WORKSHOP ON AGROCLIMATIC ZONING

- case study Kingston, Jamaica

iica/jamaica

miscellaneous publication #323
Series ISSN-0534-5391

INTRODUCTION

The Prime Minister, The Hon. Edward Seaga, M.P., expressed an interest that IICA should prepare a profile for an Agrometeorological Zoning strategy for Jamaica.

As a first step in the basic collection of data and identification of the human resources that would assist in this project in Jamaica, the Headquarters of IICA in San Jose, Costa Rica in response to a request from the IICA/Jamaica Office sent Mr. Michel Eldin to Jamaica to look into the existing quality of data and to meet the potential experts who would assist in the project.

On that occasion Mr. Eldin suggested that a workshop to explain the methodology and to test some of the existing data would be of great importance in indicating the major aspects of the exercise to be undertaken and identifying gaps for data required.

As a result, a group of four professionals met during one week in the workshop directed by Mr. Eldin. The data tested was that of the Palisadoes Meteorological Station. The results of the seminar are presented in the document titled "Workshop on Agroclimatic Zoning", jointly prepared by these four professionals and Mr. Eldin.

Since then a proposal has been written for the Agromet Zoning of Jamaica. This proposal has been delivered to the Inter-American Development Bank (IDB) as requested by the Prime Minister.

It is expected that if the zoning proposals are adopted by Jamaica they will assist in solving some important problems related to Jamaican Rural development, thereby allowing the country to assist itself of the most advanced scientific tools in the use of agricultural planning.

IICA/Jamaica has the pleasure to take this opportunity to present this report as one more example of its efforts to assist Jamaica in its rural development programme.

Percy Aitken-Soux
Director
IICA/Jamaica

"WORKSHOP ON AGROCLIMATIC ZONING"

- case study Kingston, Jamaica

by

Philemon Hoilett, Meteorological Service
Ina Pyne, " "
Calvin Gray, " "
Renford Baker, Ministry of Agriculture
Michel Eldin, Expert in Agroclimatology (Inter-American Institute for Co-operation on Agriculture

April 1982

"WORKSHOP ON AGROCLIMATIC ZONING" - case study

Kingston, Jamaica

by

Philemon Hoilett, Meteorological Service
Ina Pyne, " "
Calvin Gray, " "
Renford Baker, Ministry of Agriculture
Michel Eldin, Expert in Agroclimatology, (Inter-American Institute for Co-operation on Agriculture

1. BACKGROUND AND PURPOSE OF STUDY

Jamaica has very good soil and climatic data (more than five hundred rainfall stations), yet these data are not utilized to solve important agricultural problems related to Jamaica's rural development. In fact, it is possible to use the available information to prepare an agrometeorological study of Jamaica involving the following topics:

- Specific studies of some important crops

  If the specific climatic requirements of each crop is taken into account, it is possible to define the best zones for its cultivation and to determine the crop varieties, cropping systems and techniques that will create maximum profits from the particular climatic and soil conditions.

- Agroclimatic Zoning

  This deals with the definition of climatic potentials (length of growing period, best date for sowing, index of biomass production, erosion risks, etc.) Such zoning would:

  (a) Identify agricultural priorities in each ecological zone.

  (b) Provide a macroclimate reference outline which could help to indicate other areas where more specific agroclimatic studies are needed.

[illegible] PROGRAM ON [illegible]

[illegible]

[illegible]

[illegible], Meteorological Service
[illegible]
[illegible] Ministry of Agriculture [illegible]
[illegible]
Agriculture

[illegible] OF STUDY

Kenya has very good soil and climatic data (more than five hundred rainfall stations), yet these data are not utilized to solve [illegible] agricultural problems faced [illegible] must [illegible]. In fact, it is possible to use the available information to prepare an agrometeorological study of climatic analysis [illegible] the following topics:

(a) Climatic studies of some important crops

[illegible] climatic requirements [illegible] crop is [illegible] known, it is possible to define the [illegible] zones for [illegible] and to determine [illegible] crop varieties, cropping [illegible] techniques that would ensure maximum profits from [illegible] climatic and soil conditions.

(b) Climatic Zoning

This deals with the definition of climatic parameters ([illegible] growing period, best date for sowing, index of [illegible] precipitation, [illegible] risks, etc.) Such zoning would:

(i) Identify [illegible] in each [illegible] zone.

(ii) Provide [illegible] reference [illegible] which could help [illegible] in other areas [illegible] specific [illegible] are needed.

(c) Permit the generalization of the best results obtained in Jamaica to similar agroclimatic zones elsewhere.

- Ecological Zoning

  Agroclimatic zoning can be combined with soil and slope information in order to determine ecological zones.

For such an agrometeorological study to be properly executed, proper climatic data analysis techniques must be used. To facilitate this, the Inter-American Institute for Co-operation on Agriculture in Jamaica (IICA/Jamaica) organized a workshop in Kingston from September 8 - 10, 1981 which was conducted by Michel Eldin, expert in agroclimatology from IICA/Costa Rica. Data for Norman Manley Airport, Kingston was used for this purpose. This publication demonstrates the method used, results obtained and the agronomical conclusions drawn from using Lower Kingston as a case study.

It is clear that agricultural development in Jamaica can be enhanced if this test study on Kingston is expanded to include the entire island using the very abundant and excellent information available on soil and climatic conditions. Hence, it is of paramount importance that all meteorological information, especially daily rainfall data, be transferred to magnetic tapes, disks or disketts, to be available for computer processing. The results of such a complete agrometeorological study would be a further needed input into the management of Jamaica's agricultural resources which would result in improved agricultural production.

2. METHOD

The following climatic data processing methods were used to establish

- Crop water requirements - potential evapotranspiration.
- Lengths of growing periods.
- Best dates for sowing, planting or harvesting.

- Probability of obtaining specified amounts of rainfall.
- Amounts of rainfall that can be expected given a specific probability (e.g. every 4 out of 5 years).

2.1 Potential Evapotranspiration

Potential Evapotranspiration (PET) is a good indicator of the maximum water loss by evaporation and transpiration of any plant or crop in a given place under specific climatic conditions, at a given time. PET is therefore a very important agroclimatic parameter which should be used to determine the amount of water that needs to be utilized for irrigation purposes. The importance of water-stress and optional needs for water can also be estimated when PET is combined with biological and agricultural data (phenological stage of the crop, plant density, number of days after sowing etc.)

Many formulae have been proposed for the calculation of P.E.T. The best known is PENMAN'S [1/] which gives:-

$$PET = \frac{p^1}{p^1 + \gamma} (N + S) + \frac{\gamma}{p^1 + \gamma} E_a$$

where:-

p^1 = slope of saturation vapour pressure at air temperature

γ = psychrometric constant (same units as p^1)

N = net radiation flux density

S = soil heat flux density (same units as N)

E_a = evaporative power of air

Thus PET is expressed in the units of N.

1/ PENMAN H.L. 1948 Proc. Roy. Soc. London. A 193, 129 - 145.

This formula has a theoretical basis and is quite precise, but its application requires very sophisticated measurements such as N, S and E_a. So for this study the G. H. HARGREAVES formula was chosen which has been successfully used in the Dominican Republic.2/

By Hargreaves: $PET = 4.0132 \times 10^4.TF.RMM.CH.N.CLA$

PET: expressed in millimetres for an η day period.

TF: mean air temperature for period under consideration expressed in degrees Fahrenheit. 1/

RMM: solar radiation at the top of the atmosphere expressed in mm/η days.

where:

$RMM = 10.\eta\, G_o/L$

and η = no. of days under consideration

G_o: the solar radiation at the top of the atmosphere expressed in cal. cm.$^{-2}$ day^{-1}

L: latent heat of water in cal. gm^{-1} expressed as $L \neq 605.8 - 0.306.TF$

G_o can be calculated from the following formula:

$$G_o = 916.732[OM.\sin(LAT)\sin(DEC)+\cos(LAT)\cos(DEC)\sin(OM)].\frac{1}{ES}$$

where:

G_o is expressed in cal. cm^{-2} day^{-1}

OM: solar angle in radians, which can be calculated from

$OM = \arccos[-\tan(LAT).\tan(DEC)]$

1/ 10 years temperature data for the 10-day period (11th - 20th of each month) was used in this study (1969 - 1978).

2/ ERNESTO REYNA - MANUEL PAULET. Secretaria de Estudo de Agricultura de Republica Dominica/IICA. Documento tecnico No. 2 1979 - Requerimentos de agua para la agricultura segun el clima de la Republica Dominica.

LAT: latitude in radians

DEC: solar declination at date under consideration, in radians which can be deduced from:

$$DEC = \text{arc sin } 0.39484 \sin[0.33466(\sin 0.017214D-0.979924)+0.017214(D-79.59)]$$

where D: the number of the day in the year corresponding to the middle of the period under consideration. In this case 10 day periods were used from the 11th to 20th of each month. The following table gives the mean value of D of this period for each month.

MONTH	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
D	15.5	46.5	74.5	105.5	135.5	166.5	196.5	227.5	258.5	288.5	319.5	349.5

$\frac{1}{ES}$: correction which takes into account the variation in the earth-sun distance during the year. This can be calculated from:

$$\frac{1}{ES} = 1 + 0.033466 \cos (0.017214D)$$

Having calculated OM, DEC and $\frac{1}{ES}$, then G_o can be derived.

CH: coefficient which takes into account mean relative humidity (HM) during this period.

$$CH = 0.116 (100 - HM)$$

If actual relative humidity data is unavailable, HM can be evaluated by using the following empirical formula:

$$HM = 91.2 - 0.282TF + 1.7Pr.$$

where

HM: in percent. If the value obtained for HM is greater than 100, it is assumed that the right value of HM is 100.

TF: mean air temperature of the period in °F.

Pr: mean precipitation of the period in inches.

N: day length (sunrise to sunset) expressed in hours and tenths. If this is not measured directly, N can be calculated from:

$$N = OM/0.1309$$

CLA: factor which takes latitude into account, derived from:

$$CLA = 0.17\ (70 - 57.296\ LAT)^{\frac{1}{2}}$$

with LAT in radians and CLA $\leq$ 1.

Data for Manley Airport (Palisadoes) was used for the 10-day period 11th - 20th of each month for 39 years: 1942 - 1980. (Table 1). The Potential Evapotranspiration (PET) for this 10-day period was derived using Hargreaves Formula. (Table 2). It can be seen that PET for Manley Airport varies from 3.6 mm to 6.5 mm per day (36 mm to 65 mm/10 day). The highest climatic demand for water (6.4 mm per day to 6.5 mm per day) occurs in June and July respectively while the lowest demand (3.6 mm per day to 3.8 mm per day) occurs between October and January.

2.2 Rainfall Frequency Analysis

The 10-day rainfall shown in Table 1 was grouped into classes and the frequency distribution, cumulative frequency distribution, probability and cumulative probability determined for each month as shown in Table 3.1 to 3.12. In these tables,

f: the observed frequency of each class. (no. of occurences of rainfall within the specified range).

F: the observed frequency reduced to a standard class interval. The first class interval shown for each month was used as the standard.

c.f.: the cumulative observed frequency (i.e. to each observed frequency is added the observed frequencies of rainfall of lesser amounts).

P: the probability of obtaining rainfall within the range specified in each class during the 10-day period under consideration.

$$\text{i.e.} \quad P = \frac{F}{N} = \frac{F}{39}$$

as 39 years data was used.

CP: the cumulative probability - i.e. the probability that rainfall will be less than the amount specified. This is evaluated by $C.P. = \frac{c.f.}{N}$

A graphical interpretation of the results of this frequency analysis is demonstrated by Graphs 1 to 12, (one for each month) which show the variation in probability (P) and cumulative probability (C.P.) over the corresponding rainfall class interval. It should be noted that the probability and cumulative probability points were plotted to coincide with the mid-point rainfall amounts of each class interval. For example in the .26 - .50 rainfall class interval of Table 3.1, P = .23 was plotted at the .38 inches rainfall point on the ordinate, likewise, for C.P. = .85. Curves were however smoothed for symmetry.

Table 4 gives the rainfall amounts for the fixed cummulative probabilities of C.P. = 0.50, 0.33, 0.20 and 0.10 as extracted from the graphs. Since C.P. corresponds to the probability of obtaining less than any amount of rainfall specified then 1 - C.P., the complementary probability, corresponds to the probability of obtaining an amount greater than that specified.

For example, it is interesting to note that for the 10-day period in the middle of October, one can expect an amount of rainfall of at least 1.17 inches once every 2 years (1 - CP = 0.50), 0.45 inches twice every 3 years (1 - CP = 0.67), 1.16 inches four out of 5 years (1 - CP = 0.80) and 0.04 inches nine out of every 10 years (1 - CP = 0.90).

Table 5 gives the calculated P.E.T. and ½ PET values using Hargreaves Formula. The probability of obtaining rainfall greater or less than these PET and ½ PET amounts for each month have been extracted from the cumulative rainfall probability curves of Graphs 1 - 12 and shown in this table as well.

The notation P (Pr < PET) represents the "probability of receiving rainfall less than the potential evapotranspiration" for the 10-day period under consideration. Similarly the complementary probability of obtaining more rainfall than the potential evapotranspiration is denoted by P (Pr > PET). The variability of these probabilities throughout the year is shown in Graph 13 for P (Pr > PET) and in Graph 14 for P (Pr > ½PET).

2.3 <u>Determining the Growing Period</u>

Graph 14 can be used to determine the growing period available at Manley Airport (Lower Kingston) without irrigation, if two assumptions are made:

(a) that ½ PET represents the minimum water requirement for rainfed agriculture (crops) to ensure acceptable growth and harvesting;

(b) that the maximum acceptable risk that can be taken in order to cultivate any crop is for the growth period to be based on the occurrence of rainfall greater than ½ PET at least every one year out of two i.e. the probability (1 - C.P. = 0.5)

On Graph 14, the horizontal line representing the probability of 0.5 cuts the curve at A and B which, based on (b) above determines a growing period in September and October. Since the 10-day period 11th - 20th of each month was used in this analysis, the graph therefore indicates a probability for this period only. However it is reasonable to assume that the period 21st September to 10th October would not reflect a probability of less than 0.5, so would be also above the 0.5 probability line. Based on the extent of the curve still above 0.5 probability following the October point (this is the 11th - 20th October position) it can also be assumed that the probability of rainfall greater than ½ PET would be $\geq$ 0.5 for another 8 - 10 days taking the growing period up to October 30th. Hence it can be said that there could well be a total growing period of September 10th - October 30th, a period of 50 days.

So it would appear that in the case of the Lower Kingston region (Manley Airport) the length of the growth season would be short - 50 days - if rainfed crops are to be grown. It may be possible to grow some vegetables but the most profitable and practical agricultural practise would be to lengthen the growing period by utilizing irrigation.

It can also be deduced from Graph 14, that the best dates for sowing or planting in the Lower Kingston region is September 1st to 15th.

2.4 Calculations by Computer

All the results presented in this publication could also be obtained by processing the data by computer. For this it would be necessary to adjust the samples of 10-day rainfall data to a theoretical law.

The Incomplete Gamma function fits very well with the distribution of observed rainfall data:

$$F(x) = FO + \frac{1-FO}{\Gamma(\gamma)} \int_{0}^{u} u^{\gamma-1} e^{-u}.du$$

where: $\Gamma(\gamma)$ is the complete Gamma function:

$$\Gamma(\gamma) = \int_{0}^{\infty} u^{\gamma-1}.e^{-u}.du$$

$u = \frac{x - x_o}{S}$ is the reduced variable

x : is the variable, that is to say 10-day amount of rainfall

x_o: is a position parameter. It must correspond to the smallest possible value of the variable.

Thus, for rainfall amounts, $x_o = 0$; then $u = \frac{x}{s}$

s: is a scale parameter

γ: is a shape parameter

FO: is a curtailing parameter. FO corresponds to the probability of having no rainfall.

The parameters S, γ and FO have to be determined using the Moment Method to adjust the sample of rainfall data to the Incomplete Gamma Law.

Knowing the values of the parameters it is then possible to use the Incomplete Gamma function to calculate the probability of obtaining a given amount of rainfall or, on the contrary, to calculate at which rainfall amount a given probability occurs.

Table 6 gives, as an example, the calculations carried out using this method, to determine the parameters of the Incomplete Gamma function that fit best the sample of rainfall amounts for Manley Airport for the 10-day period beginning on the 11th of October.

3. USES

The use of statistical methods in agricultural meteorology as typified by the rainfall frequency procedure and the evaluation of crop-water requirement (and availability) demonstrated above is of paramount importance in generating increased levels of agricultural production in Jamaica. Specifically, if P.E.T. can be accurately determined as shown, production can be streamlined and enhanced as determination of the following:

1. The critical period for land preparation.
2. Identification of micro- and macro- environments where new crops could be grown.
3. Long-term market arrangements based on prediction of rainfed crop production.

In general a knowledge of P.E.T. should minimize guess work for the farming community and as a result there could be

1. Proper scheduling of critical operations resulting in reliable production targets.
2. Availability of specific agricultural commodities as their amounts could be predicted.
3. Proper marketing arrangements.

There are, as well, a number of areas of agricultural meteorology which need scientific investigation in Jamaica to which the I.I.C.A. workshop method could be applied.

1. Suitability of different crops for each climatic regime in Jamaica.

2. The levels or irrigation necessary, if any, as over-irrigation can be equally detrimental as too little irrigation.

3. The extent to which plant and animal diseases are climate related and their control (or elimination) as a result.

4. The extent of weathering in the modification of soil types and the consequent necessity to change the varieties or types of crops being grown.

5. The frequency with which severe weather can be expected to decrease agricultural production and the extent of such decrease.

6. The frequency with which significant erosion of soils can be expected.

These are but a few of the areas to which the method can be applied. During this workshop however, Manley Airport was the sole location investigated because this had the most easily retrievable and accurate long-term (39 years) meteorological data. Hence, the need to expand this study to involve all locations (certainly all agricultural areas) in the island to establish their climatic capacity for the cultivation of various crops ("Agroclimatic Zoning") cannot be over-emphasised.

4. DATA NEEDS

4.1 Meteorological Data

It is essential that meteorological data be available for very long periods of time (in excess of 25 years) so as to enhance the accuracy of the inferences drawn from climatological analysis - as no studies can be done nor agricultural production increased through the application of these investigations unless accurate, reliable, consistent and long-term data is available. The present total meteorological data base of Jamaica although good, is mostly in manuscript form so would take months of man-hours to retrieve and possible years before this expanded and similar studies can be completed. This data base for all areas of Jamaica would include:-

1. DAILY RAINFALL:- as the temporal and spatial variability of rainfall is of paramount importance to the growth, flowering and harvesting of crops especially for those crops which are rain-fed.

2. DAILY TEMPERATURE:- although temperature changes within the tropics are small, plant-life is affected by these changes.

3. SOLAR RADIATION:- this is the base for all the photosynthetic and respiratory processes of plants which determines the levels of consumable production in each crop.

4. SUNSHINE DURATION:- the variability of this parameter throughout Jamaica is again small but for each location it has to be measured so that accurate values of evapo-transpiration can be attained. Relative sunshine duration bears a known relationship to solar radiation so in the absence of the latter, measurement of sunshine duration assumes critical importance.

Other meteorological variables such as wind speed (and direction in some cases) evaporation, relative humidity and soil temperatures would be needed for other types of agrometeorological studies.

4.2 Agricultural Data

The following are also very important.

1. Soil Physical Conditions
   (a) Texture
   (b) Bulk Density
   (c) Consistence
   (d) Soil-Crop-Water relationships

2. Agronomic Data

   (a) Total water requirement for different crops
   (b) Period of maximum water requirement
   (c) Time of planting
   (d) Date of maturity

5. CONCLUSION AND RECOMMENDATION

The workshop gave one example of the methodology in using climatic data to determine the growing period. An offshoot would be to determine periods of irrigation if a decision were taken to grow crops whose growth and development may not coincide with the growing period.

Results obtained from studies such as these form valuable inputs into proper agricultural planning, both long term and operationally. If a crop is considered for cultivation and its requirements and periods of growth and development are known then from these studies the following could be determined fairly easily:

(a) optimum period for growth
(b) optimum period for development
(c) optimum period for harvest

It might very well be that there are no optimum or suitable periods for all or any of the above. In that case the decision would be wisely taken not to invest in such a crop. In fact a better system of crop insurance could result from the use of this methodology.

The most important but often over-looked aspect of long term planning is data gathering. Without reliable and long term data no meaningful analyses can be done. Frequently agencies are required to make decisions that in the absence of analyses of long term data can only be classified as "enlightened guesses". It is little wonder that sometimes production plans fall far short of their targets.

Investment in data gathering, archiving and data processing is a small price to pay for increased productivity. The Meteorological Service should be adequately financed to have increased facilities for data gathering, archiving and data processing. If by increasing the budget of the Meteorological by 5%, specifically to improve data gathering, archiving and undertake studies of this nature the agricultural productivity were increased by only 1% it would be money well spent and the cost/benefit ratio would be significant. This is shown in the following two tables.

Table Showing Production of some Export Crops in 1979 and 1980

Source: "Production Statistics 1980" Dept. of Statistics

	Sugar Cane	Bananas	Citrus
	Tons x 10^3	Stems x 10^3	Boxes x 10^3
1979	2,918	8,848	1,529
1980	2,772	4,179	2,198

Table Showing Proposed 5% of Meteorological Service Budget and Cost of Increased Production

	5% Met Budget	1% Increase Sugar Cane Cost per Ton	1% Increase Bananas Cost per Stem	1% Increase Citrus Cost per Box
1979	$40,900	$1.40	$0.46	$2.67
1980	$66,700	$2.40	$1.49	$3.03

From the above tables it can clearly be seen the tremendous investment potential that Meteorology has for increased productivity.

****

TABLE 1. - 10-DAY PERIOD RAINFALL (11th - 20th) - MANLEY AIRPORT - inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
42	.44	.03	0	0	.03	0	.07	1.77	3.06	5.37	.36	2.67
43	.01	.27	.20	.21	.66	.76	0	.08	.88	2.46	.23	0
44	.04	.03	.02	0	.14	1.74	0	7.34	1.27	9.66	.53	0
45	.49	.04	0	.77	.26	.15	0	.13	.31	2.08	5.86	0.04
46	.03	0	0	.29	.02	0	0	.23	.05	.11	.66	.42
47	.03	1.79	0	0	.08	.03	1.47	.72	4.95	2.02	0	.01
48	1.99	0	.13	.21	2.80	.51	2.11	.47	2.91	2.92	.12	.17
49	.07	0	.02	.07	1.89	.15	.20	0	.07	1.50	1.12	.14
50	0	.15	0	.14	.30	.67	.28	1.71	1.77	12.28	.18	.38
51	0	0	0	1.33	2.41	.63	.86	16.97	.48	.64	2.56	0
52	0	0	.03	1.75	.01	.58	1.05	.49	.62	.80	0	.14
53	.08	.30	0	0	0	.07	.24	0	2.12	0	.31	.09
54	0	.66	0	.35	0	1.18	.04	1.15	2.09	1.06	2.68	0
55	.10	1.04	0	.25	0	.67	0	.10	3.76	3.62	.01	.63
56	0	.01	1.01	2.04	.18	.70	0	0	.18	9.55	.08	.08
57	0	.13	.09	.16	5.14	.20	.59	.01	0	.21	0	0
58	.83	0	0	.02	9.86	1.29	.04	.22	1.44	.76	1.05	.30
59	.18	0	.11	.78	1.05	.17	.16	0	.48	4.20	2.18	.16
60	.05	.69	.18	.60	.30	3.78	.46	.53	3.04	.23	.56	1.40
61	.47	.11	0	.18	.30	.66	1.46	.24	.18	10.02	.11	.12
62	.09	.04	.25	.51	.13	1.27	.28	.06	1.86	1.32	0	.05
63	0	.13	0	0	0	0	.36	.10	1.06	.82	4.13	.65
64	.34	0	0	.53	.03	.81	.90	.28	.05	.90	.05	0

TABLE 1 (cont'd)

10-DAY PERIOD RAINFALL (11th - 20th) - MANLEY AIRPORT - inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
65	.50	0	0	0	.13	0	0	.63	1.78	.04	1.94	1.06
66	.79	0	.05	.23	.32	.27	1.66	.16	.35	1.95	.63	0
67	.02	.35	0	.02	.01	.05	0	0	1.63	1.20	.08	0
68	.62	.44	.54	0	.22	0	.34	.02	1.14	5.70	1.21	0
69	.22	.37	.05	.36	.32	1.69	.04	2.82	4.77	6.26	2.98	1.28
70	3.31	0	.01	.01	6.43	.16	1.01	.18	1.61	0	1.57	.03
71	0	.64	0	.22	0	0	.10	1.35	1.92	1.69	2.64	0
72	.42	.05	.24	0	.38	5.88	0	.05	.88	.35	.24	.28
73	.25	.10	0	.21	.08	.17	0	1.67	1.45	15.66	.10	3.65
74	.09	.09	.02	0	.09	0	.18	0	1.67	.33	1.16	0
75	0	0	0	0	0	0	.28	0	5.06	5.81	1.63	0
76	.27	.07	.23	.17	0	.14	0	.10	0	1.46	.09	0
77	0	.36	0	.19	.34	0	0	.46	2.31	.75	.02	.42
78	1.13	0	.15	.05	.42	.06	.10	.11	.14	3.99	1.35	0
79	.36	.05	0	0	2.87	.83	1.90	.92	15.08	.11	.38	0
80	.34	0	.41	.02	0	.02	.99	0	1.25	.11	1.09	.08
Mean	.35	.20	.10	.30	.95	.65	.44	1.05	2.15	3.05	1.02	.37

TABLE 2. - POTENTIAL EVAPOTRANSPIRATION (PET) - millimetres - MANLEY AIRPORT
(10-day period - 11th - 20th)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
TF	78.9	78.2	79.4	80.7	82.1	83.2	84.0	83.5	83.2	82.6	81.2	80.5
Pr.	.35	.20	.10	.30	.95	.65	.44	1.05	2.15	3.05	1.02	.37
HM	71	70	69	70	73	71	70	73	79	84	74	70
G_o	686	772	866	929	951	952	948	932	886	802	708	656
RMM	118	133	149	160	164	164	163	161	153	138	122	113
N	11.1	11.4	11.9	12.4	12.9	13.1	13.0	12.6	12.1	11.6	11.2	10.9
PET	37	43	52	58	60	64	65	59	47	36	38	36

TABLE 3. - FREQUENCY ANALYSIS OF 10-DAY PERIOD RAINFALL - MANLEY AIRPORT (11th - 20th) 1942-80

Table 3.1 - JANUARY

CLASS (inches)	f	F	cf	P	C.P.
0 - .25	24	24	24	.62	.62
.26 - .50	9	9	33	.23	.85
.51 - .75	1	1	34	.03	.87
.76 - 1.00	2	2	36	.05	.92
1.01 - 1.50	1	.5	37	.01	.96
1.51 - 2.00	1	.5	38	.01	.97
2.01 - 4.00	1	.13	39	.003	1.00

Table 3.2 - FEBRUARY

CLASS (inches)	f	F	cf	P	C.P.
0 - 0.10	24	24	24	.62	.62
.11 - 0.20	4	4	28	.10	.72
.21 - .30	2	2	30	.05	.77
.31 - .40	3	3	33	.08	.85
.41 - .50	1	1	34	.03	.87
.51 - 1.00	3	.60	37	.02	.95
1.01 - 2.00	2	.20	39	.01	1.00

Table 3.3 - MARCH

CLASS (inches)	f	F	cf	P	C.P.
0 - .10	28	28	28	.72	.72
.11 - .20	5	5	33	.13	.85
.21 - .30	3	3	36	.08	.92
.31 - .40	0	0	36	0	.92
.41 - .50	1	1	37	.03	.95
.51 - 1.00	1	.20	38	.01	.97
1.01 - 2.00	1	.10	39	.00	1.00

Table 3.4 - APRIL

CLASS (inches)	f	F	cf	P	C.P.
0 - .10	17	17	17	.44	.44
11 - .20	5	5	22	.13	.56
.21 - .30	7	7	29	.18	.74
.31 - .40	2	2	31	.05	.79
.41 - .50	0	0	31	0	.79
.51 - 1.00	5	1	36	.13	.92
1.01 - 2.00	1	.1	37	0	.95
2.01 - 3.00	2	.2	39	.01	1.00

TABLE 3 (cont'd) - FREQUENCY ANALYSIS OF 10-DAY PERIOD RAINFALL - MANLEY AIRPORT (11th-20th - 1942-80)

Table 3.5 - MAY

CLASS (inches)	f	F	cf	P	C.P.
0 - .25	22	22	22	.56	.56
.26 - .50	8	8	30	.21	.77
.51 - .75	1	1	31	.03	.79
.76 - 1.00	0	0	31	0	.79
1.01 - 1.50	1	.5	32	.01	.82
1.51 - 2.00	1	.5	33	.01	.85
2.01 - 3.00	3	.75	36	.02	.92
3.01 - 6.00	1	.08	37	0	.95
6.01 - 10.00	2	.13	39	0	1.00

Table 3.6 - JUNE

CLASS (inches)	f	F	cf	P	C.P.
0 - .25	21	21	21	.54	.54
.26 - .50	1	1	22	.03	.56
.51 - .75	7	7	29	.18	.74
.76 - 1.00	3	3	32	.08	.82
1.01 - 1.50	3	1.5	35	.04	.90
1.51 - 2.00	2	1	37	.03	.95
2.01 - 3.00	0	0	37	0	.95
3.01 - 6.00	2	.17	39	0	1.00

Table 3.7 - JULY

CLASS (inches)	f	F	cf	P	C.P.
0 - .10	18	18	18	.46	.46
.11 - .30	7	3.5	25	.09	.64
.31 - .50	3	1.5	28	.04	.72
.51 - 1.00	4	.8	32	.02	.82
1.01 - 2.00	6	.6	38	.02	.97
2.01 - 3.00	1	.1	39	0	1.00

Table 3.8 - AUGUST

CLASS (inches)	f	F	cf	P	C.P.
0 - .10	16	16	16	.41	.41
.11 - .50	11	2.75	27	.07	.67
.51 - 1.00	4	.80	31	.02	.79
1.01 - 2.00	5	.50	36	.01	.92
2.01 - 8.00	2	.03	38	0	.97
8.01 - 18.00	1	.01	39	0	1.00

TABLE 3 (cont'd) - FREQUENCY ANALYSIS OF 10-DAY PERIOD RAINFALL - MANLEY AIRPORT (11th - 20th - 1942-80)

<u>Table 3.9</u> - <u>SEPTEMBER</u>

CLASS (inches)	f	F	cf	P	C.P.
0 - .25	8	8	8	.21	.21
.26 - .50	4	4	12	.10	.31
.51 - 1.00	3	1.5	15	.04	.38
1.01 - 2.00	12	3	27	.08	.69
2.01 - 4.00	7	.88	34	.02	.87
4.01 - 6.00	3	.38	37	.01	.95
6.01 - 16.00	2	.05	39	0	1.00

<u>Table 3.10</u> - <u>OCTOBER</u>

CLASS (inches)	f	F	cf	P	C.P.
0 - .50	10	10	10	.26	.26
.51 - 1.00	6	6	16	.15	.41
1.01 - 2.00	7	3.5	23	.09	.59
2.01 - 4.00	6	1.5	29	.04	.74
4.01 - 6.00	4	1.0	33	.03	.85
6.01 - 16.00	6	.3	39	.01	1.00

<u>Table 3.11</u> - <u>NOVEMBER</u>

CLASS (inches)	f	F	cf	P	C.P.
0 - .25	16	16	16	.41	.41
.26 - .50	3	3	19	.08	.49
.51 - 1.00	4	2	23	.05	.59
1.01 - 2.00	9	2.25	32	.06	.82
2.01 - 4.00	5	.63	37	.02	.95
4.01 - 6.00	2	.25	39	.01	1.00

<u>Table 3.12</u> - <u>DECEMBER</u>

CLASS (inches)	f	F	cf	P	C.P.
0 - .10	22	22	22	.56	.56
.11 - .30	7	3.5	29	.09	.74
.31 - .50	3	1.5	32	.04	.82
.51 - 1.00	2	.4	34	.01	.87
1.01 - 2.00	3	.3	37	.01	.95
2.01 - 4.00	2	.1	39	0	1.00

TABLE 4. - SPECIFIC CUMULATIVE PROBABILITIES FOR 10-DAY PERIOD RAINFALL (inches) MANLEY AIRPORT (11th - 20th - 1942-80)

1 - C.P.	C.P.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
.50	.50	.06	.02	0	.10	.06	.15	.05	.10	1.15	1.17	.35	.05
.67	.33	.01	0	0	0	.01	.05	0	0	.5	.45	.10	0
.80	.20	0	0	0	0	0	0	0	0	.15	.16	.02	0
.90	.10	0	0	0	0	0	0	0	0	0	.04	0	0

TABLE 5. - P.E.T./ ½ P.E.T. PROBABILITIES FOR 10-DAY PERIOD 11th - 20th (MANLEY AIRPORT)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	UNITS
* P.E.T.	37	43	52	58	60	64	65	59	47	36	38	36	millimetres
P.E.T.	1.46	1.70	2.04	2.28	2.36	2.52	2.56	2.32	1.86	1.42	1.50	1.42	inches
P(Pr < P.E.T.)	0.96	0.99	0.99	0.99	0.91	0.98	0.99	0.94	0.67	0.55	0.81	0.94	
P(Pr > P.E.T.)	0.04	0.01	0.01	0.01	0.09	0.02	0.01	0.06	0.33	0.45	0.19	0.06	
½ P.E.T.	0.73	0.85	1.02	1.14	1.18	1.26	1.28	1.16	0.93	0.71	0.75	0.71	inches
P(Pr < ½ P.E.T.)	0.90	0.97	0.99	0.95	0.83	0.89	0.92	0.86	0.44	0.40	0.65	0.87	
P(Pr > ½ P.E.T.)	0.10	0.03	0.01	0.05	0.17	0.11	0.08	0.14	0.56	0.60	0.35	0.13	

* Already calculated and shown in Table 2.

TABLE 6. - ADJUSTMENT OF INCOMPLETE GAMMA LAW TO A RAINFALL SAMPLE UTILIZING THE MOMENT METHOD - MANLEY AIRPORT - OCTOBER (1942-80)

Years	x_i	x_i^2	x_i^3	x_i^4
42	5.37	28.84	154.85	831.56
43	2.46	6.05	14.89	86.62
44	9.66	93.32	901.42	8707.80
45	2.08	4.33	9.00	18.72
46	.11	.01	.001	.000
47	2.02	4.08	8.242	16.65
48	2.92	8.526	24.897	72.699
49	1.50	2.25	3.375	5.063
50	12.28	150.798	1851.804	22740.156
51	.64	.410	.262	.168
52	.80	.64	.512	.410
53	0.0	0.0	0.0	0.0
54	1.06	1.124	1.191	1.262
55	3.62	13.104	47.438	171.725
56	9.55	91.203	870.984	8317.896
57	.21	.044	.009	.002
58	.76	.578	.429	.334
59	4.20	17.64	74.088	311.170
60	.23	.053	.012	.003
61	10.02	100.4	1006.012	10080.240
62	1.32	1.742	2.3	3.036
63	.82	.672	.551	.452
64	.90	.81	.729	.656
65	.04	.002	0.0	0.0
66	1.95	3.803	7.415	14.459
67	1.20	1.44	1.728	2.074
68	5.7	32.49	185.193	1055.600
69	6.26	39.188	245.314	1535.668
70	0.0	0.0	0.0	0.0
71	1.69	2.856	4.827	8.157

TABLE 6 (cont'd) - ADJUSTMENT OF INCOMPLETE GAMMA LAW TO A RAINFALL SAMPLE UTILIZING THE MOMENT METHOD - MANLEY AIRPORT - OCTOBER (1942-80)

Years	x_i	x_i^2	x_i^3	x_i^4
72	.35	.123	.043	.015
73	15.66	245.236	3840.389	60140.498
74	.33	.109	.036	.012
75	5.81	33.756	196.123	1139.474
76	1.46	2.132	3.112	4.544
77	.75	.563	.422	.316
78	3.99	15.920	63.521	253.450
79	.11	.01	.001	0.0
80	.11	.01	.001	0.0
Σ	117.94	904.082	9521.130	115470.87

Note: x_i represents 10-day rainfall for 11th - 20th October.

$$\sum x_i = S_1 = 117.94$$

$$\sum x_i^2 = S_2 = 904.082$$

$$\sum x_i^3 = S_3 = 9521.130$$

$$\sum x_i^4 = S_4 = 115470.87$$

If $R_2 = \frac{S_2}{S_1} = 7.666$

$$R_3 = \frac{S_3}{S_2} = 10.531$$

$$R_4 = \frac{S_4}{S_3} = 12.128$$

We can obtain a first approximation, S^1, of the scale parameter S:

$$S^1 = R_3 - R_2 = 2.865$$

and a first approximation, γ^1, of the shape parameter γ:

$$\gamma^1 = \frac{1}{S} (2R_2 - R_3)$$

$$\text{So } \gamma^1 = \frac{1}{2.865} (2 \times 7.666 - 10.531)$$

$$\gamma^1 = 1.676$$

Using $R = R_2 + R_4 - 2R_3$

Then $R = 7.666 + 12.128 - (2 \times 10.531)$

$R = -1.268$

We can then obtain better approximations of R_2 and R_3 by using R_{2a} and R_{3a} respectively,

$$\text{where } R_{2a} = R_2 - \frac{2R}{3 + \frac{37}{\gamma^1 + 1} + \frac{39}{(\gamma^1+1)(\gamma^1+2)}}$$

$$\text{and } R_{3a} = R_3 - \frac{R\left(7 + \frac{16}{{}^1+1}\right)}{3 + \frac{37}{\gamma^1 + 1} + \frac{39}{(\gamma^1+1)(\gamma^1+2)}}$$

$$\text{So } R_{2a} = 7.666 - \frac{2 \times (-1.268)}{3 + \frac{37}{2.676} + \frac{39}{2.676 \times 3.676}}$$

$$= 7.66 + \frac{2.536}{20.792}$$

$$R_{2a} = 7.787$$

Similarly R_{3a} = 11.323

So to obtain more accurate values of S and γ we can use:

$$S = R_{3a} - R_{2a}$$

i.e. $S = 11.323 - 7.787$

So $S = 3.563$..........................SCALE PARAMETER

and for $\gamma = \frac{1}{S}(2R_{2a} - R_{3a})$

$$\gamma = \frac{(2 \times 7.787) - 11.323}{3.536}$$

So $\gamma = 1.202$..........................SHAPE PARAMETER

We can now calculate FO, the curtailing parameter

where $FO = 1 - \frac{S_1}{N.\ S.\ \gamma}$

where N is the total no. of observations,

So N = 39

$$\text{Then } FO = 1 - \frac{117.94}{39 \times 3.536 \times 1.202}$$

$$= 1 - \frac{117.94}{165.761}$$

Hence FO = 0.288..........................CURTAILING PARAMETER

The parameters can now be fitted into the Incomplete Gamma Function.

$$\text{i.e.} \quad F(x) = 0.288 + \frac{0.712}{\Gamma(1.202)} \int_0^u u^{0.202} e^{-u} du$$

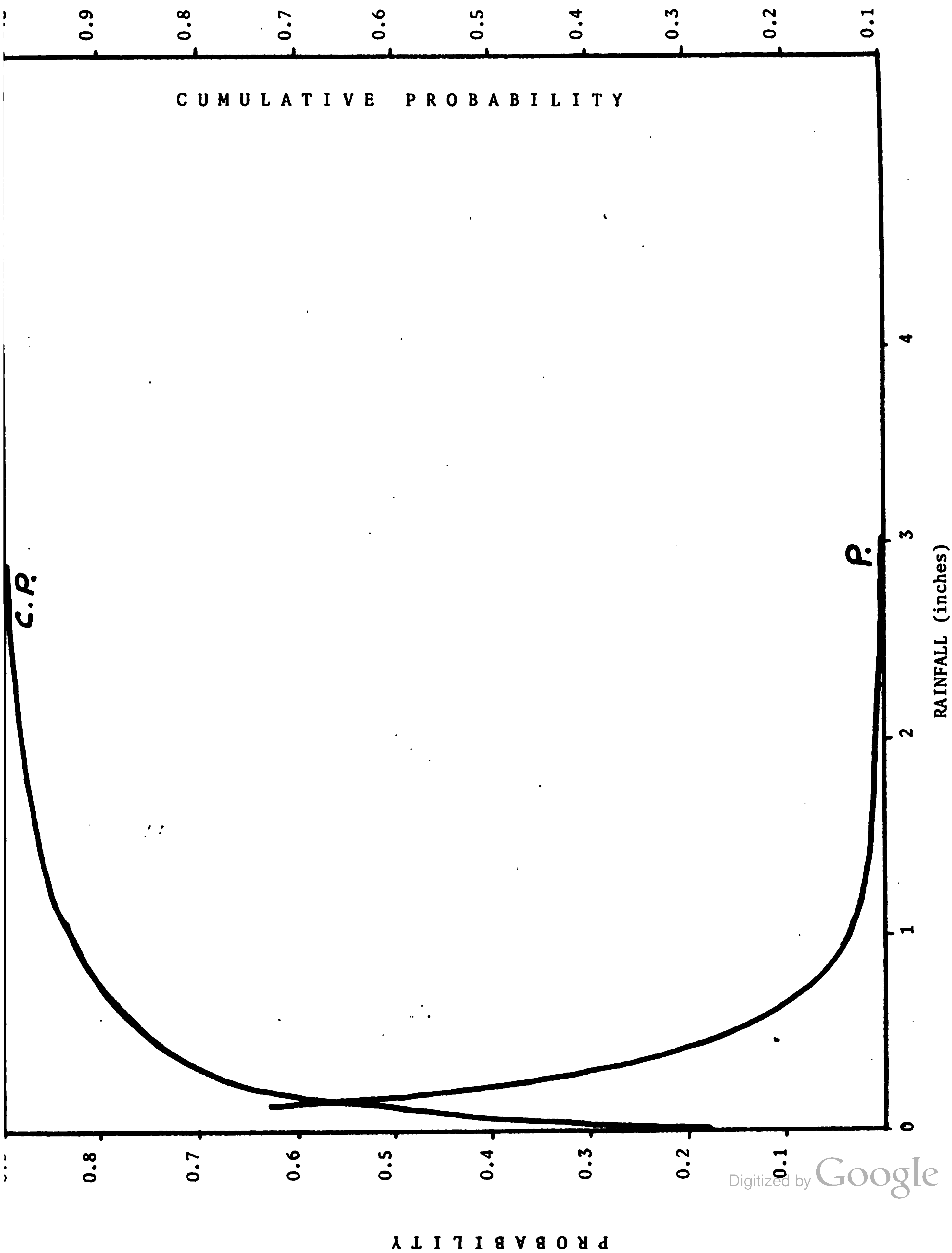
$$\text{with } u = \frac{x}{3.536}$$

$\Gamma(1.202)$ can now be read from a table giving the values of the Incomplete Gamma Function or be calculated using a formula which

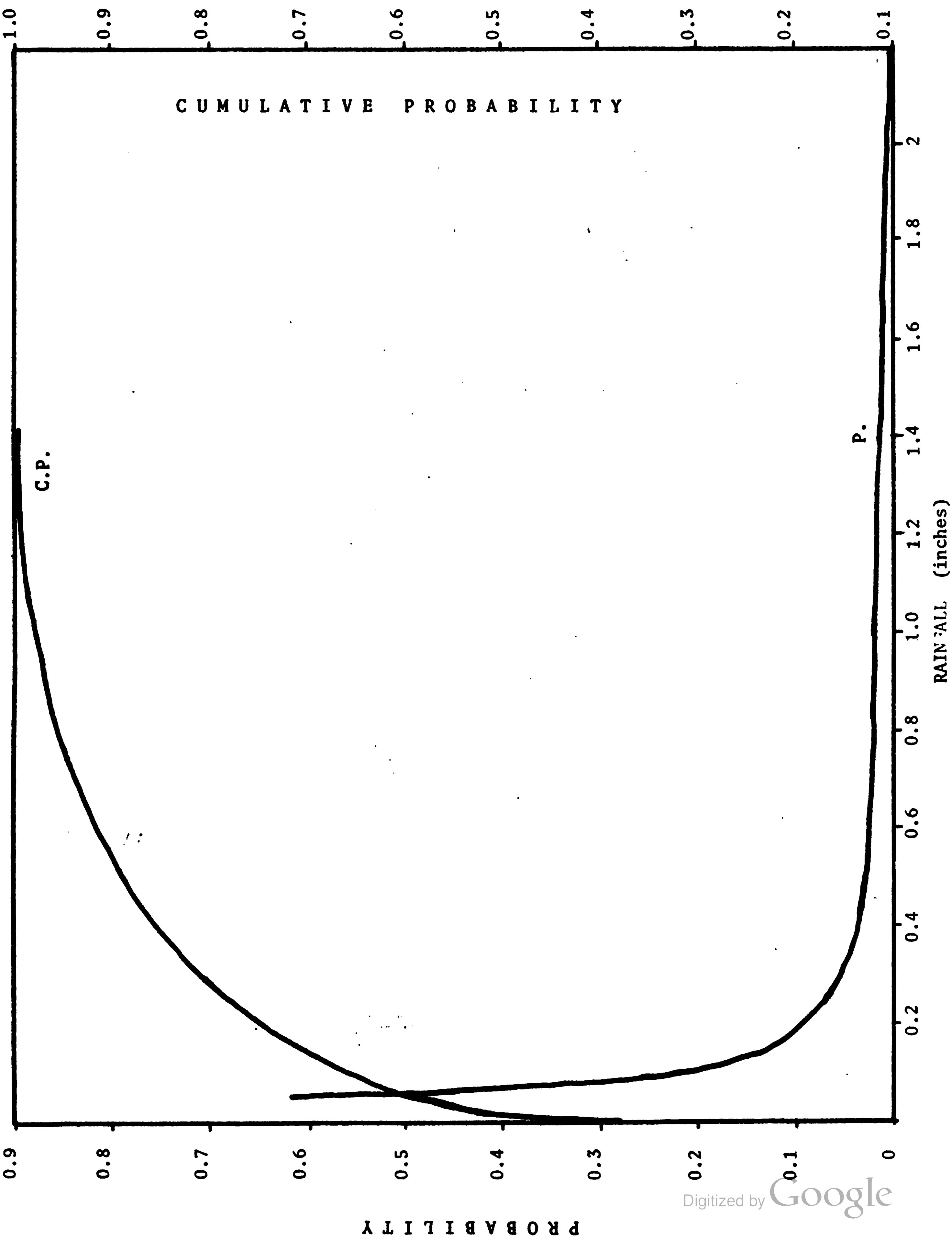
gives a close estimate of these values.

From this the probability of obtaining a specified amount of rainfall in the 10-day period October 11 - 20 or its converse can be obtained.

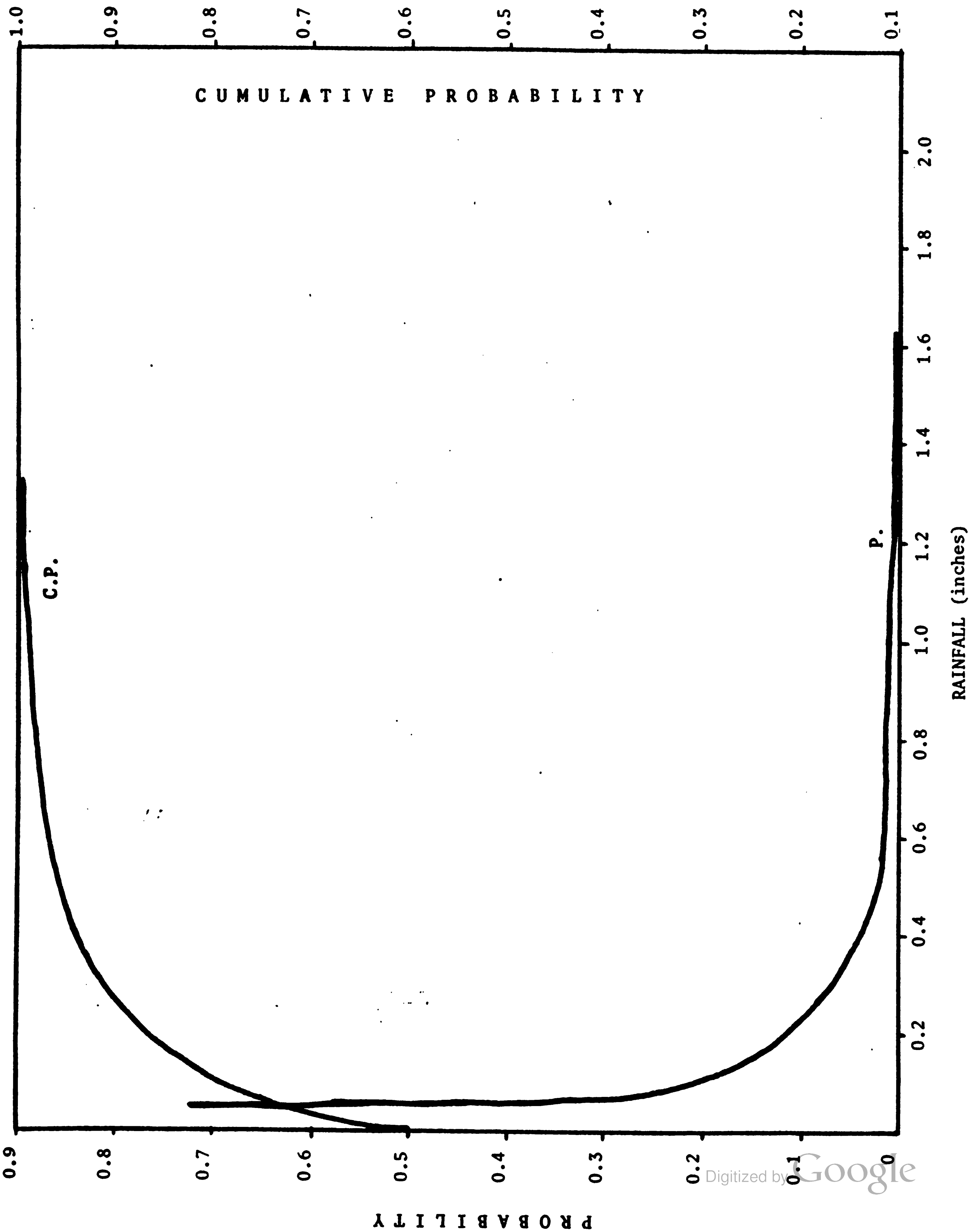
GRAPH 1. - PROBABILITY vs. RAINFALL - JANUARY 11 - 20 (MANLEY AIRPORT)



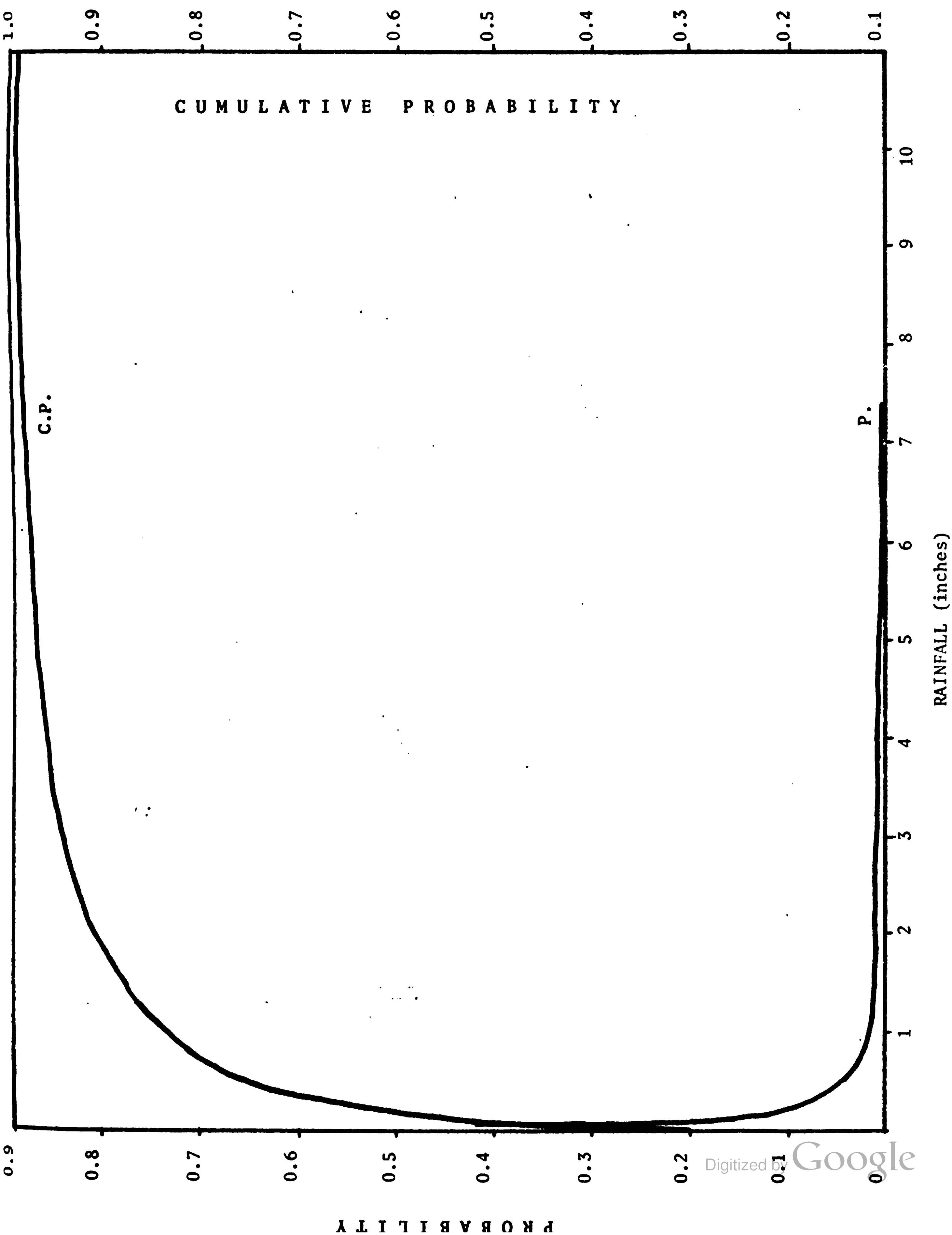
GRAPH 2. - PROBABILITY vs. RAINFALL - FEBRUARY 11-20 (MANLEY AIRPORT)



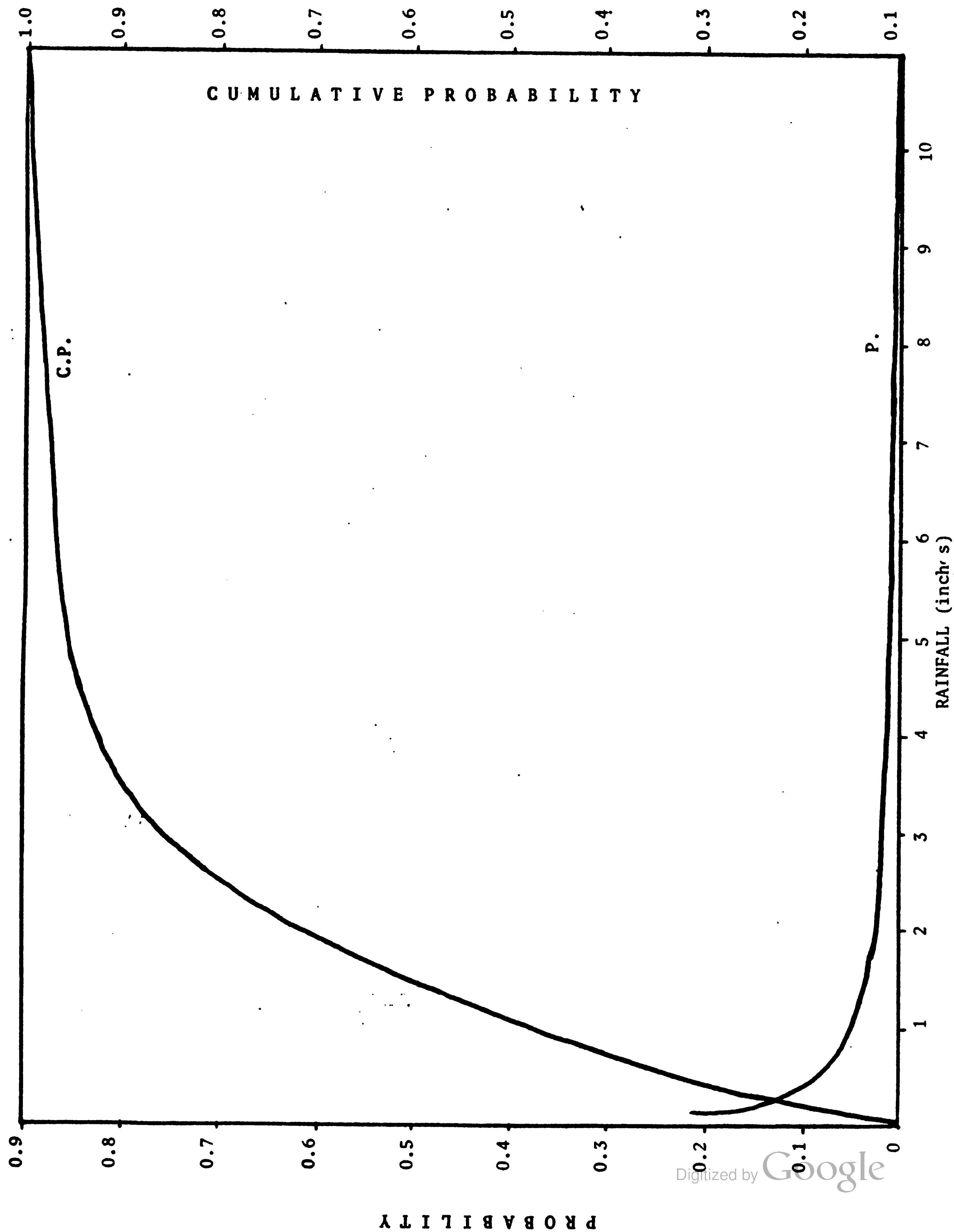
GRAPH 3. - PROBABILITY vs. RAINFALL - MARCH 11-20 (MANLEY AIRPORT)



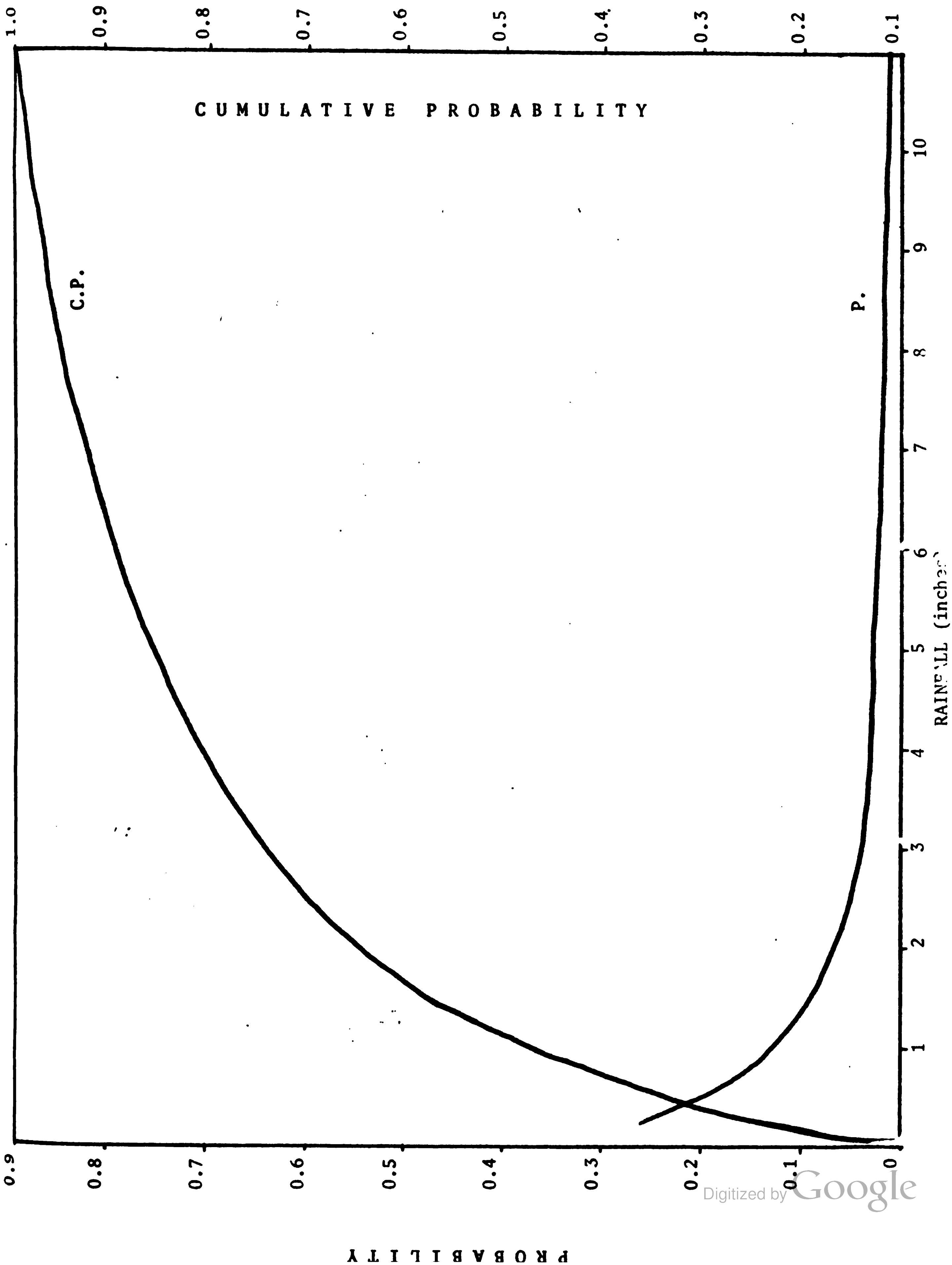
GRAPH 8. - PROBABILITY vs. RAINFALL - AUGUST 11-20 (MANLEY AIRPORT)



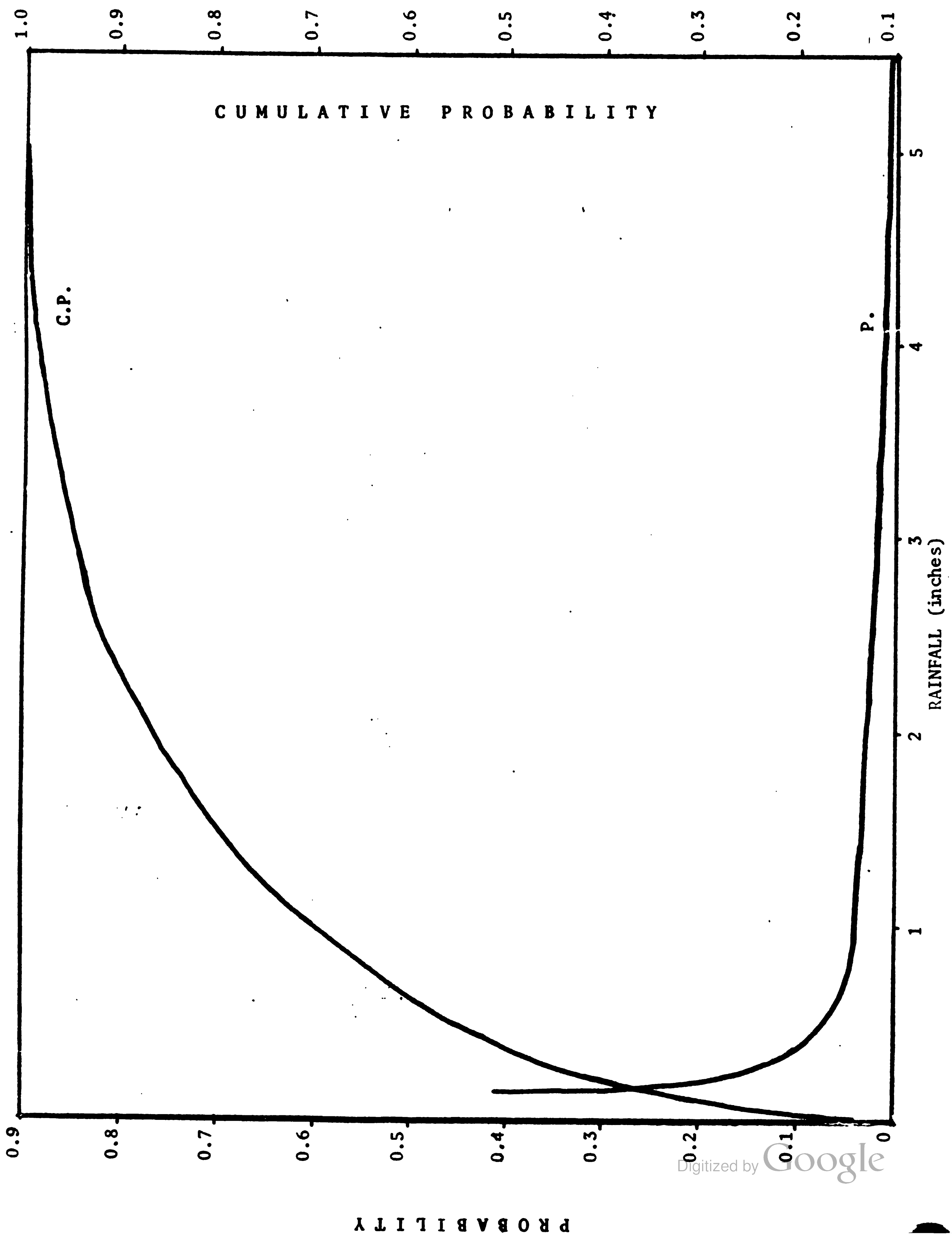
GRAPH 9. - PROBABILITY vs. RAINFALL - SEPTEMBER 11-20 (MANLEY AIRPORT)



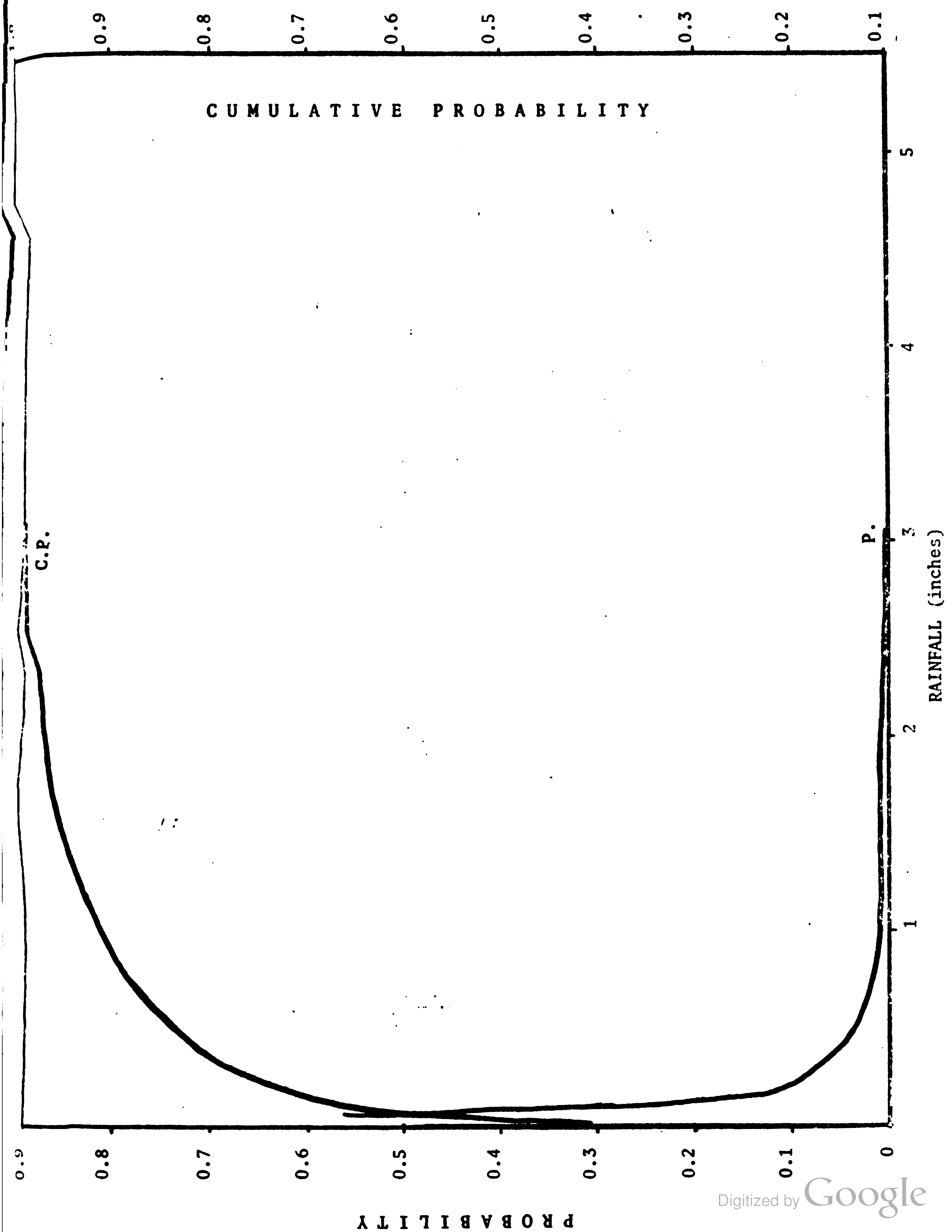
GRAPH 10. - PROBABILITY vs. RAINFALL - OCTOBER 11-20 (MANLEY AIRPORT)



GRAPH 11. - PROBABILITY vs. RAINFALL - NOVEMBER 11-20 (MANLEY AIRPORT)

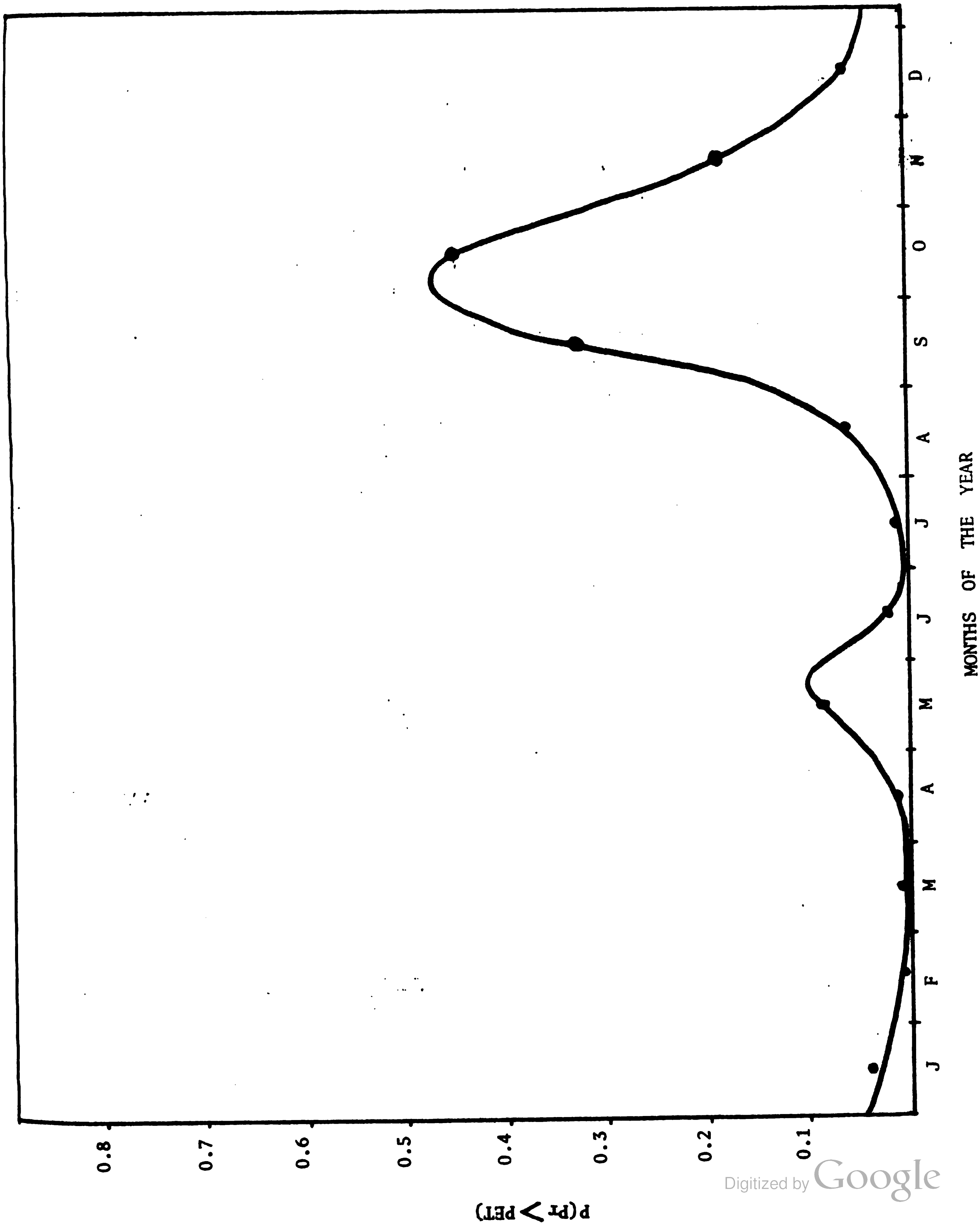


GRAPH 12. - PROBABILITY vs. RAINFALL - DECEMBER 11-20 (MANLEY AIRPORT)



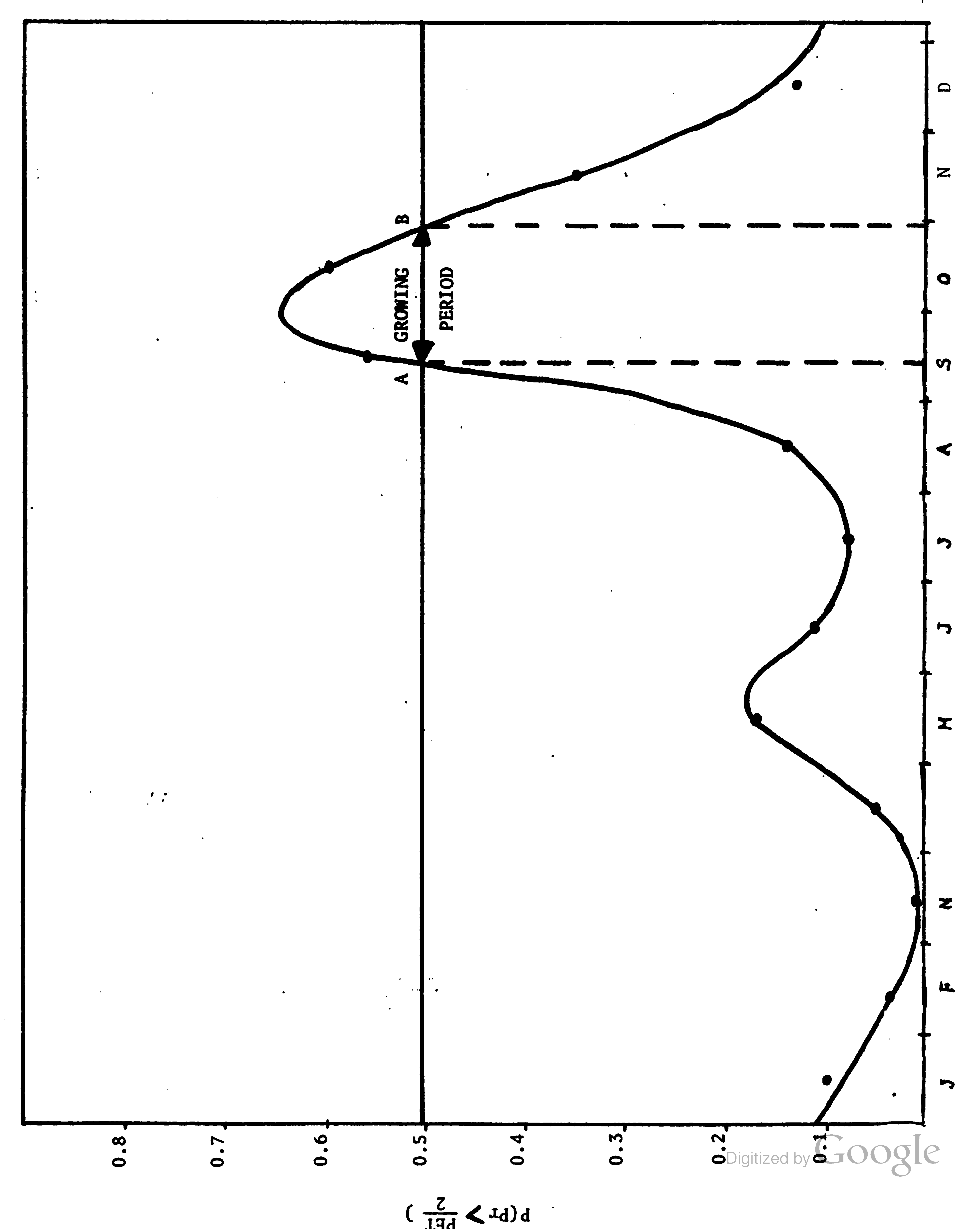
GRAPH 13. - PROBABILITY OF RAINFALL GREATER THAN P.E.T.

(1 - C.P.)



GRAPH 14. - PROBABILITY OF RAINFALL GREATER THAN ½ P.E.T.

(1 - C.P.)



AGRICULTURE IN JAMAICA

Collection of papers of the Office of IICA in Jamaica

1977 - 1978

No. I - 1	Fritz Andrew Sibbles, "Basic Agricultural Information on Jamaica Internal Document of Work", January 1977
No. I - 2	Yvonne Lake, "Agricultural Planning in Jamaica", June 1977
No. I - 3	Aston S. Wood, Ph.D., "Agricultural Education in Jamaica", September - October 1977
No. I - 4	Uli Locher, "The Marketing of Agricultural Produce in Jamaica", November 1977
No. I - 5	G. Barker, A. Wahab, L. A. Bell, "Agricultural Research in Jamaica", November 1977
No. I - 6	Irving Johnson, Marie Strachan, Joseph Johnson, "Land Settlement in Jamaica", December 1977
No. I - 7	Government of Jamaica, "Agricultural Government Policy Papers", February 1978
No. I - 8	Jose Emilio Araujo, "The Communal Enterprise", February 1980
No. I - 9	IICA and MOAJ, "Hillside Farming Technology - Intensive Short Course", Vols. I and II, March 1978
No. I - 10	Jose Emilio Araujo, "The Theory Behind the Community Enterprise - Seminar in Jamaica", March 1978
No. I - 11	Marie Strachan, "A National Programme for the Development of Hillside Farming in Jamaica", April 1978
No. I - 12	D. D. Henry, "Brief Overall Diagnosis of Hillside Farming in Jamaica", April 1978
No. I - 13	Neville Farquharson, "Production and Marketing of Yams in Allsides and Christiana", May 1978

No. I - 14 R. C. E. McDonald, A. H. Wahab, "Fertility Assessment of Newly Terraced Hillside Soils Using the Microplot Technique - the Allsides Case Study", 1978

No. I - 15 IICA - IDB, "Course in Preparation and Evaluation of Agricultural Projects", Vols. I and II, November 1977

No. I - 16 Neville Farquaharson, "Production and Marketing of Dasheen in Allsides and Christiana", June 1978

1978 - 1979

No. II - 1 O. Arboleda-Sepulveda (IICA-CIDIA), "Agricultural Documentation and Information Network in Jamaica", September 1978

No. II - 2 Victor Quiroga, "National Agricultural Information System", (NAIS-Jamaica) Project Profile, September 1978

No. II - 3 Joseph Johnson, "A Review on Land Reform in Jamaica for the Period 1972 - 1978", September 1978

No. II - 4 Neville Farquharson, "ABC of Vegetable Farming", A Draft High School Textbook, Vols. I, II, III and IV, February 1979

No. II - 5 Jerry La Gra, "Elements of an Agricultural Marketing Strategy for Jamaica", March 1979

No. II - 6 D. D. Henry, I. E. Johnson, "Agricultural Extension Service in Jamaica", March 1979

1979 - 1980

No. III - 1 H. R. Stennett, "Watersheds of Jamaica and Considerations for an Ordinal Scale of their Development", July 1979

No. III - 2 IICA-MAJ, "Hillside Farming in Jamaica", A Training Seminar, December 1978

No. III - 3 A. L. Wright, A. H. Wahab, H. Murray, "Performance of Six Varieties of Red Peas (Phaseolus vulgaris L.) on a Newly Terraced Ultisol in Jamaica", September 1979

No. III - 4 IICA/Jamaica Staff, "Agro-Socio-Economic Sample Survey of Allsides - Trelawny, Jamaica", September 1979

No. III - 5 IICA-MOAJ, "An Approach to Agricultural Settlement of Hilly Lands", October 1979

No. III - 6 IICA-MOAJ, "Tree Crops of Economic Importance to Hillside Farms in Jamaica", October 1979

No. III - 7 Canute McLean, "Production and Marketing of Peanuts", November 1979

1980

No. IV - 1 Joseph Johnson, "Production and Marketing of Red Peas in the Hilly Areas of Jamaica", January 1980

No. IV - 2 Lyn Snuffer, "Rural Women: An Annotated Caribbean Bibliography with special reference to Jamaica", January 1980

No. IV - 3 Vincent Campbell, Abdul Wahab, Howard Murray, "Response of Peanut (Arachis hypogaea L.) on a Newly Terraced Ultisol in Jamaica", January 1980

No. IV - 4 P. Aitken, A. Wahab, I. Johnson, A. Sahni, "Agro-Socio-Economic Survey - Pilot Hillside Agricultural Project 'PHILAGRIP' Southern Trelawny", February 1980

No. IV - 5 Glenys H. Barker, "Bibliography of Literature relating to Research and Development in the Agricultural Sector of Jamaica 1959 - 1979", March 1980

No. IV - 6 Milton R. Wedderburn, "Allsides Farmers' Pre-Cooperative A Socio-Economic Assessment", March 1980

No. IV - 7 Adele J. Wint, "The Role of Women in the Development Process", April 1980

No. IV - 8 Milton R. Wedderburn, "The Co-operative Input in the Development of the Pilot Hillside Agricultural Project (PHILAGRIP)", April 1980

No. IV - 9 MOJ/IICA/CARDI, Fruit Trees Seminar - "Research & Development of Fruit Trees", June 1980

No. IV - 10 Henry Lancelot, "Traditional Systems in Hillside Farming, Upper Trelawny, Jamaica", June 1980

No. IV - 11 IICA/Jamaica, "Pilot Hillside Agricultural Project", (PHILAGRIP), Project Document. Vols. I, II and III, June 1980

No. IV - 12 A. Wahab, I. Johnson, P. Aitken, H. Murray and H. Stennett, "Highlights of the Pilot Hillside Agricultural Project at Allsides", July 1980

No. IV - 13 I. Johnson, A. Wahab, P. Aitken, H. Payne, "Benchmark for a Project Profile for Developing a Peanut Industry in Jamaica", July 1980

No. IV - 14 P. Aitken, A. Wahab, I. Johnson, "The Allsides Post Peasant", August 1980

No. IV - 15 Norma Munguia, Percy Aitken, Abdul Wahab, Irving Johnson, "Salt Extraction by Solar Energy", A Mini-project, September 1980

No. IV - 16 Abdul H. Wahab, Percy Aitken-Soux, Irving E. Johnson and Howard Murray, "The Allsides Project in Jamaica - Developmental Potentials of Hillside Agriculture", September 1980

No. IV - 17 P. Aitken, A. Wahab, I. Johnson, A. Sahney and N. Munguia, "Rural Women Survey", Vols. I, II and III, October 1980

No. IV - 18 P. Aitken, I. E. Johnson, A. Wahab, "Assessment of Employment Among Small Hillside Farmers of Jamaica", November 1980

No. IV - 19 IICA/Jamaica "Pilot Hillside Agricultural Project", (PHILAGRIP), Final Project Document. October 1980.

No. IV - 20 P. Aitken, A. Wahab, I. E. Johnson, Bo-Myeong Woo, "IICA Evaluation of the First Phase FSB Allsides Project", (Internal Document of Work), November 1980

No. IV - 21 MINAG/IICA/CARDI - "Seminar on Multiple Cropping", December 1980

1981

No. V - 1 N. Munguia, P. Aitken, A. Wahab, I. Johnson, "Smoke Curing of Fish (as a household industry in Rural Jamaica)", January 1981

No. V - 2 P. Aitken, A. Wahab, I. Johnson, "Under-employment - It's Relation to the Agricultural Sector and Considerations for its Management", January 1981

No. V - 3 D. D. Henry, J. R. Gayle, "The Culture of Grafted Pimento (as spice crop for Allsides, Jamaica)", January 1981

No. V - 4 Abdul H. Wahab, Noel Singh, "Agricultural Research in Jamaica", February 1981

No. V - 5 P. Aitken-Soux, A. H. Wahab, I. E. Johnson, "Country Level Action Plan (CLAP)", May 1981

No. V - 6 P. Aitken-Soux, A. H. Wahab, I. E. Johnson, "Overview of Agricultural Development in Jamaica", May 1981

No. V - 7 Samuel Thompson, I. E. Johnson, P. Aitken-Soux, Abdul Wahab, "The Land Development & Utilization Act 1966", July 1981

No. V - 8 Abdul Wahab, Percy Aitken-Soux, Irving Johnson, Bo-Myeong Woo, Howard Murray, Joseph Dehaney, "The Experiences of Jamaica in the Management of Agricultural Production on Hillsides", July 1981

No. V - 9 Dave Hutton, Abdul Wahab, Howard Murray, "Yield Response of Yellow Yam (Dioscorea Cayenensis) After Disinfesting Planting Material of Pratylenchus Coffeae", July 1981

No. V - 10 Elaine Montague-Gordon, Abdul H. Wahab, Joseph Dehaney and Audrey Wright, "Performance of Eleven Varieties of Dry Beans (Phaseolus vulgaris) Over Two Successive Seasons on the Hillsides of Jamaica", August 1981

No. V - 11 Dave G. Hutton, Abdul H. Wahab, "Position Paper on Root Crops in Jamaica", August 1981

No. V - 12 Percy Aitken-Soux, Abdul H. Wahab, Irving E. Johnson, "Technical Assistance for the English Speaking Caribbean (Considerations for an IICA Strategy)" (Internal Document of Work), September 1981

No. V - 13 Bo-Myeong Woo, Abdul H. Wahab, Joseph Dehaney, "Crop Production on Hillsides using non-Bench Terracing Alternative Measures for Soil Conservation (first year's results of the Olive River Soil Conservation studies)", September 1981

No. V - 14 Abdul H. Wahab, Percy Aitken-Soux, Irving E. Johnson, Bo-Myeong Woo, Howard Murray and Joseph Dehaney, "Agricultural Production on Hillsides - the Allsides Project Case Study", September 1981

No. V - 15 D. G. Hutton, A. H. Wahab and J. Dehaney, "Investigating Critical Levels of Dry Rotting of Yellow Yam (Dioscorea Cayenensis) Planting Material, the Benefits of Disinfesting the Heads of Pratylenchus Coffeae and of After-Planting Nematicide Treatments", September 1981

No. V - 16 D. G. Hutton, A. H. Wahab, H. Murray and J. Dehaney, "Critical Levels of Dry Rotting of Yellow Yam (Dioscorea Cayenensis) Planting Material and Yield Responses After Disinfesting Heads of Pratylenchus Coffeae and After Post-Plant Nematicide Applications", September 1981

No. V - 17 E. Ayer and J. Reyes, "Seminar on Mediterranean Fruit Fly", September 30, 1981

No. V - 18 Bo-Myeong Woo, "Erosion Control Works in Korea", October 1981

No. V - 19 Irving E. Johnson and Percy Aitken-Soux, "Country Level Action Plan (CLAP)" (Third Revision - Internal Document of Work), October 1981

No. V - 20 Humberto Pizarro, "Programme of Work to Establish Guidelines for the Effective Administration, Operation and Maintenance of the Irrigation and Drainage District in the BRUMDEC Project" November 1981

No. V - 21 Humberto Pizarro, "The Operation of the Drainage System in the Black River Upper Morass Project", November 1981

No. V - 22 Humberto Pizarro, "Recommendations for Land Use and Irrigation Needs in the BRUMDEC Project", November 1981

No. V - 23 Humberto Pizarro, "Organization, Operations and Maintenance of the Irrigation System in the BRUMDEC Project", November 1981

No. V - 24 Humberto Pizarro, "Basic Information for Planning Water Management in the BRUMDEC Project", November 1981

1982

No. VI - 1 Vivian Chin, "Rice Research and Production in the BRUMDEC Project State-of-the-Art Review, Identification of Constraints and Interim Recommendations and Budget for Establishing 405 Hectares (1,000 acres) of Rice on the Clay Soils at BRUMDEC", January 1982.

No. VI - 2 Vivian Chin, "Programme of Work for the Short-Term Adaptive Production-Oriented Research on Rice in the BRUMDEC Project", January 1982

No. VI - 3 Claude Grand-Pierre, "Adaptive Research for Grain Production (BRUMDEC) - A Short-Term Programme", January 1982

No. VI - 4 Claude Grand-Pierre, "Experimental Procedures for Grain Crops Research in the BRUMDEC Project", January 1982

No. VI - 5 Charles Kennard, "Summary of the Proposed Programme of Work for Adaptive Production Oriented Research (Short-Term) in Vegetable Production in the BRUMDEC Project", January 1982

No. VI - 6 Charles Kennard, "Vegetable Production (BRUMDEC) - Review and Proposed Short-Term Adaptive Production Oriented Research Programme", January 1982

No. VI - 7 Bo-Myeong Woo, "Olive River Run-Off Plots - Description of the Experiment", January 1982.

No. VI - 8 Vivian Chin, "Fertilizer Experiments in BRUMDEC (Second Quarterly Report)," January 1982

No. VI - 9 Claude Grand-Pierre, "Third Quarterly Report of the Short Term Production Oriented Sorghum Research Programme", January 1982

No. VI - 10 Bo-Myeong Woo, Ministry of Agriculture, "Crop Production on Hillsides Using Non-Bench Terracing Alternative Measures for Soil Conservation", February 1982

No. VI - 11 Philemon Hoilett, Ina Pyne, Calvin Gray, Renford Baker, and Michel Eldin, "Workshop on Agroclimatic Zoning - case study Kingston, Jamaica", April 1982