

## EFFECTS OF PRECIPITATION EFFECTIVENESS ON THE YIELD OF IRISH POTATO (*SOLANUM TUBEROSUM*) IN JOS-PLATEAU, NIGERIA

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### ABSTRACT

This study investigates the effect of precipitation effectiveness on the yield of Irish potato in Jos-Plateau, Nigeria. Rainfall data for 20 years (1989–2008) was collected from National Root Crop Research Institute (NRCRI), Vom, Plateau state. Precipitation effectiveness indices including dry spell or drought, onset dates of rains, and hydrologic ratio were derived from and used together with total annual rainfall data to assess their effects on yields of Irish potato. The indices were subjected to various descriptive and inferential statistical techniques, including correlation and regression analysis. While the correlation analysis was employed to determine the degree of relationship between yields and the indices, the regression technique was adopted to identify the factors that are critical in influencing yields. Results reveal that while rainfall total correlates positively with yields, dry spell, onset dates of rains and hydrologic ratio exhibit negative correlation with yields. The correlation between onset dates of rains and yields was found to be statistically significant at 5% while others are insignificant. Step-wise regression analysis identifies onset dates of rains as the most critical factor affecting Irish potato in the area. The coefficient of determination of  $r^2=0.219$  shows that the index contributes about 22% to variations in the yields of Irish potato on the Plateau. It was recommended that further studies should consider combine effects of climate and other factors like farming practices, soil factors and cultural practices of the farmers so as to generate comprehensive information for better agricultural planning and development in the area.

**KEYWORDS:** Irish Potato, Precipitation Effectiveness, Regression Analysis, Jos-Plateau

### INTRODUCTION

Precipitation effectiveness indices are the major control of crop yield in the West African savannah region. It is not only the total amount of rainfall that matters; but how effective the rain is in terms of its time of occurrence, spread, intensity, frequency, and availability as soil moisture (Adefolalu, 1993). Irish potato plants are particularly sensitive to drought. Jones and Johnson (2000) observed that drought during the time of tuber formation in Irish potato reduces tuber yield greatly.

Studies have revealed that the plant requires more frequent supply of water than many other tuber crops. It is the moisture and nutrients that are useful to the plant at sprouting to emergence stage of Irish potato development (Burton, 1989). Sale (1973), Susnochi et al (1978), Zaag and Burton (1978), and Wolfe et al (1983) have conducted studies on water stress analysis on different varieties of Irish potato and reported that the rate of leaf expansion in the plant are slowed down or stopped and leaf variation is shortened as a result of water deficit, which adversely affect the development of the crop. In addition, physiological processes such as leaf diffusive resistance, photosynthetic efficiency and partitioning of assimilations are adversely affected as water deficit increases, thereby negatively influencing the development and yield of Irish potato.

The effect of water deficit on nine cultivars was investigated under field conditions in a semi-arid environment of Australia by Shumshi (1986). The nine cultivars were grown in the spring and summer under high temperature and under three water regimes: adequate water supply, moderate water deficit, and severe water deficit. It was discovered that severe drought reduce tuber yields in both seasons. In the same vein, Burton (1989) stated that moisture should be made available by steady rainfall throughout the flowering time up to tuberization. He also observed that rainfall without sunlight energy for photosynthesis reduces tuberization, thus decreasing yield. On the other hand, Anochilli (1978) reported that the optimum rainfall requirement of Irish potato ranges between 75cm to 125cm per annum. This is to say that growth and yield of Irish potato is particularly sensitive to rainfall and lack of it in form of drought can adversely affects the crop.

Although water stress causes reduction in yield, the relief of that stress, if it is severe, can have effect on tuber development. A research was carried out at Malheur experimental station from 1986 to 1989 to determine the soil water requirement for quality Irish potato. It was discovered that growth responded negatively to soil moisture deficit (Claton et al, 1999). Beukema and Zaag (1979) also indicated that irregular water supply during tuber development induces second tuber growth. They further stated that drought at early stages of tuber formation favours tuber attack by common scab. This points to the fact that Irish potato has high water requirement of roughly 1 inch per week. Hence, consistent soil moisture of 60-70% of field capacity is crucial especially during tuber development. This is because fluctuation in soil moisture causes abnormalities in tuber formation.

Interestingly, the National Root Crop Research Institute (NRCRI), Vom, Plateau State and other agricultural research institutions in Nigeria and abroad have made notable achievements in increasing the yield of Irish potato in the study area. The crop breeders have developed varieties of Irish potato, which are capable of responding to improved cultural practices (Zemba et al 2013). They have gone a long way towards solving the pests and diseases problems both in the field and storage (Okonkwo 1992). There has been an appreciable increase in the land area and this facilitates higher output of Irish Potato in the area. This increase could be attributed to advances in agricultural technology such as the introduction and provision of extension services as a way of diversifying sources of livelihood (Wuyep, 2012). Zemba et al (2013) have also investigated the response of Irish potato to climatic parameters of air temperature, rainfall and soil temperature. However, their work did not cover derived precipitation effectiveness such as drought or dry spell, onset dates of rains, hydrologic ration etc, which are also very critical in crop growth and yield.

### **Study Area and Methods**

This study investigates the contribution of precipitation effectiveness to the yield of Irish potato. This study employs an experimental approach to crop-climate relationship. An experimental farm located at the Headquarters of the National Root Crop Research Institute (NRCRI) Vom, in Jos-South area of Plateau state served as source of data for the study. The site lies on latitude  $8^{\circ}43'N$  and Longitude  $8^{\circ}46'E$  with an altitude of 1293.2m above sea level. Jos-South Local government area is one of the seventeen Local government areas in Plateau state of Nigeria .it is made of four districts: Vwang, Du, Gyel and Kuru.

Two sets of data were collected from the National Root Crop Research Institute (NRCRI) Vom. The first set is agricultural data of Irish Potato yields in tonnes per hectare of the Greta and B6934-11 species over a period of 20 years (1989 to 2009). The second set of data involved rainfall records, from where the precipitation effectiveness indices were derived. These precipitation effectiveness indices include onset dates of rains, hydrologic ratio, and dry spell. The following explain how these indices were computed:

## Determination of Precipitation Effectiveness Indices

### Onset Dates of Rains

This refers to the time a place receives an accumulated amount of rainfall sufficient for growing of crops. It is not the first day the rain falls, but a time when accumulated rainfall value is up 51mm. Out of several methods proposed by Walter (1967), Ilesanmi (1972), Adefolalu (1989), and Adebayo (1994) for Nigeria, the Walter's method which utilizes monthly rainfall data was adopted for this study. The formula used for computing the onset dates of rains is:

Days in the month  $\times \left[ \frac{51 - \text{accumulated rainfall of previous months}}{\text{Total rainfall for the month}} \right]$ , where the month under reference is that which the accumulated total of rainfall are in excess of 51mm of rainfall. If the previous months' records is not in excess of 51, it is disregarded and the next month with more than 51mm of rainfall is taken as the start of rainy season in order to avoid prolong drought. For the end of the rainy season, the formula is taken in reverse order.

### Hydrologic Ratio

Hydrologic ratio, the degree of wetness or dryness, is the ratio of mean annual rainfall (P) to the Potential Evapo-transpiration (PE). It is an important precipitation effectiveness parameter which determines where crop will thrive well or not (Adefolalu 1988). The formula is:  $\frac{P}{PE}$

### Dry Spell or Drought

During the rainy season, it is not expected that precipitation will occur on daily basis. However, when breaks in between rains spells are prolonged, plants may wilt and die or have reduced yield. Breaks of equal to or more than three pentades (15 days) are considered serious anomalies (Adefolalu 1993).

### Statistical Analysis

The three precipitation indices above were derived from rainfall data for each year. These were analyzed alongside the total annual rainfall and subjected to descriptive statistical technique like mean, standard deviation and variance as well as correlation and regression inferential statistical techniques. The regression analysis was employed because, according to Jackson (1997), crop yields are affected by a wide range of factors and separation of the influence of one from the others can be extremely difficult or impossible. Thus, the practice of using the multiple regression techniques when subjecting climate–crop yield relationship to statistical analysis is desirable. Therefore, in order to select the parameters that are critical to Irish potato yield, a step-wise multiple regression analysis was adopted. The yield was expressed as dependent variable (y) and precipitation effectiveness indices as independent variables (x). The equation used is:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_nx_n, \text{ where,}$$

Y = Irish potato yield in ton/ha

a = Constant

b = Is the rise or falls as X changes

X<sub>1</sub> = Total rainfall (mm)

X<sub>2</sub> = Number of dry spells between April and August (pentads with less than 2mm of rainfall)

X<sub>3</sub> = Onset dates of rains

X<sub>4</sub> = Hydrologic ratio

## RESULTS AND DISCUSSIONS

### Precipitation Effectiveness Indices and Irish Potato Yield

The descriptive statistics in Table 1 reveals that the variance is relatively high (3.94) with a standard deviation of 1.99 with respect to yields of Irish potato in Jos-Plateau. This indicates that the yields vary substantially over time. There are also significant variations in total rainfall (3182.42) and onset dates of rains (6.12), which are pointers to the fact that the dependent variables could subsequently vary as well. However, Zemba et al (2013) have already reported that such variations in soil temperatures, air temperatures and rainfall from April to August are also obtainable and contribute significantly to variations in the yields of Irish potato. To be able to assess the degree of relationship between yields and these variables, a Pearson correlation analysis was employed.

The result of correlation analysis (Table 2) shows that yields correlate well with precipitation effectiveness indices. While yields exhibit positive correlation with total annual rainfall it reveals a negative correlations with onset dates of rains, dry spell and hydrologic ratio. It is only onset dates of rains that is statistically significant at 5% level of probability. This means that if the planting is done in April, as mostly is the case, better yields would be expected than when the planting is delayed to May as a result of delay in onset date of rain. Total annual rainfall is not significantly correlated with yields because, according to Adefolalu (1993), it is not only the total that matters to crop, but how effective it is in terms of occurrence, spread, intensity and frequency. Zemba et al (2013) also observed that high rainfall during tuber initiation of Irish potato is not healthy to the crop as it causes poor aeration and subsequently poor development of the tubers. The statistically insignificant correlation between yields of Irish potato and dry spells and hydrologic ratio could be attributed to the fact that study area experiences less of drought being a highland region. In addition, the area is highly humid with little degree of potential evapo-transpiration

**Table 1: Descriptive Statistics of Precipitation Effectiveness Indices and Yields of Irish Potato**

Variables	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Total annual rainfall	20	575.30	772.10	13852.30	692.6150	56.41294	3182.419
Dry spell	20	.00	3.00	37.00	1.8500	.87509	.766
Onset dates of rains	20	100.00	108.00	2074.00	103.7000	2.47301	6.116
Hydrologic ratio	20	.70	.80	15.00	.7500	.05130	.003
Yields of Irish potato	20	11.10	19.80	286.50	14.3250	1.98518	3.941
Valid N (listwise)	20						

### Effects of Precipitation Effectiveness on Yields of Irish Potato

The combined effect of the precipitation effectiveness indices on yield of Irish potato was analyzed using step-wise regression technique. The result of the bivariate correlation discussed above only depicted the isolated relationship between the indices and Irish potato yield. It does not indicate the level of importance that the variables influence yields. Therefore, in order to clearly identify and assess the degree of importance of those parameters that are critical to Irish potato yields, these variables were subjected to step-wise regression analysis. Result of the step-wise regression analysis (Table 2) reveals that only one of those parameters contribute significantly at  $P < \text{or} = 0.01$  to the variation in Irish potato yield. This index is onset dates of rains. The variable accounts for about 22% of the total variance in the yield in the area.

**Table 2: Correlation and Regression of Yields with Precipitation Effectiveness Indices**

Variables	Correlation Coefficient (R)*	Regression				Regression Equation
		T	R	R <sup>2</sup>	F	
Total rainfall	0.153	0.542				
Dry spell	-0.045	0.097				
Hydrologic ration	-0.245	1.522				
Onset dates of rains	-0.468*	2.247	-0.468	0.219	5.047	Y = -0.037 + 0.376x

r = 0.43 is significant at 5%

## CONCLUSIONS

Based on the findings above, it can be concluded that all the precipitation indices correlate with yields at various degrees. However, onset dates of rains appear to be a very critical element influencing the yields of Irish potato. It is observed that this index contributes about 22% of the variations in the yields of Irish potato in Jos-Plateau. These findings have underscored the importance of agro-climatic parameters as significant factors determining the yields of crops in the study area.

## RECOMMENDATIONS

- Based on the findings, the following recommendations have been advanced:
- Planting of crops in the month of April should be encouraged as long as the onset dates of rains have set in. This is to allow the crop mature early enough to avert the danger of high rainfall which characterized the month of August. This is because this high rainfall is unhealthy to the tubers of the crops.
- More weather stations should be established in areas where none existed so as to facilitate generating climatic data all over the area to provide information for long term planning and development of agriculture generally in the area
- Late-blight resistance varieties of Irish potato should be developed in order to eradicate late-blight diseases which reduce greatly the yields of Irish potato.
- This study only considered the derived rainfall parameters. Research works need to be conducted in other areas like cultural practices on the farms, soil factor so as to understand the contribution of each of these factors.

## REFERENCES

1. Adebayo, A. A. (1994). The effect of climate on the growth of cotton at Ngurore, Adamawa state, Paper presented at NGA conference at College of Education, Ikere, Ekiti state, Nigeria.
2. Adefolalu, D. O. (1988) Precipitation, evapo-transpiration and the ecological zones in Nigeria, *Applied climatology*, 39, 81-89
3. Adefolalu, D. O. (1989) Ecological and Land use mapping of Niger state, phase III report.
4. Adefolalu, D. O. (1993) "Rainfall climatology and agricultural extension" Nigeria, *NGA journal*, 5, 32-36
5. Anochilli, B. C. (1978) Food crop for tropical agriculture, Macmillan press limited, 16-18

6. Beukema, H. And Zaag, D. E. (1979) Marketable yield and plant population in Irish potato improvements: Some factors and facts, *International agric Center, Wageningen, The Netherland*, 35-125.
7. Cliaton, C; Shork, D; Erik, B. G; Feibert, Y; and Lamond, D. S. (1999) Malhear Experiment Station, Oregon State University, USA
8. Jones H. And Johnson, J. (2000) Effect of irrigation at different minimum levels of soil moisture an imposed drought on yields of onions and Irish potato, *Proc. American Hort. Sc. Journal*, 71, 440-445
9. Okonkwo, J. C. (1992) Irish potato production in Nigeria, Training Workshop Paper, NRCRI, Vom, Nigeria.
10. Sale, P. J. (1973) Production of vegetable crops in a region of high solar inputs, *Australian Journal of Agriculture, Irish potato, Research*, 24, 733-749
11. Shumshi, D. (1986). The effect of high temperature and water deficit on potato, *Journal of the European Association for potato Research*, 29(1), 95-107.
12. Susnoschi, M., , D. and Meir, T. (1978) The reaction of Irish potato cultivation to different irrigation regimes, *pamphlets Agricultural research organization, Bet Dugan, No.204, 13*
13. Walter, M. W. (1967) The length of rainy season in Nigeria, *Nigerian Geography Journal*, 10, 123-128.
14. Wolfe, D. W., Fereres, E. and Voss, R. E. (1983) Growth and yield Response of two Irish potato cultivars to various levels of applied water, *Irrigation science, Journal*, 3, 211-222.
15. Zaag, D. E. and Burton, W. G. (1978) Potential yield of Irish potato crop and its limitations, *survey paper, 7<sup>th</sup> Triennial conference of the European Assoc. For Irish potato research, Warsaw,, Poland*, 7-22.