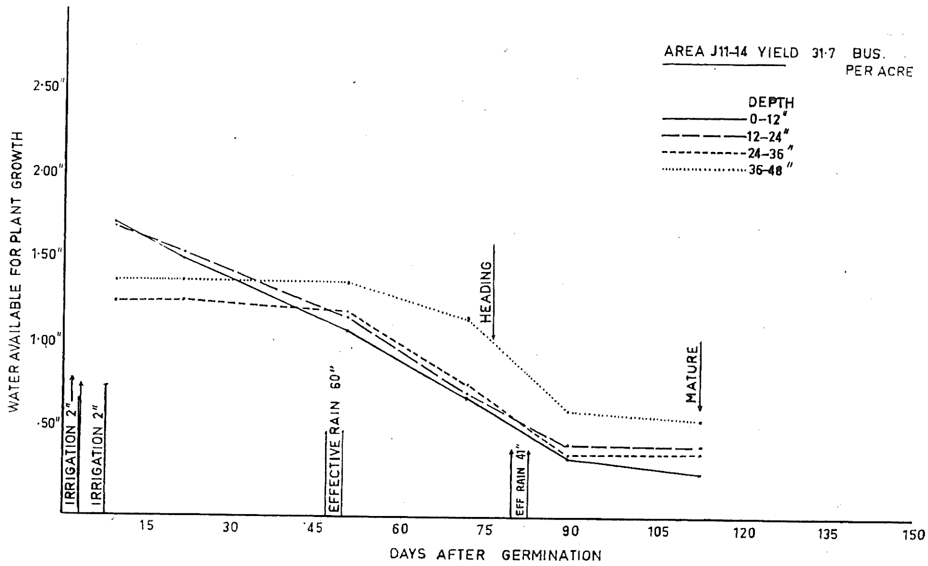

Fig. 3.

Diminution of Available Moisture in Top Four Feet of Soil During Growth of Wheat Crop, 1951.

(3) Application of Water at Flowering Time.

It was shown that in 1950 the flush growth of wheat under high moisture conditions utilised such large volumes of water in maintenance of vegetative material that the supply was exhausted before the crop reached maturity. To check on the significance of rainfall or irrigation at flowering time, a 2 in. irrigation was given on Sept. 25-26 to all plots in Blocks II and IV of the 1951 trial. This was approximately five days after Pusa 4 came into full head and the final increases in yields were not as high as those recorded for varieties which were just coming into full head when the water was applied. It may be that a similar application of water applied a week earlier on Pusa 4 would have promoted even higher yields than those recorded.

The plots that had been watered on Sept. 25-26 were sampled on Oct. 2. At this sampling the irrigated blocks contained 1·01 in. more available water in the top 48 in. of soil than the unwatered blocks, and this moisture was rapidly used by the crop. The figures show that little change in the moisture status of the lower depths occurred for some 2-3 weeks after the irrigation, indicating that the crop used the irrigation water which would have been retained in the top 12 in. of soil.

In this experiment, Pusa 4 which received the 2 in. irrigation yielded 5·4 bus. per acre more than the same variety in unwatered blocks. Varieties which were just coming into full head when the irrigation was given outyielded the unwatered blocks by up to 12·5 bus. per acre. It was reported that the irrigation applied at flowering time delayed maturity for 4-8 days, depending upon variety. The changes in soil moisture during the growing season are illustrated in Fig. 4.

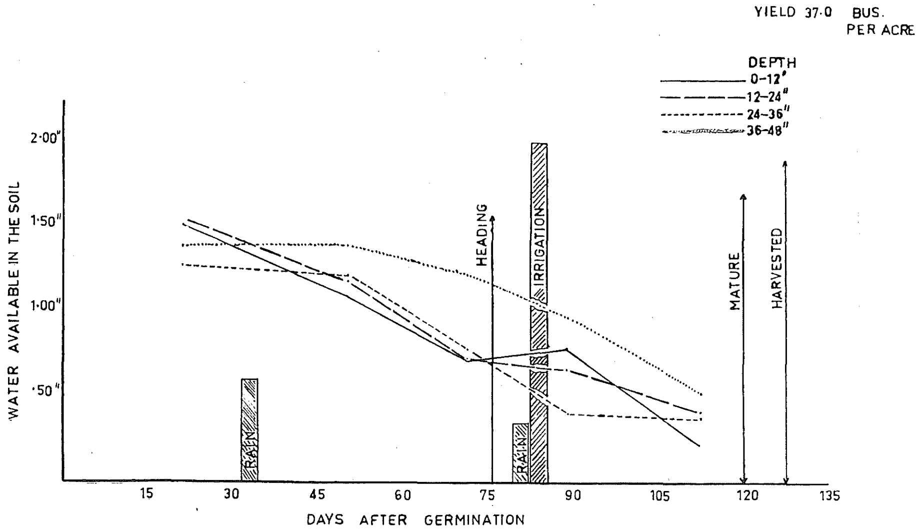

Fig. 4.

Use of Water by Wheat from Various Depths in 1951. The graph shows also the effect of a 2 in. irrigation applied at flowering.

The yield increases due to irrigation at flowering time were significant and a detailed study of grain and spikelet formation of certain varieties was undertaken. This study showed that the number of spikelets per head had not increased but that the number of grains per head and per spikelet accounted for most of the increased yield. The presence of a greater number of spikelets with three grains accounted for most of the increase in grains per head, and the grain from irrigated plots was slightly heavier than grain from the same varieties in blocks which did not receive additional water at flowering time.

(4) Comments on Moisture Utilisation.

In Fig. 5 the use of water from the soil by wheat is shown for each season. The rates of diminution of available moisture are very similar once the initial establishment of the plants is complete. In seasons where a large amount of moisture was present in the surface soil at germination and the soil had a high nitrogen status, the growth of plants was particularly rapid. It is possible that in some seasons a crop which commenced under such conditions would exhaust the available supply of water before reaching maturity.

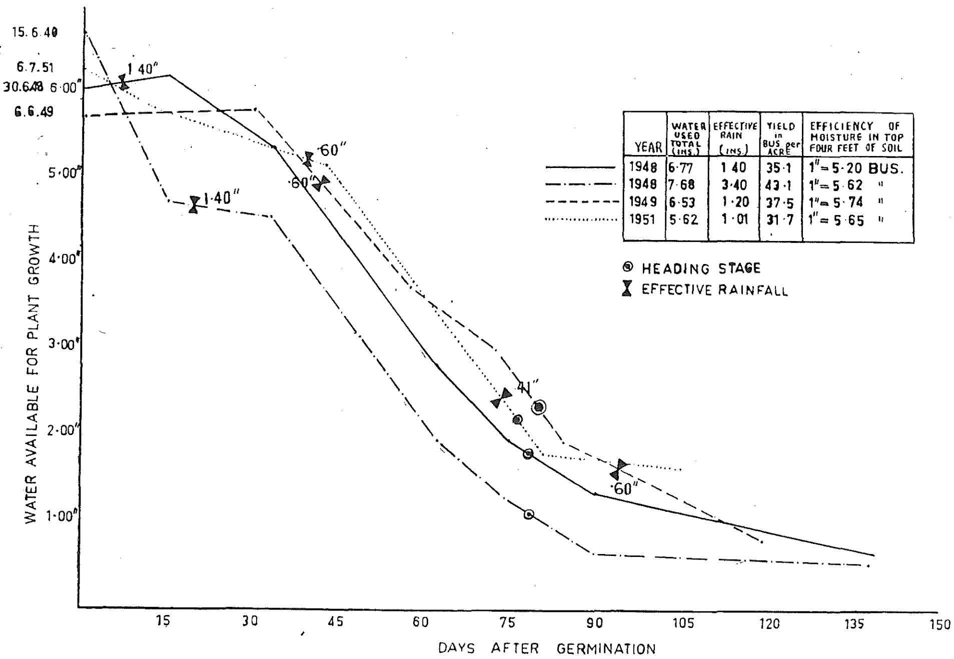

Fig. 5.

Diminution of Available Moisture in Top Four Feet of Soil During Growth of Wheat Crops in Four Seasons.

The diagram indicates that between 1·1 and 2·3 in. of available water was still present at flowering time on the occasions studied and it is considered that this finding provides the clue to successful wheat cropping in regions of deficient winter rainfall. It has been shown in the diagram relating to each separate season that at flowering time the bulk of the remaining available moisture was supplied from within the 36-48 in. soil zone. As only the heavy summer rainfall can penetrate to this depth, the conservation of this moisture by providing receptive conditions and preventing weed growth during fallow is absolutely essential.

The study of water use by wheat is being continued at Biloela Regional Experiment Station and some aspects will be studied in greater detail. In the summary of findings to date, allowance has not been made for evaporation of moisture from the soil while the crop is growing, and consequently the relationship of temperature, humidity and wind to water use and plant transpiration has not been established. The study of water use and crop yields indicates striking efficiency in production of grain when compared with results reported from other countries (e.g., Cole 1938, Mathews and Brown 1938, Thysell 1938). However, the work at Biloela has only recorded changes in moisture status to a depth of 48 in., and from the data obtained it seems obvious that in the later stages of plant development the root system of wheat in order to obtain all available moisture may penetrate below 48 in.

It is also clear that wheat will utilise water from lower depths when no moisture is present in the surface layers, and in some years an extensive surface rooting system on mature plants may not be present. Hence, in the late growing period one light fall may stimulate a crown rooting system, which could then make use of subsequent rainfall which may only be sufficient to wet the top few inches of soil.

In future, soil moisture observations will be made to lower depths in an endeavour to ascertain with even greater accuracy the ratio of water use to actual grain production. If the use of water below 48 in. totalled 1 in. in the 1948, 1949 and 1951 seasons, the ratio of yield to water use would approximate 5 bus. of grain to 1 in. of water under experimental conditions at Biloela.

As the precipitation during the growing period for wheat at Biloela is frequently inadequate to produce a crop, reliance must be placed on the efficiency of fallowing techniques to conserve up to six inches of available water in the soil before planting. A planting rain of between one and two inches will then assure a grain crop. To obtain a sufficient reserve of moisture the soil surface must be in a receptive condition for rain during the wet summer months. Furthermore, the surface must be maintained in a friable weed-free condition.

The condition of the surface soil and its ability to take in rainfall will be largely influenced by the cropping and farming methods employed. It is considered that in the majority of cases a wheat crop will utilise the current season's rainfall in addition to almost all the available moisture that can be conserved in four or five feet of soil. Only after a succession of years of exceptionally good rainfall or on areas farmed with a high degree of skill will it be possible to conserve more subsoil moisture than can be exhausted by one wheat crop.

Rotational cropping would allow some variation in the utilisation of water from different depths, and similarly the alternation of summer and winter cropping would be advantageous.

V. OTHER FACTORS AFFECTING CROP PRODUCTION.

(1) Soil Nitrogen.

An aspect of crop production which has not been discussed and which is closely related to soil moisture supply is the availability and utilisation of nitrate nitrogen in the soil.

The amount of nitrogen available to growing crops has been studied during many seasons, and the results have indicated considerable variations from year to year. The effects of seasonal conditions and the influences of tillage operations and previous crop history are of paramount importance. It has been shown (Wells 1937) that in the Callide Valley the build-up of nitrate nitrogen under a cotton crop on old cultivations is particularly rapid, and that this is undesirable for the production of good cotton yields and economic water usage by the plant.

For wheat production, however, an ample supply of available nitrogen is desirable and to obtain the best grain for flour manufacture a high nitrogen supply is essential.

The land on which the crop was sown in 1948 had grown wheat in 1946 and was not planted again until October 1947, when cowpea was sown as a short-term green manure. This crop was ploughed in and the land prepared for wheat.

The nitrate levels in the soil to a depth of 36 in. were good and in the absence of heavy leaching rains and prolific plant growth remained at a favourable level throughout the early growing period. The results of nitrate determinations are shown in Table 13.

Table 13.

NITRATE DETERMINATIONS.

Date of Sampling.	Nitrate N (ppm). Depth of Sample. 6″	12″	24″	36″
1–7–48	8·4	4·5	2·2	2·2
19–7–48	7·6	6·2	3·0	2·5
3–8–48	7·0	4·2	2·4	2·3
16–8–48	6·6	2·9	2·1	2·4
30–8–48	4·4	2·3	0·5	1·1
14–9–48	3·3	0·5	0·5	0·5
30–9–48	3·9	0·5	0·5	0·5

The 1948 wheat crop was sown on June 30 and a good germination resulted. There was an initial drop in nitrate nitrogen and slight leaching following 1·40 in. of rain before a more gradual utilisation of nitrate from the upper soil. As this was a very dry growing period, the absence of surface roots may have resulted in less nitrate being used than normally. As active growth occurred, the use of nitrate from the 12 in. level was very marked by the end of four weeks, and the supply had been almost exhausted from the 24 in. and 36 in. zones at the end of eight weeks. No indications of nitrogen deficiency were observed, but only very limited amounts of soil nitrate were present after the flowering period. It was considered possible that nitrate production occurred during the later stages of plant growth.

In 1949 the wheat crop was sown on land which had grown two crops of sorghum after four years of Rhodes grass. The nitrate content of the surface 12 in. was satisfactory. However, in some crops in the district nitrogen deficiency was observed in June and July. It was considered that flood rains during March had leached out the nitrate-nitrogen to some degree and that a heavy weed growth also diminished the available supply before ploughing could commence. Symptoms of deficiency were more obvious in those areas where only a short period elapsed between ploughing and planting of the wheat crop. The 1949 crop produced 37·5 bus. of grain per acre when effective rain during the growing period totalled approximately 1·20 in. Conserved moisture was adequate to mature the crop and nitrate reserves were also satisfactory. Nitrate determinations were made on soil samples from 6 in. and 12 in. depths during the growing period, and although some nitrate was available in the top 12 in. of soil at flowering time, the crop would have exhausted the supply at the lower depths. In the absence of surface moisture and crown rooting the plants were unable to utilise all of the available nitrogen from the top 12 in. of soil.

This point was supported by observations in 1951, when the nitrate content of the upper soil was compared in plots irrigated at flowering time and in plots which did not receive additional water. Samples taken from the irrigated plots indicated 1·6 ppm of nitrate, while the dry plots contained 6·1 ppm in the top 6 in. soil layer. The application of 2 in. of irrigation water at flowering time stimulated root activity and subsequent utilisation of water and nitrate, and increased the yield of grain by 6-12 bus. per acre for different varieties. The nitrate in the unwatered plots was not being utilised by the crop owing to absence of a surface rooting system.

(2) Frosts.

Frost damage which prevents head formation or results in damaged heads and pinched grain is of importance in the Callide Valley wheat areas. Severe frosts in the early stages of growth, which would cause tipping, are not common. Climatic records have been kept at Biloela Regional Experiment Station since 1926 and a study of the incidence of frost has allowed evaluation of planting dates so that the wheat crop will not be in the critical flowering stages during the periods when frosts are of frequent occurrence.

The mean number of frosts (30·4°F. or lower) per month for the last 25 years is as follows:—

Month.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Total for year.
Days per month	0·2	1·7	6·2	10·0	7·1	1·4	0·1	27·3

It will be observed that the occurrence of frost is most frequent in July and August; the latter month is of considerable importance in wheat grain production. A severe frost when heads are being exserted and when flowering has started will cause damage to pollen or small grain. Abortion will also occur to some extent. With a more advanced crop the grain may be checked in formation and a yield of inferior quality will result.

Very low temperatures are recorded in late July and early August and crops sown in May are particularly susceptible at this time.

To overcome the risk of frost damage, planting should be so arranged or varieties so selected that flowering does not occur at the critical period. In practice, using fairly early maturing wheat, plantings during the second week in June have been most successful. In 1930, wheat sown on May 26 was severely damaged by frosts on Aug. 11 and 15, resulting in many sterile heads, and since then it has become a fairly general practice to plant early-maturing varieties for grain production no earlier than the first week of June. With hay wheat these precautions are not necessary.

(3) Varieties for Grain and Hay Production.

During the past 25 years wheat varieties have been grown at Biloela Regional Experiment Station for observation on yield, time of maturity, resistance to drought, and diseases. A certain amount of breeding and selection of strains has been undertaken from time to time.

In the earlier years greater attention was given to hay or dual-purpose types, such as Florence, Warchief and Warren. The low net return for grain wheat did not attract attention nor allow scope for long-term fallowing, and in most years following late summer ploughing there was only sufficient moisture available to permit a hay crop of approximately 100 days' duration to be grown. If sufficient rain was received during the growing period the crop could be stripped for grain, and in favourable years yields ranging from 22 bus. to 30 bus. per acre were recorded.

Effective fallowing and control of weeds after summer rains were somewhat limited in these years by shortage of suitable agricultural machinery. The present equipment permits more efficient and rapid methods and the overall cost of land preparation is proportionately reduced.

By 1930 over a hundred varieties and strains were under observation and it was usual to classify wheats maturing in 132 to 136 days as early types. The plant breeder has been able to reduce this period to 120 days in some present-day varieties without a grave reduction in yield of grain.

In the mid-thirties Florence was still popular, with Warchief, Warren and Clarendon also being widely used for hay. Clarendon and Florence were also satisfactory for grain, and varieties such as Seafoam, Cedric, Flora, Pusa, Seaspray and Three Seas were being sown in increasing amounts. By 1940 Warput was a popular hay type for the Callide Valley, and work was done with many grain varieties in studying resistance to rust. In recent years the varieties under observation for yield and growth studies have been Charter, Seafoam, Gabo, Pusa 4, Puora, Flora, Fedweb 5, Warput, Puglu, a longer term variety Kendee, and many selected strains supplied by wheat breeders.

VI. TIME OF SOWING AND SELECTION OF VARIETIES.

(1) Grain Crops.

The planting rains should be adequate to link up with the underlying wet soil. It has been shown that planting rains exceeding 1·5 in. are more reliable in the late May and June periods (see Tables 8 and 10) and for any degree of success the available moisture must be equivalent to 5 in. of water, as indicated by wet soil present to a depth of at least 40 in. To assure high yields, wet soil should be present from near surface level to slightly over 48 in. in an average Callide Valley alluvial soil.

Observations have shown that early planting, even though limited by planting rains, is unsatisfactory in relation to water use by the crop. When mid-season or early-maturing varieties are planted very early in March or April in order to obtain use of the June rains during the growing period, they do not gain any advantage, owing to the longer growth period imposed upon the crop by early planting. Mid-season varieties sown in April require 160 days to reach maturity, while the same varieties sown in early June reach maturity in 140 days.

The longer life span is not desirable as it necessitates the availability of water over a longer period and the moisture factor is so critical at the termination of the growing period that utilisation over an additional 10-20 days may result in a significant reduction in crop prospects. In addition to this, earlier planting increases the risk of frost damage by bringing the flowering stage into July or early August, when frost incidence is at a maximum.

Thus to encourage earliness of maturity and consequent efficient use of the limited available moisture, the later plantings which also coincide with better prospects of planting rains are generally recommended.

It has also been shown that very late plantings are to be avoided, as establishment rains in the late July-August period are most unreliable. The crop should be matured and harvested before the onset of storms in November; hence a late May or early June planting is desirable to avoid this risk.

When all factors are considered it becomes clear that a fairly early maturing variety sown in the mid-planting season appears most desirable. Varieties with this essential characteristic are under test for yield and resistance to disease at the Biloela Station.

It should be noted that in years of highly favourable conditions the long-term varieties may outyield the short-season types, but the degree of risk involved in the Callide Valley is high and crop failures would be common.

In most years some moisture stress is evident between the flowering and maturity stages and it is during this critical period that rain can be of considerable value in the production of a good grain crop. It is believed that the stimulation of crown rooting and subsequent utilisation of even small rainfalls which moisten the top few inches of soil are essential requirements for very high yields. Normally some forcing of maturity is noted as available soil moisture is exhausted, and only the short-season varieties can reach full heading before moisture deficiency becomes obvious. Sufficient water can be stored in these soils to produce a good grain crop—say 30 bus. per acre—but in years where only limited conservation has been possible further rain at flowering time is essential to obtain such yields.

From 1948, 20 selected varieties have been tested for Callide Valley conditions and six of these have been grown in seven consecutive years. Comparable yield data are shown in Table 14. The yield figures do not indicate significant differences by statistical analyses but a definite trend is shown in favour of Gabo and Pusa 4 over the 7-year period.

Table 14.

YIELD OF SIX LEADING WHEAT VARIETIES, BILOELA REGIONAL EXPERIMENT STATION, 1948–1954.

Year.	Germination.	Gabo.	Pusa 4.	Puno.	Charter.	Puora.	Seafoam.
		bus./ac.	bus./ac.	bus./ac.	bus./ac.	bus./ac.	bus./ac.
1948	30–6–48	37·4	38·8	42·1	39·7	38·1	34·2
1949	6–6–49	39·7	34·3	37·5	31·9	33·0	33·4
1950	2–6–50	40·0	41·2	34·2	35·1	34·8	31·8
1951	6–7–51	30·3	31·7	27·5	29·8	28·9	26·5
1952	3–6–52	36·6	25·1	24·9	26·5	26·2	32·4
1953*	2–9–53	23·1	18·8	24·3	24·4	16·6	15·8
1954	9–6–54	36·2	40·5	38·3	39·6	40·6	42·3
Mean of 7 years		34·8	32·9	32·7	32·4	31·2	30·9

* Extremely dry winter and very late plantings.

Kendee has given good yields when sown early under favourable conditions and with sufficient moisture to maintain the crop over a longer growth period, and the early variety Spica has given very favourable results over the last three years. Saga and Festival have also been grown, the former yielding over 40 bus. per acre in 1954.

In assessing the potential value of varieties, factors such as resistance to rust and other diseases, straw strength and the quality of grain must be evaluated. Spica lodged badly in 1952 and Festival lodged more than any other variety in 1954. Pusa 4, Puora and Puno are susceptible to rust. Gabo is rather deceptive and often exceeds a visual estimate of yield. The grain of KGPF 4521, a high-yielding variety, was unsuitable for milling. A number of selections and strains are giving favourable results and work in collaboration with the wheat breeders will continue.

(2) Hay Crops.

The availability of green fodder for grazing in the winter months is most desirable in the dairying districts and hay may be conserved for general or drought feeding. Quite different circumstances are required to produce a crop primarily suitable for haymaking, although in practice many crops grown for grain are utilised for hay or grazing when it is obvious that the grain yield will be very poor.

Hay crops may be harvested 90-110 days after germination and the time factor as related to water use is less critical than for grain production. As the grain has not to be matured, long-season or mid-season varieties can be grown to produce satisfactory bulk. Very early plantings in March or April are not recommended, since observations in the Callide Valley have shown that planting and establishment rains are not favourable and high water usage in the April-May period may result in crop failure through moisture deficiency. In some years high yields of hay were obtained by early planting, but in these cases heavy rains were recorded in April or May. (One year Florence was sown on Mar. 1 and due to good rains in April a hay cut of $2\frac{1}{2}$ tons per acre was obtained on May 22, 83 days afterwards).

For grain production it is a disadvantage to produce lush vegetative growth in the early stages, as the maintenance of such a stand through to maturity demands far more water than can be stored in the soil, and rains must be received to produce a crop. However, such years are favourable for hay production and with mid-season or long-term varieties there is a good chance of carrying a crop which commenced under luxury conditions for 90-100 days on stored moisture to obtain a satisfactory harvest. Short-season varieties, though more economical in regard to water use, normally fail to produce the bulk of green material on good stout stems so necessary for hay production. It is true that plantings for hay should be made somewhat earlier than when grain varieties are used and that longer term varieties should be sown. If early growth is good or the crop shows signs of going to head too early, a light grazing may be beneficial, but in the Callide Valley in most seasons the nitrogen level may be inadequate to produce a heavy crop after the first flush has been grazed off.

The long-season varieties may be sown from early May and the mid-season types from the middle to the end of May. To avoid risk of frost damage in late July and August, if the crop is carried through for grain, dual-purpose crops should not be planted before the end of May.

Testing of present varieties of hay or grazing wheats has been rather limited at the Biloela Station. However, the most suitable available varieties are Lawrence and Celebration, and a selection from Currawa (CHFCur) is showing very promising results.

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