World Rural Observations

Websites:
http://www.sciencepub.net
http://www.sciencepub.net/rural

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Factorial Analysis on Factors That Affect Plant Growth (Maize)

Oladimeji O. A.(1)*, Adesanya K. K.(2), Oyenuga I. F.(3), and Oyenuga R. O.(4)

[1]Department of Statistics, Federal Polytechnic, Ile-Oluji, Ondo State, Nigeria
[2]Health Information Management Department, Ogun State College of Health Technology, Ilese-Ijebu, Nigeria
[3]Department of Mathematics and Statistics, The Polytechnic, Ibadan, Nigeria
[4]Department of Mechanical Engineering, Osun State College of Technology, Esa-Oke, Nigeria
*Corresponding Author: adedipupo.oladimeji@gmail.com

ABSTRACT: Maize crop is a key source of food and livelihood for millions of people in many countries of the world. It is produced extensively in Nigeria, where it is consumed roasted, baked, fried, pounded or fermented. This study focuses on effect of factors on yield of maize from the results of the experiment carried out at Federal college of agriculture, Akure, Ondo state. A 3^3 factorial design is employed since three factors each occurring at three levels replicated eight times per cell. From the Analysis of variance on yield, It id found out that there is significant difference in the fertilizers effect on the yield of maize, there is significant interaction effect between fertilizers and herbicides on the yield of maize and also there is significant interaction effect between herbicides and water volumes on the yield of maize since their respective P-values is less than probability of error margin at 5%. [Oladimeji O. A., Adesanya K. K., Oyenuga I. F., and Oyenuga R. O. **Factorial Analysis on Factors That Affect Plant Growth (Maize).** World Rural Observ 2022;14(2):34-42]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 6. doi:10.7537/marswro140221.06.

Keywords: Environmental Factor, Fertilizers, Growth, Herbicides, Yield, Investigators, Maize, Reliability, Significant, Variation.

INTRODUCTION

Plant growth, measured either as the gradual and continued enlargement of the vegetative parts or as the ultimate production of the reproductive organs, is modified by some factors which surround the plant. In either case the magnitude of the response of the plant and the variation in the factors are more easily determined than the effect of one or all of these factors on the development of the plant. To obtain quantitative measures of the influence of factors on the growth of plants, most investigators have studied each factor separately. This is especially true of laboratory and greenhouse experiments where an attempt is made to keep all the factors constant, except one. Few investigators have attempted to study the influence of factors on plants grown under field conditions because of the uncertainty of adequately evaluating the influence of these factors. Recent advances in statistical methods, however, provide means of segregating different factors and of relating a given factor to one or more definite responses of the plant.

Another difficulty encountered in field studies dealing with the effect of factors is that only one crop can, be matured each season while the results of several seasons are necessary to obtain measurable variations in factors. In this study it was possible, within a given season, to modify certain of the factors by varying the rate of planting. A third difficulty arises in that organisms show variation in their rate of growth at different stages of their life, cycle. Consideration was given, therefore, to the stage of development of the plant in evaluating the effect of the factors on any particular growth response. Experiments on which this paper is based have been carried on under field conditions. Factors like fertilizer contributes significantly to yield/ response of crop, other factors like environmental factor can also contribute to the growth of plant. Plant responses which are correlated with the environmental factors include rate of growth of the various vegetative parts of the plant, relative rate of photosynthesis, carbohydrate fractions of the leaves, time of development, protein content of the reproductive parts of the plant, and yield of the plants. The factors to be considered in this study are fertilizer, herbicide and water volumes.

STATEMENT OF THE PROBLEM

Emphasis has been placed on maize yield research which involves the establishment of quantitative relationships between maize yields and multiple factors of production. Although numerous factors, both controlled and uncontrolled, affect maize production, the use of controlled variables such as plant nutrients from fertilizers has attracted the most attention. It has been noted by many scientists that particular maize may vary in its response to applied fertilizers depending on season and location effects. This presents a problem in extrapolating predicted yields from one experimental location to a larger geographical general area and, therefore, recommendations also. The causes of this uncertainty have, in general, been recognized, but not much attempts have been made to account for their effects on response of maize to applied fertilizers. This uncertainty concerning the influence of uncontrolled variables accentuates the need to conduct yield research in a framework that will provide for the quantification of the effects of herbicides and water volume on the response of crops to applied fertilizers.

AIM AND OBJECTIVES OF THE STUDY

The aim of this research work; is to apply a three-factor factorial design in determining the significant effect of fertilizers, herbicides, and water volumes on the yield of maize with the following objectives:

1. to determine the significant difference in the effect of fertilizers on the yield of maize.
2. to determine the significant difference in the effect of herbicides on the yield of maize.
3. to determine the significant difference in the effect of water volumes on the yield of maize.
4. to determine the significant interaction effect between fertilizers and herbicides on the yield of maize.
5. to determine the significant interaction effect between herbicides and water volumes on the yield of maize.

RESEARCH HYPOTHESES

Based on the focused of the research and its objectives, our hypothesis would be combination of the null and alternative statement of hypothesis viz:

Let τ_i represents fertilizers' effect

Let β_j represents herbicides' effect

Let $\gamma_k$represents water volumes' effect

Let $(\tau\beta)_{ij}$ represents fertilizers and herbicides interaction's effect

Let $(\beta\gamma)_{jk}$ represents herbicides and water volumes interaction's effect

Let $(\tau\gamma)_{ik}$ represents fertilizers and water volumes interaction's effect

Let $(\tau\beta\gamma)_{ijk}$ represents fertilizers, herbicides and water volumes interaction's effect

LITERATURE REVIEW

Plant growth analysis is now a widely used tool in such different fields as plant breeding Wilson and Cooper, (1970); Plant physiology, Rodgers and Barneix, (1988) and plant ecology Grime and Hunt, (1975); Its methodology started to evolve in the 1920s Blackman, (1919); West et ai, (1920) with what is now called the 'classical' approach. In this method, the relative growth rate (RGR) is calculated by dividing the difference in In-transformed plant weight between two harvests by the time interval between those harvests. Compound rates, like the net assimilation rate (NAR; increase in weight per unit of leaf area and time), are computed in a similar, discrete, way. The classical method was challenged in the 1960s, when increased computational power enabled curve-fitting procedures with polynomial equations on progressions of plant weight and leaf area with time Vernon and Allison, (1963); Hughes and Freeman, (1967). Although this method, which will be called the 'polynomial' approach, evaded some of the problems encountered in the classical approach, its application is not always satisfactory. For example, choice of the degree of the polynomial carries large consequences for growth parameter estimates Nicholls and Calder, (1973).

Alternatively, it has been suggested that specific growth equations like the Richards function, in which the parameters have a biologically more relevant meaning, are used. Notwithstanding the large body of literature on the methodology of growth analysis; little attention has been paid to such practical problems as how the experimental design used affects growth parameter estimates and how adequately different methods describe time trends in RGR and NAR. However, since underlying trends in RGR and its components are not known, these comparisons can never yield a conclusive answer to the question of which method is the most accurate. In the present paper three problems encountered when using growth analysis are considered, by constructing hypothetical populations of plants for which were imposed variability in dry weight as well as time trends of growth rates. Firstly, some consequences of transforming or not transforming plant weights to log-normal values will be examined. Secondly, the consequences of the choice of different experimental designs on the reliability of the mean RGR estimate will be explored. Thirdly, the three different curve-fitting methods will be compared for their adequacy in describing time trends in RGR, NAR and leaf area ratio (LAR, leaf area/total plant weight). For other aspects of growth analyses, like testing differences in RGR and NAR, or the application of growth functions designed for plants grown in competition.

In recent years, the effect of exogenous organic amendments on soil properties has received renewed attention Birkhofer et al., (2008); Herencia et al., (2008). Although the utilization of mineral fertilizers could be viewed as the best solution in terms of plant productivity, this approach is often inefficient in the long-term in tropical ecosystems due to the limited ability of low-activity clay soils to retain nutrients Lal, (2006). Intensive use of agrochemicals in agricultural systems is also known to have irreversible effects on soil and water resources, such as a reduction of soil organic matter (SOM) stocks and pollution of surface and ground water resources Townsend et al., (2008). In this context, restoring and maintaining SOM contents are thus essential for the long-term chemical quality of the soil and crop productivity in the tropics. Numerous studies have shown the beneficial effects of OM amendments, such as crop residues and compost, on soil fertility, crop yield and ecosystem services i.e.Herencia et al., (2008); Decomposing organic amendments slowly release nutrients which may be taken up by plants Lal, (2006); and thus result in improvedagroecosystem productivity. The utilization of exogenous OM improves ecological functions such as the water and nutrient storage capacity, resistance to compaction and erosion, infiltration and aeration, and resistance to infection of roots by soil borne pathogens Whalen et al., (2003). OM amendments are also favorable for the development of soil macrofauna which play a key role in improving soil quality and providing ecosystem services Birkhofer et al., (2008).

Among soil organisms favored by organic fertilization, earthworms have been identified as a key functional group and are considered as soil engineers due to their influence on soil biological, physical and chemical properties.

Earthworm activity is also used for the management of organic waste and the production of high-quality compost, known as 'vermicompost' Edwards et al., (2004). This substrate has been shown to improve the germination, growth, and yield of plants, due to faster release of nutrients than traditional composts, and the production of plant growth hormones Arancon et al., (2008). Vermicompost has been extensively studied as a plant growth media and soil amendment Edwards and Arancon, (2004); but its utilization in interaction with endogeic earthworms has only been addressed in a few studies. Furthermore, few studies have been made on vermin compost produced from buffalo manure, which is the main source of OM for many farmers in Asia, especially in Northern Vietnam.

The aim of this study was to investigate the impact of compost and vermin compost produced from buffalo manure on plant growth in the presence or absence of earthworms. We used a common agricultural soil from the red river delta in Northern Vietnam and an endogeic earthworm species Metaphireposthuma found in the same area. A one-year experiment was carried out in a greenhouse where a maize–tomato–maize cycle was planted in containers with and without earthworms. Our hypotheses were that (i) vermicompost amendments lead to increased plant growth compared to the application of compost and chemical fertilization and that this effect is constant over time (Edwards et al., 2004), (ii) earthworm development is higher with compost than vermicompost, due to the chemical stabilization of vermicompost and (iii) earthworm activity will improve plant growth and yield.

METHODOLOGY

Sir Ronald Fisher, the statistician, eugenicist, evolutionary biologist, geneticist, and father of modern experimental design, observed that experiments are only experience carefully planned in advance, and designed to form a secure basis of new knowledge' (Fisher, 1935). Experiments are characterized by the: (1) manipulation of one or more independent variables; (2) use of controls such as randomly assigning participants or experimental units to one or more independent variables; and (3) careful observation or measurement of one or more dependent variables. The first and second characteristics—manipulation of an independent variable and the use of controls such as randomization—distinguish experiments from other research strategies. In an experiment, we deliberately change one or more process variables (or factors) in order to observe the effect the changes have on one or more response variables. The (statistical) design of experiment (DOE) is an efficient procedure for planning experiments so that the data obtained can be analyzedto yield objective conclusions.

An experimental design is a plan for assigning experimental units to treatment levels and the statistical analysis associated with the plan (Kirk, 1995) Design of experiments begins with determining the objectives of an experiment and selecting the process factors for the study. An experimental design is the laying out of a detailed experimental plan in advance of doing the experiment. Well-chosen experimental design maximizes the amount of "information" that can be obtained for a given amount of experimental effort. The experimenter has control over certain effect called treatment populations, or treatment combinations. The experimenter generally controls the choice of the experimental unit of whether are to be into homogeneous. An experimental design is the laying out of a detailed experimental plan in advance of doing the experiment. Well-chosen experimental design maximizes the amount of "information" that can be obtained for a given amount of experimental effort. The experimenter has control over certain effect called treatment populations, or treatment combinations. The experimenter generally controls the choice of the experimental unit of whether are to be into homogeneousgroups called BLOCKS. Design and analysis of experiment involve the use of statistical methods in planning and executing the research to ensure that necessary data are collected and processed to facilitate valid conclusions. A factorial design as one of the areas of deign of experiment is often used by scientists wishing to understand the effect of two or more independent variables upon a single dependent variable.

THE 3^K FACTORIAL DESIGN

The 3^k factorial design, that is, a factorial arrangement with k factors, each at three levels. Factors and interactions will be denoted by capital letters. We will refer to the three levels of the factors as low, intermediate, and high. Several different notations may be used to represent these factor levels; one possibility is to represent the factor levels by the digits 0 (low), 1(intermediate), and 2(high). Each treatment combination in the 3^k design will be denoted by k digits, where the first digit indicates the level of factor A, the second digit indicates the level of factor B... and the kth digit indicates the level of factor K. For example, in a 3^2 design, 00 denotes the treatment combination corresponding to A and B both at the low level, and 01 denotes the treatment combination corresponding to A at the low level and B at the intermediate level.

RESEARCH DESIGN

In this research work, secondary data (yield of maize) were collected from farm cultivated on half plot of land in the year 2016. The half plot of land was first cleared before the ridges were made, the total ridges made were 216 which were segmented into (9), each containing 24 ridges. The 24 ridges were also segmented into 3, which makes it 8 replicates per factor level. The maize (Soar 1) was planted in June 2016, the herbicides (Altraforce, Xtraforce and Metaforce) were applied a day after planting, the water volumes (5Litres, 7.5Litres and 10Litres) were also applied everyday according to how the ridges were segmented irrespective of rainfall. The fertilizers

{N:P:K(20:10:10), N:P:K(15:15:15), and UREA} were applied in August and the maize were harvested in September on the farm land and weighed per ridge in kilogram (kg). In this research work, there is one dependent variable (Maize yield) and three independent variables (Fertilizers, Herbicide and Water volume) each at three levels. The experimental design employed was a 3×3×3 factorial experimental design with eight (8) replicates per cell. The maize yield data collected was presented in Table 4.1 below. Data collected were analyzed electronically using Statistical Package for Social Science (SPSS) version 20.

DATA ANALYSIS

The data presented is a table form of data presentation of 3^3 factorial design of maize yield (kg) with 8 replicates per cell as shown below:

Table 4.1: Showing the data collected on Yield of Maize with 8 replicates per cell.

HERBICIDES	FERTILIZER								
	NPK 201010			NPK 151515			UREA		
	WATER VOLUME			WATER VOLUME			WATER VOLUME		
	5 liters	7.5 liters	10 liters	5 liters	7.5 liters	10 liters	5 liters	7.5 liters	10 liters
ALTRAFORCE	0.10	0.10	0.16	0.17	0.19	0.19	0.04	0.02	0.15
	0.03	0.10	0.10	0.13	0.14	0.30	0.05	0.22	0.20
	0.24	0.33	0.09	0.10	0.90	0.24	0.15	0.15	0.11
	0.09	0.05	0.12	0.12	0.13	0.15	0.13	0.10	0.15
	0.07	0.30	0.11	0.03	0.23	0.37	0.04	0.15	0.15
	0.15	0.05	0.11	0.24	0.15	0.50	0.04	0.15	0.15
	0.18	0.10	0.11	0.10	0.15	0.20	0.12	0.15	0.15
	0.12	0.14	0.11	0.17	0.15	0.20	0.12	0.15	0.15
XTRAFORCE	0.17	0.25	0.14	0.35	0.16	0.11	0.13	0.15	0.07
	0.24	0.19	0.08	0.37	0.13	0.19	0.11	0.11	0.16
	0.15	0.11	0.29	0.35	0.34	0.24	0.10	0.16	0.05
	0.16	0.26	0.19	0.26	0.17	0.09	0.13	0.10	0.12
	0.18	0.20	0.09	0.05	0.10	0.26	0.15	0.06	0.03
	0.04	0.20	0.10	0.12	0.70	0.47	0.05	0.13	0.04
	0.19	0.20	0.01	0.30	0.05	0.24	0.12	0.13	0.08
	0.19	0.20	0.11	0.12	0.16	0.08	0.91	0.13	0.08
METAFORCE	0.04	0.04	0.14	0.06	0.11	0.19	0.24	0.20	0.04
	0.34	0.06	0.14	0.09	0.11	0.17	0.10	0.12	0.08
	0.44	0.10	0.16	0.16	0.07	0.29	0.15	0.14	0.15
	0.24	0.12	0.14	0.06	0.02	0.27	0.06	0.15	0.16
	0.13	0.12	0.15	0.25	0.05	0.03	0.13	0.10	0.10
	0.25	0.12	0.19	0.24	0.10	0.13	0.08	0.11	0.14
	0.16	0.12	0.09	0.17	0.16	0.17	0.15	0.16	0.15
	0.27	0.12	0.11	0.17	0.29	0.18	0.15	0.20	0.14

Source: Field Experiment 2016, Federal College of Agriculture, Akure

DATA ANALYSIS AND INTERPRETATIONS

Table 4.2: showing the validity of the data collected

Between-Subjects Factors

		Value Label	N
Water_Volu	1	5LITRES	72
	2	7.5LITRES	72
	3	10LITRES	72
Herbicides	1	Altraforce	72
	2	Xtraforce	72
	3	METAFROCE	72
Fertilizer	1	NPK202020	72
	2	NPK151515	72
	3	UREA	72

Interpretation: the above table 4.2 shows that all cases are entered on SPSS correctly.

Table 4.3: showing the Analysis of variance on Yield
Tests of Between-subjects Effects
Dependent Variable: Yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Water_Volu	.004	2	.002	.149	.862
Herbicides	.032	2	.016	1.337	.265
Fertilizer	.164	2	.082	6.868	.001
Water_Volu * Herbicides	.152	4	.038	3.180	.015
Water_Volu * Fertilizer	.057	4	.014	1.182	.320
Herbicides * Fertilizer	.078	4	.020	1.632	.168
Water_Volu * Herbicides * Fertilizer	.097	8	.012	1.013	.427
Error	2.261	189	.012		
Total	2.845	215			

Based on decision rule of hypothesis testing procedure, the following inferences can be made from the Analysis of variance table in table 4.3 above;

Interpretation1: the P-value of 0.862 > 0.05, shows that effect of water volumes are not statistically significance on the yield of maize.

Interpretation2: the P-value of 0.265 > 0.05, shows that effect of herbicides are not statistically significance on the yield of maize.

Interpretation3: the P-value of 0.001 < 0.05, shows that effect of fertilizers are statistically significance on the yield of maize.

Interpretation4: the P-value of 0.015 < 0.05, shows that interaction effect of water volumes and herbicides are statistically significance on the yield of maize.

Interpretation5: the P-value of 0.320 > 0.05, shows that interaction effect of water volumes and fertilizers are not statistically significance on the yield of maize.

Interpretation6: the P-value of 0.168 > 0.05, shows that interaction effect of fertilizers and herbicides are not statistically significance on the yield of maize.

Interpretation7: the P-value of 0.427 > 0.05, shows that interaction effect of water volumes, fertilizers and herbicides are not statistically significance on the yield of maize.

Table 4.4: Multiple comparisons of means on Water Volumes

Multiple Comparisons

Dependent Variable: Yield
LSD

(I) Water_Volume	(J) Water_Volume	Mean Difference (I-J)	Std. Error	Sig.
5LITRES	7.5LITRES	.0031	.01823	.867
	10LITRES	.0097	.01823	.594
7.5LITRES	5LITRES	-.0031	.01823	.867
	10LITRES	.0067	.01823	.715
10LITRES	5LITRES	-.0097	.01823	.594
	7.5LITRES	-.0067	.01823	.715

Interpretation: since all P-values are greater than 0.05, it means there is no significance effect of water volumes at $\alpha = 0.05$ significance level.

Table 4.5: showing the multiple comparisons of means on fertilizers

Multiple Comparisons

Dependent Variable: Yield
LSD

(I) Fertilizer	(J) Fertilizer	Mean Difference (I-J)	Std. Error	Sig.
NPK201010	NPK151515	-.0474*	.01823	.010
	UREA	.0181	.01823	.323
NPK151515	NPK201010	.0474*	.01823	.010
	UREA	.0654*	.01823	.000
UREA	NPK201010	-.0181	.01823	.323
	NPK151515	-.0654*	.01823	.000

Interpretation1: when pair of NPK20:10:10 and NPK15:15:15 is compared, there is effect on the model that is P-value < 0.05

Interpretation2: when pair of NPK20:10:10 and Urea is compared, there is no effect on the model that is P-value > 0.05

Interpretation3: when pair of NPK15:15:15 and NPK20:10:10 is compared, there is effect on the model that is P-value < 0.05

Interpretation4: when pair of NPK15:15:15 and Urea is compared, there is effect on the model that is P-value < 0.05

Interpretation5: when pair of Urea and NPK20:10:10 is compared, there is no effect on the model that is P-value > 0.05

Interpretation6: when pair of Urea and NPK15:15:15 is compared, there is effect on the model that is P-value < 0.05

General conclusion is: we conclude that the group means of NPK15:15:15 is the highest of the three fertilizers used in the study leading to the rejection of the null hypothesis on fertilizers, that is leading to the statistically significance of fertilizers on the model.

SUMMARY AND CONCLUSION

From the table of Analysis of Variance on Yield (Table 4.3) in previous chapter, the P-value of .001 for Fertilizers implies that the null hypothesis of no significant difference in the fertilizers effect on the yield of maize is rejected. The P-value of 0.862 for Water volumes implies that the null hypothesis of no significant difference in the water volumes effect on the yield of maize is not rejected. The P-value of 0.265 for Herbicides implies that the null hypothesis of no significant difference in the herbicides effect on the yield of maize is not rejected. The P-value of 0.320 for Fertilizers and Water volumes interaction implies that the null hypothesis of no significant interaction between fertilizers and water volumes on the yield of maize is not rejected. The P-value of 0.168 for Fertilizers and Herbicides interaction implies that the null hypothesis of no significant interaction between fertilizers and herbicides on the yield of maize is rejected. The P-value of 0.015 for Water volumes and Herbicides interaction implies that the null hypothesis of no significant interaction between fertilizers and herbicides on the yield of maize is rejected. The P-value of 0.467 for Fertilizers, Water volumes and Herbicides interaction implies that the null hypothesis of no significant interaction between fertilizers, water volumes and herbicides on the yield of maize is not rejected.

On the basis of the scope, methodology and analysis of the data, it can be concluded that at 5% significant level:

1. There is significant difference in the fertilizers effect on the yield of maize.
2. There is no significant difference in the herbicides effect on the yield of maize.
3. There is no significant difference in the water volumes effect on the yield of maize.
4. There is significant interaction effect between fertilizers and herbicides on the yield of maize.
5. There is no significant interaction effect between fertilizers and water volumes on the yield of maize.
6. There is significant interaction effect between herbicides and water volumes on the yield of maize.
7. There is no significant interaction effect between fertilizers, herbicides and water volumes on the yield of maize.

REFERENCES

Arancon, N.Q., Edwards, C.A., (2006b). Effects of vermicomposts on plant growth. In: Proceedings of the Vermi-Technologies Symposium for Developing Countries, Department of Science and Technology—Philippine Council for Aquatic and Marine Research and Development, Los Banos, Philippines.

Birkhofer K., et. al. (2008). Long term organic farming fosters below and above ground biota. Implications for soil quality, biological controland productivity. Soil biology and biochemistry 40(2008) 2297-2308

Blackman, V. H. (1919). The compound interest law and plant growth. Annals of Botany 33:353–360

Edwards, C.A., Burrows, I., (2004). The potential of earthworm composts as plant growth media. In: Edwards, C.A., Neuhauser, S.P.B. (Eds.), Earthworms in Environmental and Waste Management. Academic Publication B.V., The Netherlands, pp. 211–220.

Fisher,R.A. (1935).*The Design of Experiments*. Edinburgh and London: Oliver and Boyd.

Grime, J. B. & Hunt, R. (1975). Relative growth rate: its range and adaptive significance in a local flora. Journal of Ecology, 63, 393-422.

Herencia Juan F., Ruiz J.C., Esmeralda M., Sebasriana M., Jaime Villaverde, Celia Miq (2008). The effect of organic and mineral fertilization of micronutrient availability in soil. Soil science 173(1), 68-80.

Hughes A.P. and Freeman F.R. (1967). Growth analysis using frequent small harvests. Journal of Applied Ecology, 4(2) 553-560.

Kirk, R.E. (1995) ***Experimental Design*****:** Procedures for the Behavioral Sciences (3rd edn.). Pacific Grove, CA:Brooks/Cole.

Lal, R. (2006) Enhancing Crop Yields in the Developing Countries through Restoration of the Soil Organic Carbon Pool in Agricultural Lands. Land Degradation & Development, 17, 197-209.

Nicholls A.O., Calder D.M. (1973). Comments on the use of regression analysis for the study of plant growth. 72(3), 571-581.

Rodgers, C.O.; Barneix, A.J (1988). Cultivar differences in the rate of nitrate uptake by intact wheat plants as related to growth rate Physiologia Plantarum (Denmark) ISSN: 0031-9317 Volume:72 Issue:1

Townsend, C. R., S. S. Uhlmann, and C. D. Matthaei. Individual and combined responses of stream ecosystems to multiple stressors. (2008) Journal of Applied Ecology 45(6):1810 – 1819

Vernon A.J. and Allison J.C.S. (1963). A method of calculating net assimilation rate. Nature, Lond. 200, 814.

West, C., G. E. Briggs, and F. Kidd. (1920). Methods and significant relations in the quantitative analysis of plant growth. New Phytologist 19:200–207

Whalum J.K., Hu Q., and Liu, A. (2003). Compost applications increase water-stable aggregates in conventional and no-tillage systems. Soil sci.soc Am. J. 67: 1842-1847

Wilson D., Cooper J.P. (1970). Effect of Selection for Mesophyll cell size on growth and assimilation in LoliumPerenne L. New phytol (1970) 69, 233-245.

4/25/2022