# RELATIVE IRRIGATION REQUIREMENTS OF SUGAR CANE.

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## Introduction.

The Specific problems connected with the canal irrigation system in the province are, firstly, to determine the minimum water requirements of the crop with the object of obtaining an optimum yield for a given supply of water, secondly, to work out the irrigation requirements of the crop at various stages of growth, thirdly, to study the effect of liberal and restricted irrigation applications on the accumulation of sugar and maturity of the crop, and finally, the selection of varieties possessing high relative efficiency of irrigation requirements of the crop. In laying out the programme of irrigation requirements of the crop these specific problems were kept in view. The experiments were, therefore, mostly conducted under field conditions in order that the conclusions derived may be applicable to the irrigated conditions prevailing in this province.

## Historical.

Leather (1911) was pioneer in estimating the water requirements of the sugar cane crop. He studied the water requirements of tropical variety, Ashy Mauritious, in pot culture and studied (1) the rate of water loss during different periods of the growth cycle of the cane crop, and (2) effects of various manurial treatments on its relative water requirements. He observed that the plant required maximum quantity of water when it had begun to grow rapidly and the conditions of drought prevailed. With the increase in humidity there was a fall in the rate of transpiration. He also noticed that application of manure reduced the water requirements per unit of dry matter produced. Further, some work of importance on the subject had been conducted at Shahjehanpur in the United Provinces and at Manjari and Hadaspur in Bombay Presidency which provided the basis for systematic investigations on irrigation requirements of the crop at Shahjehanpur and Padegaon. At Shahjehanpur the later investigations conducted relate to the inter-relationship of nitrogenous manuring, water duty and date of planting on the growth and yield of sugar cane. It is indicated that optimum return was obtained with considerably low water duty when 100 lbs. dose of nitrogen was applied. With low nitrogen dose optimum yield was realised with medium watering. 80,000 gallons per watering (medium watering) proved superior to low (60,000 gallons) or high (100,000 gallons) watering per acre. High watering per irrigation induced early maturity of the cane. In the Deccan canal tract, i.e. at Padegaon, the attempt has been to study the problem of 'judicious utilisation of water' both in pot culture and field conditions with four levels of water duty, viz., 70, 95, 120 and 130 inches and with one level of nitrogen application, namely, 150 lbs. Records of soil moisture lost through seepage were also maintained. For the investigations two varieties were put under test. Besides, the critical periods of water supply for the crop were also determined (Rege, 1937). With 150 lbs. nitrogen application the optimum requirements worked out to 95 inches. Application of 70 inches fell short of the normal requirements and 130 inches decreased physiological activity of the plant at later stages of its growth which resulted in significant decrease in the crop yield. Further, the interaction between nitrogen application and water duty has been noted to be significant indicating the value of higher manuring with higher irrigation. P O J 2878 utilised water more effectively than *Pundia*. Water requirements were observed

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to be the highest during the grand growth period and flowering stages, and lowest during the maturity stage. Singh and Colleagues (1936) estimated in pot culture the relative water requirements of the various varieties of the crop, and thus compared relative efficiency of water requirements with other crops, namely, wheat, cotton, potato, rice, mustard, barley, peas, oats, tobacco and linseed; correlated the water requirements with the dry matter produced; studied the influence of the length of the life-cycle on water requirements; determined the critical periods in the life-cycle of the crop, and worked out the absolute amount of irrigation required by sugar cane for the full maturity of the crop. Their results are that the minimum requirements of sugar cane at Benares are 45 inches; that the varieties of sugar cane differ more widely in their relative water requirements than cotton; and that the efficiency of water requirements is directly proportional to the yield of the different varieties tested in the pot culture.

Very comprehensive work has been done on the irrigation requirements of the sugar cane crop in Hawaii. Shaw and Sweezy (1937) have summed up the results of eight years' irrigation investigations carried out under field conditions. In the first part of the report the subjects discussed are: (1) relation of plant to soil moisture, (2) single value soil constants, (3) movement of soil moisture, and (4) surface forces of soil. In the second part of the report the results discussed are: (1) relation of cane growth to maximum field capacity and wilting coefficient, (2) suggested use of soil moisture in determining proper irrigation control, (3) crop estimation with particular reference to loss in cane yield from delayed irrigation, and (4) value of rainfall as irrigation for the crop. Preceding these investigations a large amount of pot culture work had been done and formed the basis of the above reported investigations. In Hawaii pot culture work indicated that moisture equivalent was the only one constant which showed the most satisfactory relationship to the wilting coefficient of the soil. Pot studies though had local application were greatly influenced by weather and general growing conditions such as the effect of root binding, water distribution, excessive evaporation and transpiration, etc., etc. As the water dries out from the soil a critical moisture content is reached when water is withheld by the soil with increasing tenacity and for each further increment of water loss the force tending to bind the water to and around the soil granules increases tremendously until water completely becomes unavailable. The point at which water became increasingly unavailable for active plant growth was termed as wilting percentage. The water above this limit up to the maximum field capacity was all available for active growth. This range of available moisture was a function of the soil type and could be employed for determining proper irrigation interval. The effect of delayed irrigation on potential cane loss, particularly during grand growth period, was worked out by plotting curves of accumulated possible and actual growth of the cane plant.

These in brief are the lines of investigations followed in systematising irrigation of the cane crop. Following these investigations we have attempted to work out the relative irrigation requirements of the cane crop under the conditions obtained in the North-West Frontier Province.

## Environment and Habitat.

The climate of the sugar cane tract in the North-West Frontier Province is characterised by extremes. The summer maximum temperatures occasionally touch 120°F and in winter frosts of 4 degrees are very common. The mean precipitation for the tract amounts to 14·5 inches, half of which is received during the summer period and the other half during the winter months. The environment becomes suitable for good germination in March when planting is usually done. The plants are able to complete their effective tillering by about the end of May when the growth passes on to the grand period stage. This lasts till about the fourth week of September. This period is characterised by sunny days which accelerate growth. Ripening stage follows it and in this stage, almost always, from the first week of December to the second week of February, the frosty period intervenes which hampers cane maturity and occasionally depresses juice quality.

Soil type of the tract is generally light loam with a fairly deep water table (20 to 25 ft.). Water seeps in the soil quickly. In perfect moist condition the soil can be worked with ease. Few soils in the tract cake and fissure, and such soils can be corrected by addition of heavy doses of organic matter. The soils are generally deficient in nitrogen only. Little response to the application of potassic or phosphatic fertilizers has been indicated. Given the proper quantity of nitrogen and organic matter the crops grow normally.

## Experimental Procedure.

The procedure of working out the relative irrigation requirements was in essential the same as standardised by Shaw and Sweezy (1937) for the Waialua irrigation investigations. In brief the procedure with suitable modifications is described below:—

### 1. *Determination of the critical soil moisture limit.*

Critical soil moisture limit for plant growth was determined both in the pot culture and the field plots. Pot culture tests were carried out with cotton plant as indicator. The method of determining critical moisture content was the same as described by Briggs and Shantz (1912). The soil used for the tests was obtained from the plots dug to a depth of 1½ feet under the irrigation experiment. Ten pots were used for the series. The critical moisture limit of soil was determined when the plants had wilted and would not recover in an humid atmosphere of a bell jar. In the field tests the indicator plant used was sugar cane. The procedure adopted for working out the critical moisture limit for active plant growth was similar to that described by Shaw and Sweezy (1937). Soil moisture estimations were carried out at regular intervals till the point when the plants showed a slowing down of growth in length of the plants' shoots. Some of the details are explained below:—

(*a*) *Selection of shoots.*—Under the environment of Tarnab it was noticed that the shoots of the first order survived in greater numbers than those of the second order. In table I are given the percentages of mature canes of the different orders in various cane varieties under test. From the data it is evident that shoots of the first order, or mother

Table I.

*Survival per cent in shoots of different orders.*

| Variety. | Number of clumps examined. | Order of branching. | | | |
|---|---|---|---|---|---|
| | | *a* | *b* | *c* | *d* |
| Co 281 .. | 10 | 80 | 76·2 | 23·3 | Nil |
| Co 299 .. | 10 | 90 | 62·1 | 39·0 | Nil |
| Co 312 .. | 10 | 100 | 60·7 | 20·0 | Nil |
| Co 313 .. | 10 | 70 | 68·5 | 36·7 | Nil |
| Co 427 .. | 10 | 70 | 82·3 | 33·3 | Nil |
| Co 549 .. | 10 | 80 | 82·7 | 57·3 | 1·10 |
| Mean .. | .:.. | 81·7 | 73·81 | 34·9 | 0·20 |

shoots, were the ones that survived the most. Therefore, these shoots were labelled in the selected plants of the same date of emergence from the soil. In order to have a good mean value growth data were recorded on ten labelled shoots in each case in the varietal and other experiments. Another reason for selecting the mother shoots was that the life history of the plant is more completely generalised in the mother shoots than shoots of the other orders which emerge at various intervals. In the varietal trials the shoots for the study were labelled in one representative replication out of the six planted for the experiment. The labelled plants lay at random two in each of the five experimental rows of the net experimental plot. For growth measurement of the plants in the irrigation and the manurial trials laid in confounded designed a representative sub-block of a replication was selected and ten shoots were labelled in the same manner as described above. The shoots for the measurements were always under constant observation for fungal and insect attack. Whenever any shoot was damaged it was replaced by a new one. But then the replaced one started with the same initial reading as recorded for the discarded one. This expedient was adopted in the absence of any other method of continuing the measurements on all the ten plants under study. In practice it was noticed that this procedure involved comparatively slight difference and it was essential to do so lest arrested growth of the plant vitiated the results of determinations of critical moisture limit of the soil.

(b) *Technique of growth measurement.*—The procedure in brief was that the growth measurements were recorded as far as possible at regular intervals by the same observer to avoid personal factor. A peg was fixed at the base of the shoot and that formed the basal point for recording the total length made at successive intervals. To be more exact a pencil or India ink mark was given exactly parallel to the top of the peg on the sheath of the new shoot. No sooner that point dimmed it was re-marked on the shoot. But usually it was not necessary to do so for the point was shifted up the stalk as soon as it had made more than 20 cms. of growth. The observations were recorded up to the first place of decimal.

In Fig. 1 are represented the data of mean length values of ten shoots of variety Co205 raised for the purpose of determining critical moisture limit of the soil. It will be noticed that on the whole the curve of growth is a normal logistic type. In the curve, however, will be noticed a few points at which the curve tends to run parallel to the ordinate. The points at which such a tendency is evident truly represent the approach of critical moisture limit of the soil. We have indicated such points by triangles. The points at which the irrigation was applied are shown by arrow marks. It will be noticed that during the interval between the point of critical moisture limit and the irrigation date the growth tended to continue but the rate considerably slowed down and normal conditions immediately returned when the crop was irrigated once again.

(c) *Soil moisture estimation.*—For estimating the moisture content of the soil, the samples were drawn with an augur to a depth of 18 inches. It was observed in some preceding experiments that the effective depth for root development was about 18 inches for the varieties in the trial. Therefore, three samples in duplicate were drawn in three successive depths of six inches each, at a distance of 12 inches from the previous holes. Two borings and duplicate samples were found to yield satisfactory results. In the growing period of the crop sampling was, therefore, a continuous process and it was avoided on dates when there was more than half an inch of rainfall.

The aluminium sampling cans were weighed and samples were dried for 22–24 hours in an air oven working at $100 \pm 2$°C. This period was found by tests to be sufficient to yield accurate results. A conversion chart was employed for direct calculation of the soil moisture content on the dry basis of the samples. For the purpose, therefore, 100 gms. samples were weighed to determine the soil moisture content.

2. *Measurement of irrigation water.*

The procedure of measuring irrigation water by means of rectangular contracted weir as described by Christiansen (1935) was employed for the purpose. The weirs were constructed and caliberated by the Executive Engineer, Malakand for the use in the stream flow of 0·30 to 1·00 cusec. While running the water into the plots for experimental purposes the flow of water was recorded at every five minutes' intervals and therefrom the quantity of water applied per plot was worked out.

3. *Irrigation interval.*

From a series of observations of soil moisture and plant growth critical moisture limit of soil was determined. This formed the basis of determination of irrigation interval between the two successive readings. Dates of irrigations were plotted on the curve of growth to work out the mean irrigation interval during formative, grand growth and senescent phases of growth of the crop.

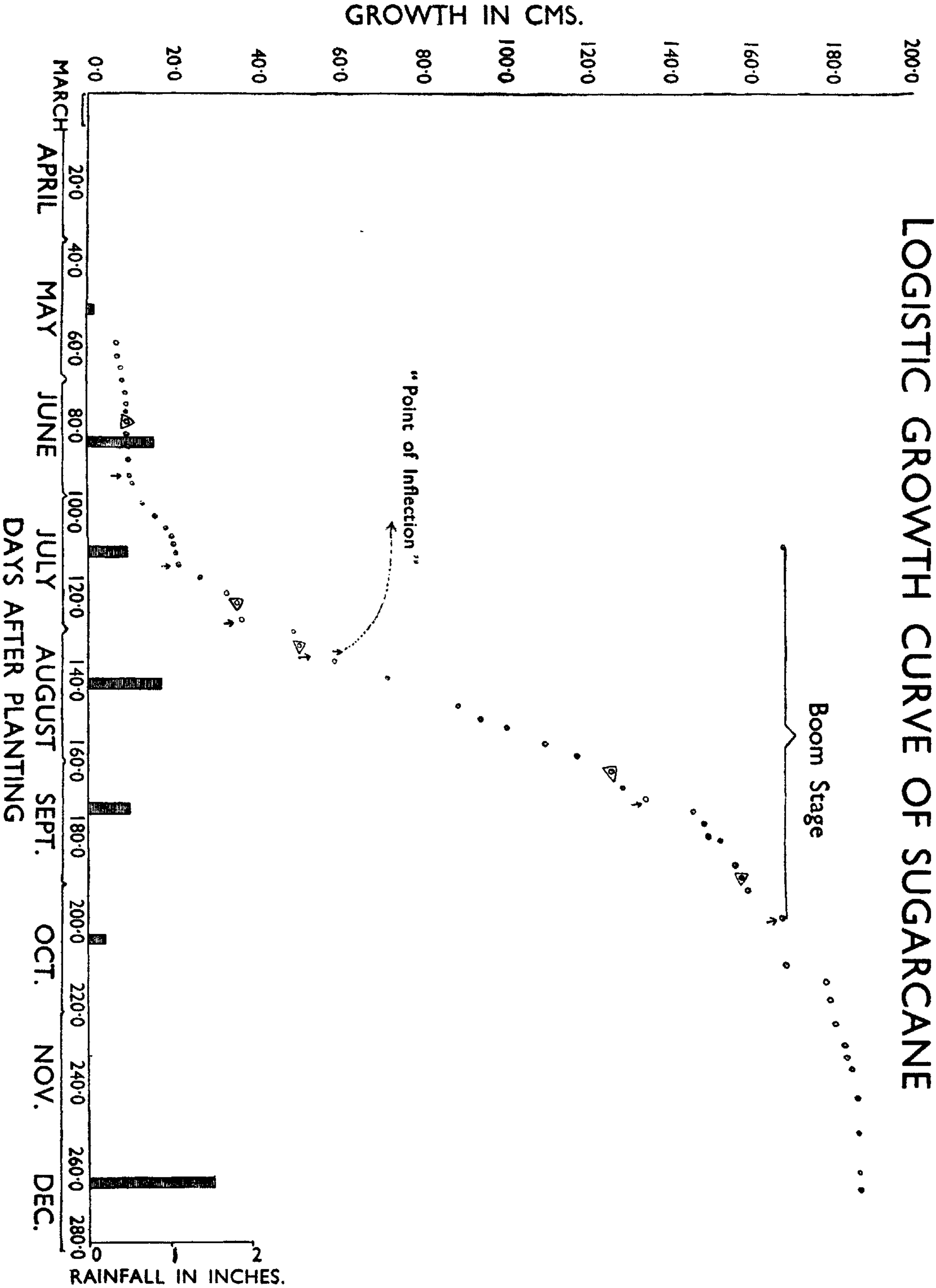
LOGISTIC GROWTH CURVE OF SUGARCANE
GROWTH IN CMS.
0·0
20·0
40·0
60·0
80·0
100·0
120·0
140·0
160·0
180·0
200·0
"Point of Inflection"
Boom Stage
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
DEC.
DAYS AFTER PLANTING
RAINFALL IN INCHES.
0
1
2

Fig. 1.

4. *Efficiency of irrigation requirements.*

The values of the irrigations applied in acre inches were summed up for the various intervals. These values of water applied were calculated from the chart (Table II) given below:—

TABLE II.

*Estimation of the water applied to the field plots.*

| Serial No. | Gauge Reading ft. | Equivalent Discharge Cusecs. | Relative time taken to irrigate an acre to a depth of 0·10 ft. | |
|---|---|---|---|---|
| | | | Hrs. | Mint. |
| 1 | 0·75 | 1·94 | 0 | 37 |
| 2 | 0·70 | 1·76 | 0 | 41 |
| 3 | 0·65 | 1·57 | 0 | 46 |
| 4 | 0·60 | 1·39 | 0 | 52 |
| 5 | 0·55 | 1·22 | 0 | 59 |
| 6 | 0·50 | 1·06 | 1 | 8 |
| 7 | 0·45 | 0·90 | 1 | 21 |
| 8 | 0·40 | 0·76 | 1 | 36 |
| 9 | 0·35 | 0·62 | 1 | 57 |
| 10 | 0·30 | 0·48 | 2 | 31 |
| 11 | 0·25 | 0·37 | 3 | 16 |
| 12 | 0·20 | 0·27 | 4 | 29 |
| 13 | 0·15 | 0·17 | 7 | 7 |
| 14 | 0·10 | 0·09 | 13 | 26 |
| 15 | 0·05 | 0·04 | 30 | 5 |

From the calculated values tons of water required to produce a ton of cane was worked out for each of the varieties, highest value amongst determinations showing the least requirement per ton of cane produced.

5. *Irrigation interval and juice quality.*

Three irrigation intervals were compared to study the effect of irrigation supply on the maturity of cane. The intervals studied were—weekly, ten days and critical moisture stage. At harvest commercial cane sugar values were worked out for the three treatments. Results for the C.C.S. per cent values and sugar recoverable per acre were worked out and are tabulated. These values were studied in three experiments.

## EXPERIMENTAL RESULTS.

1. *Critical moisture limit for active growth.*

For the critical moisture limit of soil in pots three tests were performed. The results are given in table III.

Out of the thirty observations three had been spoiled and have been omitted out of calculation. The mean value of the critical moisture limit of the soil in the pots worked out to $13{\cdot}81 \pm 1{\cdot}34\%$. As stated already these values were obtained with cotton plant as indicator.

TABLE III.

*Moisture content at critical moisture limit of soil. Pot culture series.*

| Pot No. | Per cent moisture in the soil. | | |
|---|---|---|---|
| | I Test. | II Test. | III Test. |
| 34 | 15·93 | 14·95 | 13·20 |
| 47 | 14·98 | 12·99 | 12·74 |
| 48 | 13·78 | 13·44 | 12·60 |
| 52 | 12·36 | 12·44 | 12·44 |
| 58 | 13·14 | 13·25 | 12·30 |
| 63 | 14·18 | 16·93 | 15·49 |
| 67 | 12·71 | .. | 14·92 |
| 83 | 13·55 | .. | 13·80 |
| 91 | 15·82 | 14·27 | 14·40 |
| 95 | 11·12 | 15·15 | .. |

Mean 13·81 S.E. = ± 1·34

The tests of critical moisture limit for active crop growth were performed several times in the same trial of varieties. The representative sample data for the series are reported below:—

TABLE IV.

*Soil moisture content at the critical moisture limit of soil. Field series.*

| Variety. | Moisture per cent in the soil before irrigation. | | | | | |
|---|---|---|---|---|---|---|
| | I Replication. | | | II Replication. | | |
| | 0–6″ | 6–12″ | 12–18″ | 0–6″ | 6–12″ | 12–18″ |
| Co 205 .. .. | 13·40 | 16·50 | 17·80 | 13·88 | 14·39 | 17·90 |
| Co 281 .. .. | 16·63 | 19·46 | 19·37 | 16·44 | 19·59 | 20·08 |
| Co 290 .. .. | 15·75 | 17·60 | 19·89 | 14·88 | 16·39 | 18·69 |
| Co 331 .. .. | 13·00 | 15·10 | 16·37 | 13·30 | 16·67 | 16·39 |
| Co 432 .. .. | 14·52 | 17·20 | 19·46 | 13·95 | 16·84 | 19·38 |

From a perusal of the results it will be observed that the maximum depletion of soil took place in the upper six inches of soil, sub-soil 6–12 inches was less depleted and soil depth 12–18 inches except by varieties Co 331 and Co 205 was comparatively the least tapped one by the root system of the plants. The mean value for the soil moisture within the six inches layer for all the varieties in the two replications for which the results are given in the table worked out to 14·57 ± 1·24%. This value, it will be observed, almost closely agrees with the pot tests (13·81 ± 1·34%). Therefore irrigations to the field were applied when the critical limit of water in the upper six inches was attained for the plant.

2. *Irrigation interval.*

The experiment was planted in March, 1940 and harvested in January, 1941. The crop completed its apparent germination about the fourth week in March. During the period the moisture content of the soil never was allowed to run below the critical stage of moisture limit within the first 3 inches of depth, i.e., within the vicinity of the sett. Once the crop had completed its germination it was irrigated when the moisture within 6 inches of the top had approached critical water limit for active growth of the crop.

A perusal of data presented in table V will show that April, May and June, although are the hottest months of the year, the crop needs irrigation sparingly, for the rate of

TABLE V.

*Monthly Growth Data.*

| Varieties | Growth in cms. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | April- ay | June | July | Aug. | Sept. | Oct. | Nov. | December. |
| Co 290 | 8·22 | 7·76 | 37·67 | 74·68 | 44·07 | 16·32 | 8·18 | 2·00 |
| Co 281 | 9·55 | 5·87 | 30·01 | 74·27 | 43·27 | 17·34 | 6·98 | 0·60 |
| Co 331 | 8·38 | 10·00 | 38·47 | 69·85 | 46·70 | 14·25 | 7·25 | 1·62 |
| Co 205 | 8·62 | 5·01 | 36·92 | 69·03 | 40·77 | 22·07 | 6·29 | 1·40 |
| Co 432 | 8·57 | 4·75 | 25·98 | 78·72 | 41·48 | 19·20 | 5·40 | 1·43 |
| Mean | 8·68 | 6·67 | 33·82 | 73·31 | 43·14 | 17·84 | 6·82 | 1·40 |

growth during those months is low. On the average the rate per month is 5 cms. The irrigation interval shortens during July, August and September months, principally due to increased growth of the crop. In the months of October, November and December, when growth is successively on the decline, the requirement is the least for then the temperatures are not conducive to high loss due to evapo-transpiration. Thus, during the seven weeks from 25th April to 15th June, three irrigations were necessary. Later as the rate of growth of the crop became more rapid the irrigation interval decreased to about ten days. But with the approach of the senescent phase of growth of the crop the interval again began to increase to 20 days in September and over a month in October. During November and December we had enough rainfall for the crop so that soil never needed further irrigation till it was harvested in January (Table VI).

TABLE VI.

*Irrigation Interval Data.*

| Month. | Dates of irrigation. | No. of irrigations. |
|---|---|---|
| March .. | 23/3 | One |
| April .. | 2/4, 13/4, 25/4 | Three |
| May .. | 11/5, 24/5 | Two |
| June .. | 16/5, 28/6 | Two |
| July .. | 9/7, 22/7 | Two |
| August .. | 1/8, 11/8, 20/8 | Three |
| September .. | 3/9, 24/9 | Two |
| October .. | 25/10 | One |

3. *Tons of water per ton of cane.*

The figurative data for the mean discharge from the rectangular weir and the total time taken to irrigate the plots at various intervals for all the sixteen irrigations applied are given in table VII. With this information we obtain acre inches of irrigation applied to an acre field. Since one acre inch equals 101 tons of water we easily derive tons of water

TABLE VII.

*Irrigation requirements.*

| Particulars. | Varieties. | | | | | Mean Values. |
|---|---|---|---|---|---|---|
| | Co 205 | Co 281 | Co 290 | Co 331 | Co 432 | |
| 1. Total time minutes .. | 339 | 336 | 336 | 336 | 337 | 336·6 |
| 2. Mean Gauge reading—Ft. | 0·375 | 0·379 | 0·379 | 0·379 | 0·380 | 0·3785 |
| 3. Mean discharge Cusecs .. | 0·69 | 0·70 | 0·7025 | 0·70 | 0·7027 | 0·699 |
| 4. Acre inches water applied | 33·12 | 34·12 | 34·32 | 34·13 | 34·46 | 34·05 |
| 5. Rainfall Inches .. | 6·28 | 6·28 | 6·28 | 6·28 | 6·28 | 6·28 |
| 6. Total requirements—Acre inches .. .. | 39·40 | 40·40 | 40·60 | 40·41 | 40·74 | 40·33 |
| 7. Tons of water per acre .. | 3979·4 | 4080·4 | 4100·6 | 4081·4 | 4114·74 | 4073·33 |
| 8. Mean crop yield—Tons | 23·39 | 14·10 | 19·26 | 28·79 | 25·93 | 22·29 |
| 9. Tons of water per ton of cane .. .. | 170·1 | 290·3 | 212·8 | 141·5 | 158·7 | 182·3 |
| 10. Relative efficiency of irrigation requirements .. | 0·83 | 0·48 | 0·66 | 1·00 | 0·83 | .. |

per acre added to each of the four varieties. With the mean yield figures tons of water per ton of cane crop produced is obtained.

On the average crop with 22·29 tons of cane yield, the irrigation requirement was 40·13 acre inches or 182·3 tons of water per ton of cane. In actual practice minimum amount of irrigation required to mature an optimum crop thus worked out to 40 acre inches.

4. *Relative efficiency of irrigation requirements.*

Besides, it will be noticed that some of the varieties made more economical use of water than others. Shaw and Sweezy (1937) have stated that wilting percentage apparently was a function of the soil rather than the plant subject to seasonal variations, to age and variety of the plant. In our results irrigation requirements of the varieties though strictly not comparable, in view of the fact that varieties were not allowed to deplete the soil of its moisture to the same extent, (absolute water requirements) have a lesson in them. Given the same amount of water they yielded differently. For instance Co 331 definitely was more economical in the use of water than either Co 281 or Co 290 and even Co 205 and Co 432. Thus our results are clear on one issue that the varieties, given the same interval of irrigation and almost irrigated to the same depth every time, make use of the water differently. Some are able to make better use of water in greater production of vegetable mass than others under the same given conditions. This is in accord with the results reported by Briggs and Shantz (1911), Dillman (1931), Singh and Colleagues (1935) and Khanna and Raheja (1938). Their general conclusion was that varieties differ very widely in their efficiency of water requirements and that the maximum yielding strain was the most economical in its water expenditure.

5. *Practical advantage of minimum irrigation (critical moisture stage) application.*

Three irrigation experiments were carried out during the season 1941-42. As already stated, the three treatments of irrigation tested were weekly, ten days and critical moisture

TABLE VIII.

*Cane yield and Sugar values of experiments on irrigation.*

| Irrigation treatments. | Period of planting × Varieties. | | | Basal treatments. × Top dressings. | | | Methods of planting × Nitrogen levels. | | |
|---|---|---|---|---|---|---|---|---|---|
| | *a* | *b* | *c* | *a* | *b* | *c* | *a* | *b* | *c* |
| | Mds. | % | Mds. | Mds. | % | Mds. | Mds. | % | Mds. |
| 1. Weekly Interval | 739 | 5·96 | 48·3 | 871 | 5·40 | 47·4 | 649 | 6·20 | 39·0 |
| 2. Ten days Interval | .. | .. | .. | 785 | 5·65 | 43·1 | 701 | 5·47 | 37·3 |
| 3. Critical Moisture limit .. | 506 | 6·73 | 36·4 | 838 | 5·87 | 48·1 | 555 | 7·23 | 40·3 |
| S.E. per plot | ±137·03 | ±1·08 | ±10·04 | ±162·2 | ±1·23 | ±10·57 | ±102·9 | ±1·57 | ±8·89 |
| C.D. between treatment means at 5% .. | 88·7 | 0·70 | 6·56 | 110·1 | 0·83 | 7·19 | 89·2 | 1·36 | 7·69 |

*Note.*—*a* = Cane yield in Mds. per acre. *b* = C.C.S. % value. *c* = C.C.S. yield per acre Mds.

stage irrigation intervals. The results are given in table VIII above. In the first experiment the two varieties—Co 290 and Co 312 were planted in autumn and spring respectively. The autumn planted cane continued to receive normal irrigation supply till March when spring planting for comparison was carried out. From mid-March onwards the crop received irrigation according to the schedule of the experiment. Half the number of plots received liberal irrigation supply i.e., at weekly intervals and the other half received at the critical moisture limit stage of the crop. The second experiment was a confounded design—(3) [3]. The three treatments compared were—(*a*) fallow dressed with eight cartloads of compost (160 mds.), (*b*) shaftal (Trifolium resupinatum) green manured in March and then cane planted and (*c*) cane planted in shaftal and shaftal green manured when in bloom. The top dressing treatments consisted of (*a*) 75 lbs. nitrogen plus 75 lbs. phosphoric acid applied at planting, (*b*) farm compost eight cartloads dressed at planting and another dose of compost half mixed with *Khakshora* applied after the germination was completed and (*c*) manure top dressed in three doses—first dose consisted of 8 cartloads of compost, second dose of 3 cartloads *Khakshora* and third dose of 5 cartloads *Dherai* per acre. Here *Khakshora* refers to earth from the dilapidated mud buildings and *Dherai* to earth from the old ruins. Experiment No. 3 was again a confounded design which provided comparison of three levels of nitrogen, namely, 50, 100 and 150 lbs. respectively, three methods of planting cane in the furrows, namely, (*a*) flat planting in shaftal, (*b*) furrow method with setts covered lightly with earth (shaftal green manured in early March) and (*c*) standard Pusa method with shaftal green manured in early March as in (*b*) above (Sayer *et al.*, 1928), and three irrigation treatments as already explained. In all these three experiments the harvest sugar values were worked out in the form of commercial cane sugar by the undermentioned formula:—

$$\text{C.C.S.} = 3P/2(1-10+F/100)-B/2\left(1+6+\frac{6+F}{100}\right),$$

where P = Polarisation, B = Brix and F = Fibre in cane.

After obtaining the C.C.S. per cent values, C.C.S. yields per acre were derived individually from the plots. The figures given above are the mean yields of the replication summations. It is apparent that the critical moisture stage irrigation lowered the yield of cane in all the three experiments. But there was a corresponding increase in C.C.S. per cent values of the crop in all the trials. In two out of the three trials this increase was more than sufficient to compensate for the decrease in yield. In fact, in two trials there was an extra return of sugar per acre with the critical moisture stage irrigation application compared to even liberal irrigation treatment. It is for this reason, that Hawaiian planters have adopted critical moisture stage irrigation system to reduce the cost of water applied to the crop (Wadsworth, 1937).

## Summary.

Irrigation requirement studies were carried out in a varietal experiment by the method of critical moisture stage irrigation previously standardised by pot and field tests. The effect of critical moisture stage irrigation was compared to the liberal and restricted irrigation intervals in respect of yield and sugar content of the crop in three other irrigation experiments. The results of the investigations were as under:—

1. The mean value of the critical moisture limit of the soil in the pot tests with cotton plant as indicator worked out to $13{\cdot}81 \pm 1{\cdot}34\%$. This agrees closely with the soil moisture within the six inches under field conditions. For field tests, therefore, whenever the soil moisture approached about 14% that was taken as indication that the soil had attained its critical moisture limit.
2. The irrigation interval during the formative stage was about a fortnight, during the grand growth period stage it was reduced to ten days and in the senescent phase of the crop it again prolonged to 20 days and more.
3. On the average cane crop as represented by the five varieties, namely, Co 290, Co 281, Co 331, Co 432 and Co 205, required about 40 acre inches of irrigation to develop normally. Per ton of cane the water required was 182·3 tons. This represents the gross and not the absolute requirements, for it includes the loss due to seepage, evaporation, etc., etc.
4. The varieties showed wide differences in their efficiency of irrigation requirements and the maximum yielding strain was the most economical in its water expenditure.
5. Critical moisture limit irrigation increased the commercial cane sugar per cent values of the crop and at harvest in two out of three trials the sugar yields per acre were higher than weekly or ten days interval irrigation treatments, inspite of the higher cane yield realised by the latter treatments. This indicated the beneficial value of the adoption of scientific irrigation control on large estates.

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