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Metrics and Indicators to Aid in the Financing of Agricultural Loans to Rural Families: A Systematic Review

By Euclides Alfredo Matusse

Abstract- The use of indicators provides several benefits among which the effective evaluation in the financing of agricultural loans to borrowers and also the support to the credit manager and portfolio in making strategic decisions. Despite the relevance of using metrics to aid in the financing of agricultural credit given the diversity of the existing business model, organizations have neglected their practice. Reasons for this fact include: (i) although access to credit is an significant factor in the adoption of agricultural technologies and increased agricultural incomes among rural farmers, are generally not sufficiently mature to make use of measurements or 2) researchers are not yet widely aware of the need for exploratory studies that identifies a mechanism to propose an agricultural credit financing strategy based on indicators through the analysis of a set of metrics. In this context, this article aims to conduct a systematic review to collect evidence on the existence of metrics and indicators that are specific for financing agricultural loans to rural families. The study produced 64 articles selected from the current literature and were not repeated because they were relevant.

Keywords: *loans, credit, accessibility, metrics, indicators, systematic review.*

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METRICS AND INDICATORS TO AID IN THE FINANCING OF AGRICULTURAL LOANS TO RURAL FAMILIES AS A SYSTEMATIC REVIEW

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Metrics and Indicators to Aid in the Financing of Agricultural Loans to Rural Families: A Systematic Review

Euclides Alfredo Matusse

Abstract The use of indicators provides several benefits among which the effective evaluation in the financing of agricultural loans to borrowers and also the support to the credit manager and portfolio in making strategic decisions. Despite the relevance of using metrics to aid in the financing of agricultural credit given the diversity of the existing business model, organizations have neglected their practice. Reasons for this fact include: (i) although access to credit is an significant factor in the adoption of agricultural technologies and increased agricultural incomes among rural farmers, are generally not sufficiently mature to make use of measurements or 2) researchers are not yet widely aware of the need for exploratory studies that identifies a mechanism to propose an agricultural credit financing strategy based on indicators through the analysis of a set of metrics. In this context, this article aims to conduct a systematic review to collect evidence on the existence of metrics and indicators that are specific for financing agricultural loans to rural families. The study produced 64 articles selected from the current literature and were not repeated because they were relevant. After the initial filter, 42 were pre-selected to identify potential primary studies by reading the title, summary, and conclusion using the PICO method (population, intervention, comparison, and outcome) and a new subset by the reading criterion in depth by the total reading of the article. Those who presented consistent information about metrics and indicators for agricultural credit financing remained. In this second stage (final selection) 18 studies were selected for a detailed comparative analysis.

Keywords: loans, credit, accessibility, metrics, indicators, systematic review.

I. INTRODUCTION

Microfinance Institutions (MFIs) play a vital role in supporting the agrarian sector, as well as in rural development by issuing loans to farmers Yara et al. (2019). Microcredit is a product of providing financial services to low-income borrowers, including consumers and independent workers, who traditionally do not have access to banking and related services (Gonzalez-Vega, 2008). This initiative enables several benefits such as adopting technologies, building assets, smoothing consumption, managing risks and increasing incomes among farmers (Omonona et al. 2008; Mosca and Dadá 2014), but also growth of employment and poverty reduction (Soubotina et al. 2000).

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However, to achieve these benefits, it is necessary to implement the rigorous planning, because the risks arising this strategy can affect the viability and sustainability of microcredit institutions due to the characteristics of the loan Onyeagocha et al. (2012).

However, the dynamic nature of the financing of agricultural credit imposes several challenges caused by the accessibility of the loan Khalid Mohamed (2003), capacity for reimbursement and spatial distance between the place of farmers (arable land) in Loan sources Abiodun et al. (2009). These challenges were classified as technical, non-technical, and hybrids illustrated in table VII. The factors are related to determinants of access to credit and reimbursement capacity Adu et al. (2019); non-technical challenges are related to characteristics of borrowers, firms and lenders, and hybrid factors are challenges that relate to delinquency characteristics of reimbursement and institutional factors Allan Mitei et al. (2016).

Faced with these challenges in order to support agricultural credit financing for rural families, we conducted a systematic review of existing solutions in the literature, which allowed us to identify the approaches, models, techniques, methodologies and their particularities. Thus, this article aims to present and analyze the results of this review, considering the technical, non-technical and hybrid aspects of each approach.

The remainder of the work is organized as follows: section 2 presents a characterization of access to agricultural credit financing to the rural family; In step 3, it describes the methodology of the review and its use; In section 4, the results of the study: maps of the questions and the solutions identified in this literature; Step 5 analyzes and identifies approaches, comparing their characteristics; In section 6 presents the conclusions and finally, 7 discusses the opportunities for future work and bibliographical references.

II. ACCESS TO THE FINANCING OF AGRICULTURAL CREDIT THE RURAL FAMILY

Microfinance is the provision of a wide range of financial services such as deposits, loans, payment services, money transfers and insurance for poor and low-income families Conroy (2002). This definition have

to be based on poor customers to have access to high-quality service, which include not only agricultural credit, rural credit, but also savings, insurance, and funds transfer.

Although the terms "rural credit," "agricultural credit" are often used alternately, it matters to note the subtle differences between them, because there is a logical sequence in the way that credits has to be obtained in financial sectors CGAP (2003). Rural credit refers to credit services in rural areas that target people in all incomes; agricultural credit is likely to finance activities related to agriculture Le Thi Minh (2014).

The financing of agricultural credit remains a challenge categorized into three main areas: inherent characteristics of borrowers such as guarantees, high liquidity interest, lack of insurance and their business, the credit institution and Appropriateness of the loan product to the borrower and, systematic risk of external factors, economic, political and business environment in which the borrower is inserted by Derban et al. (2005).

Looking for a representation that defines the level of financing of agricultural credit, Figure 1 illustrates the scenario (determinants of access to formal and semiformal credit) and the relationship between them, considering the spatial distance between the site of the small Farmers in relation to loan sources (Abiodun et al. 2009, Njoku, 2016). The representation of groups of farmers is composed of members located in cooperatives requesting credit to mitigate the agency's problems, moral risk and adverse selection to replace the requirement of guarantees. In turn, credit demand has an overview of the borrower's business and its determinants, to extract an indicator to direct agricultural credit financing to rural families Matusse (2019).

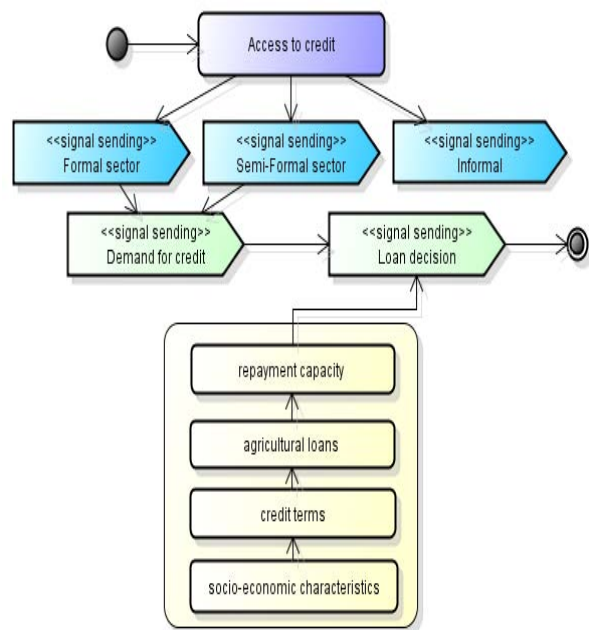


Fig. 1: Determinants of access to credit. Source: Author's summary.

In this sense, credit managers are concerned about the initial stage because it provides useful information to help the decision-making process to improve access to credit by the majority of small-scale producers. In this way, it has to be observed that was financing agricultural credit with appropriate criteria is not a trivial solution, it is necessary to take into account some particularities that go beyond technical issues, which cannot be ignored, such as trust, management of Cultural diversity, education, domestic wealth, land fragmentation and credit amount Hussien Komicha and Bo Öhlmer (2007).

III. SYSTEMATIC REVIEW PROCESS

A systematic review of the literature emerges as a means of evaluating and interpreting all available researches relevant to a particular research question, thematic area, or phenomenon of interest with scientific value Kitchenham (2007). The systematic review intends to present a fair evaluation of a research topic, using a reliable, rigorous, and auditable methodology Kitchenham (2007). Thus, the objective of this review is to identify existing solutions to support credit and portfolio managers in decision-making based on indicators in the financing of agricultural credit to rural families. The evaluation of the quality of the studies have classified according to the proposal in Dyba and Dingsoyr (2008).

a) Definition of research issues

The formulation of the questions and strings of research presented is adapted from Santos (2007) includes the elements defined below:

- **Population:** Which set will be the subject of the review? Works that discuss the combination of techniques the financing of agricultural credit; recommendations of the evaluation using indicators;
- **Intervention:** What have be evaluated in this set of elements of the population? These are the technical approaches and methods for assessing the financing of agricultural credit;
- **Comparison:** Elements that will serve as a basis for comparison, considering the similarities of objectives, presented in section 5;
- **Outcomes:** Output information expected with the search. Comparative study of the approaches and analysis of the methods used in the financing of agricultural credit aimed at investigating the limitations and potentiality of existing evaluation approaches.

Seeking to direct efforts during the execution and understanding of the State of research on issues related to metrics and indicators to support the financing of agricultural credit in various geographic locations, the following Research issues led to this study:

Q1: Based on the evidence found, what information is used to aid the financing of agricultural credit to rural families?

Q2: What empirical research methods were used?

Q3: What types of research contributions have been found?

b) Description of Search Strategies

Bibliographic research consisted of two phases. In stage 1, electronic databases have to be researched with the keywords that guide the research to answer the questions. The search strings were generated from the combination of the key terms and synonyms using OR and AND, possible peculiarities of the digital libraries and adaptations to have to be recorded. Therefore, the research should be done in the English language, combining the synonyms defined in table I. Thus, the studies were obtained from the following sources:

- IEEE Xplore (<http://ieeexplore.ieee.org/>)
- Elsevier Science Direct (www.sciencedirect.com)
- Google Scholar (<http://scholar.google.com>)
- Citeseerx (<http://citeseer.ist.psu.edu/index>)
- Academia (<https://www.academia.edu>)
- Semantic Scholar (<https://www.semanticscholar.org/>)

In the second stage, manual conduction has to be conducted in the rural observer, symposiums and conferences (International Conference on African Development) to find articles relevant to the research published between 2003 and 2019.

The events have maintained a good number of articles submitted, which has significantly accentuated the presence of foreign researchers. In these specific cases, the search for the articles will have to be conducted in Portuguese and English to cover the largest number of cases relevant to answer the research questions. The selected document types based on expert queries represented in table II.

Table I: Keywords used the Study

String	
Population	"Access to rural credit of households/farmers ," "access to rural loans of households/farmers ," "factors affecting access to rural credit ," "Determinants of access to rural credit ," "Rural credit markets ," "Credit Restrictions " , "Credit share " , "Credit terms " , "Credit refund " , "Credit refund standards," "Loan Repayment performance," "socio-economic characteristics of households/farmers "
Intervention	"financing " or "auxiliary in financing "
Outcome	"metric " OR "indicator "
Search strategy: Population AND Intervention AND outcome	

Table II: Rural Observer, Symposiums and Conferences

Type	Source	Acronym
Rural Observer	Rural Environment Observatory	OMR
Symposiums	The International Symposium on Agriculture	AGROSYM
Conferences	International Conference on African Development	TICAD

c) Study selection criterion

The initial search for articles returns a lot of studies that are not relevant Kitchenham (2007). Thus, inclusion criteria [I] and exclusion [E] should be based on the research related to the topic addressed. Therefore, irrelevant studies are discarded at the beginning. The inclusion of the document is determined by relevance about research issues by the analysis of the title, abstract, Words – Key, introduction and conclusion. Articles classified as [I] are candidates to become a primary study and articles classified as [E] indicate irrelevant and discarded articles based on the title analysis, summary unrelated to metrics and indicators for financing Agricultural credit. According to the classification below:

[I1]. The published papers must relate directly to metrics and indicators to help the financing of agricultural credit to rural families.

[I2]. Articles consisting of opinions, recommendations of the evaluation using metrics and indicators for support and understanding the financing of agricultural credit.

[E1]. Repeated studies. If it is available in different search sources, the first is considered.

IV. STUDY RESULTS

a) General vision of Studies

The review was conducted in the period from January to August 2019, according to the plan presented in section 3.

Figure 2 illustrates the course performed for the studies found in the set with the search string in the sources used and manual search.

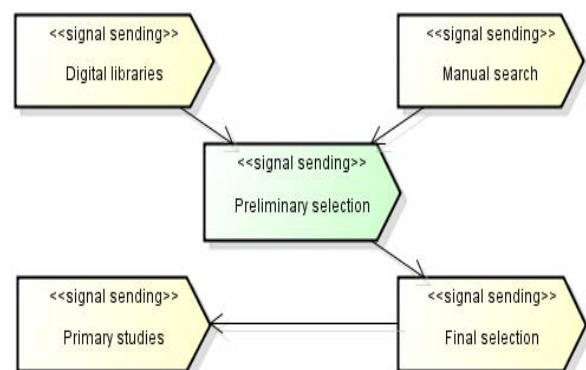


Fig. 2: Search filter and choice of primary studies

The search procedure produced 64 initial studies. Of these 64 were not repeated, after the initial

search (preliminary selection), 42 articles were pre-selected because they were relevant to identify primary studies by reading the title, summary and conclusion. From analyse, a new subset was obtained by the reading criterion in depth through the total reading of the article Remained those who presented consistent information about metrics and indicators for the financing of agricultural credit. In this second stage (final selection) 18 studies were selected for a detailed comparative analysis (Table X).

A study on accessibility metrics and loan restrictions in the agricultural sector has increased in recent years, particularly since 2012. The number of publications in 2019 was not discrete since the data were collected in August 2019. Table III shows the frequency of publication of the selected papers from 2003 to 2019.

Table III: Trend of Publications (Per Year)

Year	Percentage (%)	Frequency
2003	5.56	1
2005	5.56	1
2007	5.56	1
2008	5.56	1
2009	5.55	1
2010	5.55	1
2012	16.67	3
2013	5.55	1
2015	5.55	1
2016	5.55	1
2018	11.11	2
2019	22.23	4

Figure 3 Maps the source of the publications, most of the studies are Journal (94.45%). The distribution is as follows: Rural Observer (0), conferences (5.55%), and symposiums (0).

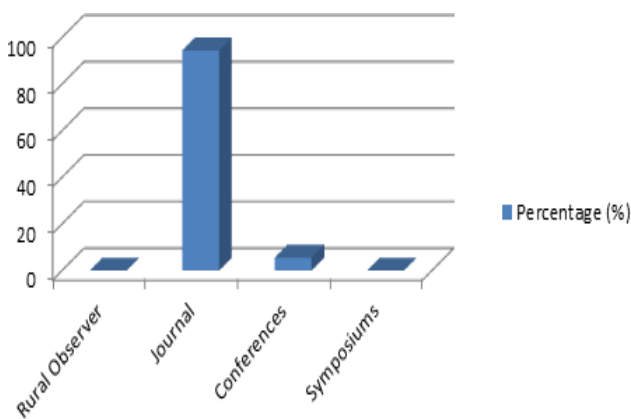


Fig. 3: Publication by Source Type

b) Classification of studies

The process of extracting information has to be based on the focus of studies presented in table IV. Thus, a categorization between objective and subjectivity of the results was established. The articles revealed problems or evaluation of solutions, where

5.55% deal with determinants of repayment and performances in microcredit programs that can be divided into three factors: borrower, firm and lender; 11.11% discuss the determinants of credit terms and repayment performance; the focus of 27.78% on access to agricultural loans, characteristics of the borrowers rural and socio-economic credit markets; 50% practices to guide repayment capacity, socio-economic characteristics of rural farmers, factors affecting demand for credit and repayment performance; Highlighted issues 5.56% on evidence of factors affecting the amortization rate and institutional.

Thus, we followed the classification of each publication according to the configuration of the study presented in table V, almost 61.11% of the studies are from the market; 27.78% are academic, and 11.11% are in the research project scenarios.

Table IV: Study Focus

Article result	Percentage (%)	Frequency
Issues	0	0
Mixed	94.45	17
Strategy	5.55	1

Table V: Distribution of Studies

Study Configuration	Percentage (%)	Frequency
Market	61.11	11
Academic	27.78	5
Research Project	11.11	2

c) Based on the evidence found, what information is used to aid the financing of agricultural credit to rural families? Q1

In the primary studies carried out and, also in the current literature, some metrics identified standard repayment credit criteria in table VI and VII, respectively. For example, in the work of Bob Ssekiziyivu et al. (2018) used credit terms and repayment performance of loans, having as the collateral requirement, loan period and interest rate, while experimental study of Matusse (2019) seeks to establish (co) relationships and demonstrates how repayment capacity affects the accessibility of the loan of farmers in Boane district using metrics, to extract an indicator to aid agricultural credit financing to rural family and to support credit managers in decision-making.

In another study, Fred Nimoh et al. (2012) discusses the factors influencing the pattern of credit then proceeds with policy recommendations based on the results to help simplify the operations of similar governmental projects. Fred Nimoh et al. (2012) will conclude the probit model explains the probability of delinquency of credit as a result of the independent variables identified. In the approach proposed by Hussien Komicha and Bo Öhlmer (2007), a set of practices to estimate the technical efficiency of agricultural credit restriction of farmers, employing the

stochastic frontier technique in data from research in Southeastern Ethiopia.

The theoretical study by Ben Soltane Bassem (2008) investigated and described the main vulnerable factors affecting the performance of repayment of group loans in the states of Tunisia. Criteria identified according to the classification proposed by Abiodun et al. (2019) presented in table VII.

Thus, the data presented in table VI and VII show that there is only one article related to indicators derived from the correlation between the metrics to support credit managers and portfolio in decision-making, by Matusse (2019).

Table VI: Identified Metrics

Metrics	Autores
Factors influencing credit accessibility, restriction on agricultural credit	[1] [2] [10] [15] [14] [25] [19]
Borrowers' repayment capacity, standard loans repayment rates, repayment performance factors	[4] [24] [26] [6]
Lending affordability and repayment capabilities prospect of borrowers, credit terms and repayment performance of loans	[5] [12]
Socio-economic characteristics of borrowers, characteristics of rural credit markets, credit standard and loan repayment delinquency	[13] [17] [30]
Factors affecting the amortization rate, repayment performance of loans and institutional factors	[24] [32] [3]

Table VII: Analysis Criterion

Criteria	Classification
Interest rates, loan period, warranty requirements, distance from loan sources, the amount granted, profitability and portfolio diversity	Determinants of access to credit, and repayment capacity
Age, educational level, gender, business experience, monthly income, household; threat imposed by creditors, regular monitoring, cost of the transaction; loan amount, amortization method, amortization period	Characteristics of borrowers, firm and lender
Poor rains, burnt, provision of the late entry, pest infestation; legal structure, ownership/control/financing, leadership, human resources, management, auditing	Delinquency characteristics of repayment and institutional factors

d) *What empirical research methods were used? Q2*

The articles is classified according to the method used by Tonella (2007), which consists of five research methods: 1) Literature review (means of evaluating and interpreting existing researches); 2) Experimental (studies that apply to measure any specific effect and controls); 3) descriptive research;

4) Exploratory research (record of lessons learned); and 5) Case study (Investigation of real-world situations). Although the exploratory research and survey method is not part of the method used by Tonella (2007), it was included in table VIII by the method used in the research, where 5.55% were experimental studies; (27.78%) descriptive research; (16.67) comprise the theoretical study; (22.23%) used the case study method; (5.55%) literature review; (5.55%) exploratory study, and (16.67%) reports from the survey.

Table VIII: Search Method used

Search method	Percentage (%)	Frequency
Literature Review	5.55	1
Descriptive research	27.78	5
Case study	22.23	4
Experimental study	5.55	1
Theoretical study	16.67	3
Exploratory study	5.55	1
Survey	16.67	3

e) *What types of research contributions have been found? Q3*

According to the classification developed for research needs, table IX illustrates the primary research of studies. Thus, the distribution is as follows 11.11% of the articles deal with the proposed solution; evaluation survey (66.67%); analysis research articles (16.67%); (5.55%) research validation article.

Table IX: Contribution Types of Research

Search Type	Percentage (%)	Frequency
Solution proposal	11.11	2
Validation Search	5.55	1
Evaluation Survey	66.67	12
Analysis Research	16.67	3

V. ANALYSIS OF EXISTING SOLUTIONS TO SUPPORT THE FINANCING OF AGRICULTURAL CREDIT TO RURAL FAMILY

During data extraction, it was not possible to identify the correlation of credit terms and repayment capacity, since the level of flexibility of the credit terms was directly associated with the repayment level of the Ndiege loan (2016), but We used the criteria of guarantee requirement, loan period and the interest rate that composes a particular project in the credit application process Eze and Ibekwe, (2007). Based on the assumption that there is a relationship between the credit term that makes up the process and the reimbursement capacity to rural families, factors affecting the access of small farmers to formal credit has been included in the study and shows that improving access to extension services and the possession of secure land in order to increase production and productivity, Lighton Dube et al. (2015). However, work of Allan Mitei et. al. (2016) identifies and

analyzes the types of classification that refer to social factors that affect the repayment of loans by borrowers. Table X presents the main comparative analysis of the models identified.

Table X: Models Proposed and Identified During the Systematic Review

Search model	Related articles	Search method	Techniques	Features	Search Type
Study to identify determinants of repayment and performances in microcredit programs that have to be divided into four factors: borrower, firm and lender	Nawai e Shariff, (2010)	Literature Review	Evidence Gathering	Characteristics of the borrower, characteristics of the firm, characteristics of the lender	Evaluation Research
The study sought to establish the social factors that affect the repayment of loans by borrowers, to determine economic factors that affect the repayment of the loan by borrowers.	Allan Mitei et al. (2016)	Descriptive research	Descriptive statistics and multiple regressions	Loan standard, loan repayment, loan factor terms	Solution proposal
The study describes the socioeconomic characteristics of the interviewees analyzed the factors that determine the access of farmers to formal and informal agricultural loans and identified their restrictions	Abiodun, et al. (2009)	Descriptive research	Descriptive statistics and binomial test model	Access to formal and informal agricultural loans, restrictions on access to agricultural loans	Analysis Research
The work investigated the lending rate and repayment capacity of the borrowers of the micro-finance banks (MFBs) at Oyo State in the southwest, Nigeria	Adu, et al. (2019)	Case study	Descriptive statistics and Cox regression	Determinants of repayment capacity of borrowers	Analysis Research
The research investigated the repayment of the loan in the southeastern states of Nigeria, using multiples sampling techniques in three segments (formal, semi formal and informal)	Onyeagocha, et al. (2012)	Case study	Ordinary multiple regression (OLS)	Determinants of loan repayment	Analysis Research
The research seeks to establish (co) relationships and demonstrate how repayment capacity affects the accessibility of the loan of farmers in Boane district using metrics, to extract an indicator	Euclides Alfredo Matusse (2019)	Goal Question Metric	Spearman's non-parametric correlation (p)	Determinants of lending accessibility, determinants of loan repayment	Validation Search
The research examined the determinants of access and demand for formal credit by small cassava farmers in Okene, Okehi, and a Davi areas of the local government of the state of Kogi.	Adebayo C.O. (2018)	Primary data through a questionnaire and descriptive statistics	Probit model	Factors affecting credit demand, restrictions on formal credit demand, determinants of credit access among small-scale manioc farmers	Evaluation Research

The research study was to establish the relationship between the characteristics of borrowers, the credit terms and the amount of repayment of loans from MFI customers in the district of Luwero Kampala	Bob Ssekiziyivu et al. (2018)	Primary data through a questionnaire and descriptive statistics	Pearson Correlation analysis and regression analysis	Determinants of credit terms, factors and characteristics of borrowers, repayment performance of loans	Evaluation Research
The research seeks to discover the factors influencing the standard of credit, then make policy recommendations based on the results to help simplify the operations of similar governmental projects.	Fred Nimoh ¹ et al. (2012)	Primary data were collected by the use of structured questionnaires and interviews.	Probit model	Credit Standard determinants, socio-economic characteristics of borrowers, defaults (reasons) of repayment delinquency	Evaluation Research
The research focuses on rural credit markets, the determinants of farmers' access to markets, the socio-economic impacts of access to credit	Ta Nhat Linh et al. (2019)	Detailed literature review with secondary data collection and interviews	Probit model	Determinants of access to rural credit, socio-Economic characteristics of borrowers, rural credit markets	Evaluation Research
The research sought to identify factors that limit or increase the formal access to credit for small farmers in the Asebu Kwamankese Abura District in central Ghana.	Dzadze P. et al. (2019)	Descriptive statistics and a logistic binary model	Logistic regression model/logistic regression model	Determinants of credit Access	Evaluation Research
The research sought to determine factors influenced the standard rates of repayment of loans among poultry farmers in Ijebu Ode Local Government Area of Ogun State Nigeria	Oni O.A, (2005)	Structured questionnaires, descriptive statistics	Probit model	Determinants of factors influenced standard loans repayment rates, socio- economic characteristics of borrowers	Evaluation Research
The research study was to determine the factors the accessibility of formal credit by the small farmers, artisanal fishermen in the attendance to the sector of microenterprises.	Khalid Mohamed (2003)	Structured questionnaires, descriptive statistics, cross tabulations by means of computer software STATA 7	Regressions and T-Test	Factors influencing the accessibility of credit, socio-economic characteristics of borrowers	Evaluation Research
The research examined the determinants of credit access by rural farmers in the state of Oyo Nigeria	Ololade R.A. & Olagunju F.I. (2013)	Structured questionnaires, descriptive statistics and multistage sampling procedure	Logit/Binomial Logistic Regression model	Socio-economic characteristics of rural farmers	Evaluation Research
The research investigated the factors affecting small farmers' access to formal credit and shows that improving extension services and the possession of secure land in order to increase production and productivity in Zimbabwe.	Lighton Dube et al. (2015)	Questionnaires, descriptive statistics and inferential statistics	Logit regression model/Logistic binary regression	Socio-economic characteristics of rural farmers, factors affecting access to credit, restrictions identified rural farmers	Evaluation Research

A set of practices to estimate the technical efficiency of agricultural credit restriction of farmers, employing the stochastic frontier technique in data from research in Southeastern Ethiopia.	Hussien Hamda Komicha & Bo Öhlmer (2007)	Descriptive statistics and inferential statistics	Stochastic frontier	Characteristics restriction to agricultural credit	Evaluation Research
The research investigated and described the main vulnerable factors affecting the repayment performance of group loans.	Ben Soltane Bassem (2008)	Descriptive questionnaires and statistics	Logit model	Repayment Performance factors	Solution proposal
The study sought to investigate the repayment of loans and the financial performance of SACCO's in the municipality of Embu, Kenya.	Katula R. & Kiriinya S. (2018)	Questionnaires through the Drop and Pick method	Cronbach's Alpha method, Multiple regression	Loan appraisal, loan interest rates, loan follow-up procedures and customer characteristics	Evaluation Research

a) Evaluation of the quality of the studies

The analysis of the studies followed criteria established for the Evaluation of experimental studies present in Dyba (2008). The screening criteria were related to the quality of the reasoning communication of a study according to the caption below:

✓ *Caption:* This issue is within this area of responsibility

Issues:

1. Has the study reported empirical research or was it just considered as lessons learned, the report based an expert opinion?
2. Have the goals been reported?
3. Was there an adequate description of the context in which the research was conducted?
4. Was the research project suitable for attacking the research objectives?
5. Was there an adequate description of the sample used and the methods to identify and recruit the samples?
6. No control group was used to compare treatments?
7. Adequate data collection methods were used and described?
8. There was an adequate description used to analyze the appropriate methods to ensure that data analysis??
9. The relationship between the researcher and the research participants is appropriate??
10. Has the study provided credible results and justified conclusions??
11. Have they provided the value for research or practice?

From table XI, it is observed that the evaluation of the study consists in verifying the adequacy of the framing of the articles in the area of responsibilities according to the questions pre-established by the criterion adopted by Dyba (2008).

Table XI: Evaluation of the Quality of Studies

Articles	Criteria										
	1	2	3	4	5	6	7	8	9	10	11
[19]	■	■	■	■	■	■	■	■	■	■	■
[2]	■	■	■	■	■	■	■	■	■	■	■
[5]	■	■	■	■	■	■	■	■	■	■	■
[13]	■	■	■	■	■	■	■	■	■	■	■
[30]	■	■	■	■	■	■	■	■	■	■	■
[10]	■	■	■	■	■	■	■	■	■	■	■
[26]	■	■	■	■	■	■	■	■	■	■	■
[15]	■	■	■	■	■	■	■	■	■	■	■
[25]	■	■	■	■	■	■	■	■	■	■	■
[3]	■	■	■	■	■	■	■	■	■	■	■
[1]	■	■	■	■	■	■	■	■	■	■	■
[4]	■	■	■	■	■	■	■	■	■	■	■
[24]	■	■	■	■	■	■	■	■	■	■	■
[12]	■	■	■	■	■	■	■	■	■	■	■
[17]	■	■	■	■	■	■	■	■	■	■	■
[14]	■	■	■	■	■	■	■	■	■	■	■
[6]	■	■	■	■	■	■	■	■	■	■	■
[32]	■	■	■	■	■	■	■	■	■	■	■

VI. CONCLUSION

In this paper, we analyze the results of the systematic review of 18 studies in metrics and indicators to aid in the financing of agricultural loans to rural families. The research presents the relation of the characteristics of research studies published per year, type of research used, characteristics and techniques approached. This research is important because of it highlights gaps and opportunities in evidence on the use of indicators to support the financing of agricultural credit. Based on the data collected, it is possible to identify the following conclusions:

Conclusion # 1: Most studies are related to the accessibility of agricultural credit in rural families and contexts based on evaluation research.

Most studies are related to issues of determinants affecting access to formal credit and

determining repayment from the perspective of borrowers, which means that researchers tend to discover the problems by the theoretical and descriptive study rather than proposing an experimental study.

Conclusion # 2: There is a shortage of research focusing on metrics in the financing of agricultural credit in microcredit institutions.

There are two plausible reasons for the lack of this research focus: 1) Although access to credit is an significant factor in the adoption of agricultural technologies and increased agricultural incomes among rural farmers, are generally not sufficiently mature to make use of measurements or 2) researchers are not yet widely aware of the need for exploratory studies that identifies a mechanism to propose an agricultural credit financing strategy based on indicators through the analysis of a set of metrics, to predict and evaluate how technical and non-technical, human behavior and communication aspects affect both microfinance institutions and borrowers in the repayment of the loan.

Conclusion # 3: There is a need for further studies focusing on quality metrics and indicators to infer a total index in the financing of agricultural loans to rural families.

The results of the review shown in table X indicate that most of the proposals so far are, in large part, related the issues accessibility of agricultural credit to farmers and significant factors of constraints separately based on Analysis of association variables. The results of the articles do not suggest studies of the relationship between metrics and indicators analyzing the four determinants such as access to formal agricultural loans, repayment capacity, credit terms and socio-economic characteristics of borrowers.

In this context, it is believed that the evaluation of metrics related to indicators becomes necessary to ensure that the quality in the financing of agricultural credit offering a prospect to the credit manager and portfolio to measure and monitor their expertise in services of microcredit.

VII. FUTURE WORKS

The result of the work identified a series of difficulties to address agricultural credit financing based on metrics and indicators to the rural family. The causes of this difficulty are related to processes and terms of access to agricultural credit unstable to make use of measurements. Its complexity increases with the effect of late arrival of the credit package resulting from the reasons such as fires, pest infestation and weak rainy season. The terms and conditions offered to borrowers should be revised, making it more flexible to suit farmers. As future work, we intend to elaborate an agribusiness simulator to assist in the financing of agricultural credit based on the correlation of access metrics to formal and

informal agricultural loans, credit terms and repayment capacity of borrowers.

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Foliar Application of Green Synthesized Zinc Sulphide and Zinc Oxide Nano Particles Enhances Growth, Root Attributes, Yield and Oil Quality of Sunflower (*Helianthus Annuus* L.)

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Abstract- A balanced nutrition for enhanced nutrient use efficiency is important to achieve potential crop yield. A deficiency of secondary and micronutrients is known to impair growth and quality of oil seed crops such as sunflower. The present study examined the effect of foliar application of nano-scale zinc particles in combination with boron on the growth and yield attributes of sunflower cv. RFSH-130 in a controlled environment. The treatments comprised foliar application of different nanoparticles (ZnS @ 400 ppm and ZnO @ 1000 ppm) and conventional ZnSO₄ @ 5000 ppm at 35 and 55 DAS. Further, these were combined with or without spray of boron @ 0.5% at 40 DAS. The sizes of the green synthesized nanoparticles of ZnS and ZnO in the presence of a biopolymer, chitosan were 60 and 38 nm respectively. ZnS and ZnO in nano formulations were absorbed by sunflower foliage to a greater extent compared to bulk ZnSO₄. The results revealed that green synthesized ZnS and ZNO nanoparticles enhanced the growth and yield of sunflower.

Keywords: sunflower, nano ZnO, nano ZnS, NPs, FE-SEM, XRD, boron, ZnSO₄, foliar spray.

GJSFR-D Classification: FOR Code: 070302



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Foliar Application of Green Synthesized Zinc Sulphide and Zinc Oxide Nano Particles Enhances Growth, Root Attributes, Yield and Oil Quality of Sunflower (*Helianthus Annuus* L.)

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Abstract- A balanced nutrition for enhanced nutrient use efficiency is important to achieve potential crop yield. A deficiency of secondary and micronutrients is known to impair growth and quality of oil seed crops such as sunflower. The present study examined the effect of foliar application of nano-scale zinc particles in combination with boron on the growth and yield attributes of sunflower cv. RFSH-130 in a controlled environment. The treatments comprised foliar application of different nanoparticles (ZnS @ 400 ppm and ZnO @ 1000 ppm) and conventional ZnSO₄ @ 5000 ppm at 35 and 55 DAS. Further, these were combined with or without spray of boron @ 0.5% at 40 DAS. The sizes of the green synthesized nanoparticles of ZnS and ZnO in the presence of a biopolymer, chitosan were 60 and 38 nm respectively. ZnS and ZnO in nano formulations were absorbed by sunflower foliage to a greater extent compared to bulk ZnSO₄. The results revealed that green synthesized ZnS and ZnO nanoparticles enhanced the growth and yield of sunflower. Among all the treatments, foliar applied nano ZnS @ 400 ppm + boron @ 0.5 % significantly increased plant height (146.47 cm), leaf area index (0.377), total dry matter production (19.91 g plant⁻¹), and seed yield (10.24 g plant⁻¹). This treatment also significantly increased root length (80%), root diameter (33%), root volume (92%) and root surface area (48%) over control. Application of nano zinc oxide @ 1,000 ppm + boron @ 0.5 % as well as nano ZnS @ 400 ppm + boron @ 0.5% have recorded higher seed oil content (41.15 % and 41.07 % respectively). While, lower growth and yield parameters were observed in control.

Keywords: sunflower, nano ZnO, nano ZnS, NPs, FE-SEM, XRD, boron, ZnSO₄, foliar spray.

I. INTRODUCTION

Oilseed crops constitute a major part of nutrition in human beings and globally, sunflower (*Helianthus annuus* L.) ranks second next to soybean among annual field crops grown for edible oil. Micronutrient deficiency is a main constraint in oilseed

production which affects the growth, yield and oil quality. Among micronutrients zinc deficiency is prominent in Indian soils and if oilseed crops like sunflower is cultivated in nutrient deficient soils the growth, yield and quality parameter of the crop is severely impaired. Similarly, sulphur is important as secondary nutrient for protein synthesis and is known to be a constituent of sulphur containing amino acids like cystine, cysteine and methionine which improves oil quality. Sulphur application on sulphur deficient soils can augment the supply of edible oils considerably ⁽¹⁾. Boron is another essential microelement for sunflower, helps in several processes like flowering, pollen germination, fruiting processes and seed setting. Hence, supply of balanced nutrition with enhanced nutrient use efficiency can help to achieve full yield potential of crop.

The desire to improve efficient use of zinc arises because zinc fertilizers are not always adequate to overcome the crop production constraints. Zinc fertilizers rapidly form insoluble complexes in the soil, rendering them unavailable for the plant uptake. Many efforts are being done in the field of nanotechnology to deal with various metals and their oxides as a source of essential plant nutrients ^(2, 3). The physico-chemical and biological advantages of nano scale ZnS and ZnO has been thoroughly reviewed ⁽⁴⁾. The use of ZnO NPs has a potential advantage, though the potential adverse effects are reported ^(5,6). There are reports indicating that nano scale zinc oxide particles increased stem and root growth and pod yield of groundnut when compared to zinc sulphate application ⁽⁷⁾; fruit yield of tomato ⁽⁸⁾ and nano iron oxide particles improved soybean yield ⁽⁹⁾.

Foliar application of trace elements being a common practice among farming community, the use of nanoparticles as foliar spray will be advantageous as it would reduce the bulk besides improving the efficiency. Use of a high analysis source of zinc such as ZnSO₄ is not soluble in water and foliar application of ZnSO₄ may not penetrate the leaf tissue effectively due to their bigger size. In such situations sources of zinc such as metal oxides if used as nano particles and in less than

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100 nm dimensions can considerably modify their physico-chemical properties compared to bulk ⁽¹⁰⁾. Hence an effort is needed for alternative optimum fertilization strategies for enhancing or maintaining the yield levels. Our previous study evaluated the foliar application of nano ZnS with different concentrations (100, 200, 300, 400 and 500 ppm) at 35 and 55 DAS. Foliar application of nano ZnS 400 ppm at 35 DAS registered significantly improved plant height from 9.5 to 17.6 % between 40 DAS and harvest, number of green leaves plant⁻¹ (17.13-33.40 %), leaf area (14.35-61.32%), leaf area duration (38.9-56.8 %) over water spray and soil application of zinc sulphate ⁽¹¹⁾.

The zinc nanoparticles possess high surface area, promote better absorption and translocation even at low concentrations have proved to be effective in enhancing plant growth, development and yield of oil seed crops. Similar results with the use of nano ZnS

were observed in sunflower ⁽¹²⁾ and with nano ZnO in groundnut in the field ⁽⁷⁾. Although many researchers have reported the effects of nanoparticles and conventional fertilizers in oilseed crops, the information on combination of these with time of foliar application during the growth stages of sunflower to assess the yield enhancement is meager. In view of the above facts the present study was carried out with the objective to know the effect of foliar application of nano zinc particles on growth, yield and oil quality of sunflower.

II. MATERIAL AND METHODS

a) Physico-chemical properties of the soil

A composite soil sample was collected and the soil was air dried and sieved through 2 mm mesh. The initial properties of soil were analyzed following standard protocols.

Table 1: Properties of soil used in the pot experiment

Texture	Course sand (%)	Fine sand (%)	Silt (%)	Clay (%)	pH	ECe (d sm ⁻¹)	Organic carbon (g kg ⁻¹)	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Available S (ppm)	Available Zinc (mg kg ⁻¹)
Clay loam	34.70	30.40	16.30	18.60	7.8	0.80	0.51	145.60	13.67	255.75	7.80	0.48

b) Green synthesis of ZnO and ZnS NPs

Colloidal stable Zn-chitosan NPs with a size range of 38-60 nm for ZnS and ZnO have been successfully synthesized through green synthesis in the presence of a biopolymer, chitosan. Solution of nano ZnO was prepared by dispersing the commercial grade nanopowder (Sigma-Aldrich, USA) in Milli-Q water through ultrasonication (250W, 50kHz) for 30 minutes using chitosan biopolymer as substrate. Similarly, nano zinc sulphide was synthesized in a one-step colloidal synthesis of bio-compatible water-soluble ZnS quantum dot/chitosan nanoconjugates ⁽¹³⁾.

c) Characterization of ZnO and ZnS NPs

The estimation of the dimension of the nanoparticles was based on band gap energy value of UV spectrophotometer, particle size analyzer and size of the ZnS nano-crystals was estimated using the empirical model published in the literature ^(14, 15). The concentration of ZnS and ZnO in samples was determined by drying a known volume of solution in hot air oven at 60 °C for 6 hours. X-ray Diffraction analysis (XRD) and UV-Visible spectroscopy (SP-UV500VDB, Spectrum Instruments) were used to characterize these NPs.

d) Pot experiment

The achenes of sunflower cv. RSFH-130, a short duration hybrid (95–98 days) were used. Initially three healthy achenes were sown in each pot and one healthy plant was retained after 15 days. Each of the treatment had three pots as repetitions in a complete randomized block design. A total of 72 pots were prepared for destructive sampling at three growth stages (Plate 1).



Plate 1: A view of the pot experiment

Each pot was fertilized with the recommended dose of nitrogen, phosphorus and potassium at the rate of 35:50:35 kg N, P₂O₅ and K₂O per hectare in the form of urea, diammonium phosphate and muriate of potash. Farm yard manure was incorporated 15 days before sowing in all the pots @ 8 t ha⁻¹. Spray volume for each concentration determined by measured quantity of water utilized for spray on one plant based on calculated total required quantity of spray volume to whole plants for each concentration. The pots of each set of sampling were randomly rotated from time to time to avoid over exposure to environmental variations in the screen house,. The minimum and maximum temperature increased during the experiment reaching 22.6°C and 39.3°C respectively at late booting stage. The maximum temperature exceeded 30°C one week before buttoning and 4-5 days before anthesis. However, temperature remained stable in the range 22-26°C during most of crop cycle.

e) *Analysis of below ground parameters*

The root washing for harvest samples was performed using 0.5% solution of sodium hexameta phosphate and washed roots were placed in root scanner trays in the root scanner computer system (Regent- STD 1600 + which uses a win RHIZO™ 2013 software programme; Regent instrument, Canada). Parameters such as root length (cm), average diameter (mm), root volume (cm³), root length volume (cm m⁻³), root surface area (cm²) and forks class were analyzed.

f) *Harvesting and threshing*

The crop was harvested when dorsal side of the capitulum turned to lemon yellow colour. The heads from the pots were cut and seed yield was recorded after thorough drying. The stalks were left in pots for a week and were cut at ground level with the help of sickle and weight was recorded. The plant samples were oven dried at 65°C.

Various biometric observations, plant height, number of green leaves, leaf area, leaf area index, total dry matter, seed weight, stalk yield, seed oil content and harvest index were recorded at final harvest.

g) *Sulphur and Zn uptake*

S and Zn uptake at harvest was computed using the formula:

$$\text{Sulphur or Zn uptake (kg ha}^{-1}\text{)} = [\text{S or Zn (\%)} \times \text{above ground dry matter (kg ha}^{-1}\text{)}] / 100$$

Oil content and oil yield

Dried achenes of sunflower drawn from each treatment were used for estimation of per cent oil content using Nuclear Magnetic Resonance (NMR) Spectrophotometer facility at Indian Institute of Oil Seeds Research, Hyderabad, India. Oil yield was calculated by multiplying the oil per cent with seed yield as follows:

$$\text{Seed oil yield (g plant}^{-1}\text{)} = [\text{Seed oil content (\%)} \times \text{Seed yield (g plant}^{-1}\text{)}] / 100$$

h) *Statistical analysis*

The data were analyzed statistically using the Fisher's analysis of variance. Least significant difference (LSD) test at 5% probability level was used to compare the differences among treatments' means when F-value is significant for observations⁽²⁹⁾.

III. RESULTS AND DISCUSSION

a) *Particle size analysis*

The UV– visible absorption spectra of ZnS was obtained at different reaction time (Fig. 1-a) and the excitation wavelength was 275.6 nm (Fig. 2-a). The absorption peaks at 30 and 35 h exhibited great blue shift and strong intensity. Such a strong peak is known to arise due to quantum confinement effect, which occurs when the particle size becomes comparable with, or smaller than, the Bohr radius of excitation conformity as done by Vogel *et al.*⁽¹⁶⁾.

A typical XRD pattern of green ZnO NPs was found in the range 5°-50° (Fig. 1-b). The diffraction peak at 2θ with crystal planes corresponded in the order 33.62° (100), 35.2° (002), 39.30° (101), 48.68° (102), 58.26° (110), 75.26° (103), and 88.28° (200). Average size of ZnO green NPs was determined as 38 nm with crystalline structure from the width of dominant peaks (100) and (101) reflections according to the Debye-Scherrer's equation. The broadening of the peaks can be attributed to the decrease in the particle size of the synthesized ZnO. An absorption peak was observed in each spectrum at 383.8 nm as a characteristic band for the zinc oxide indicating the high purity of the synthesized ZnO NPs. The average size of green ZnS nanoparticles estimated from particle size analyzer was 60 nm. This is fairly in good agreement with the size estimated by Scherrer's equation (Fig. 2-b).

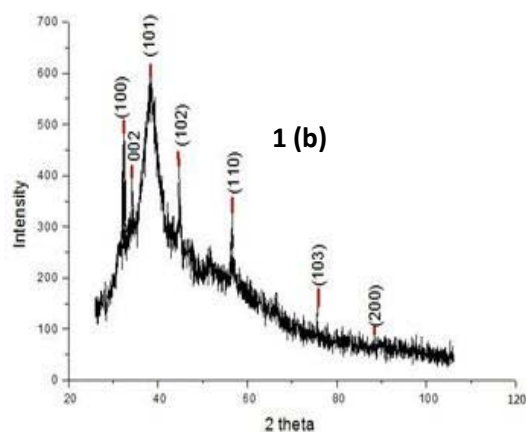
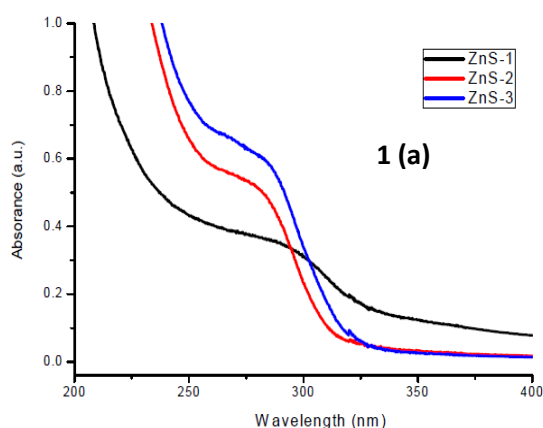


Fig. 1: (a). UV–vis spectroscopy analysis of green ZnS-chitosan conjugates synthesized at different pH 4.02, 5.0, and 6.0 of sample 1, 2, and 3 respectively. Based on E_{OD} results, the average sizes (diameter) were calculated were 4.7 ± 0.1, 4.4 ± 0.1 and 3.8 ± 0.1 nm for pH = 4.0, 5.0 and 6.0, respectively. Fig. 1(b). XRD patterns of the ZnO-chitosan conjugated NPs.

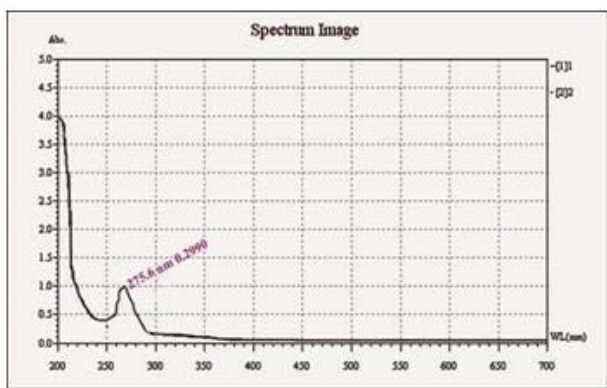


Fig. 2 (a): The UV- visible absorption spectra of ZnS

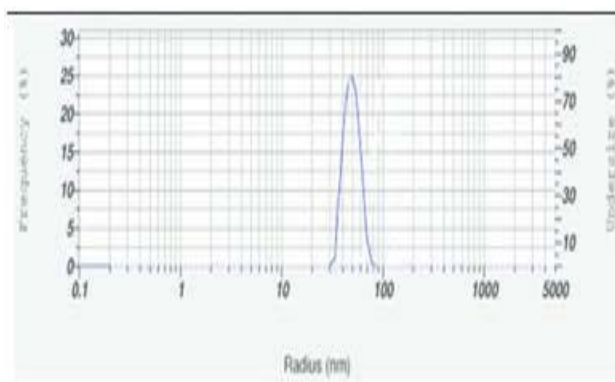


Fig.2 (b): Particle size analysis of ZnS

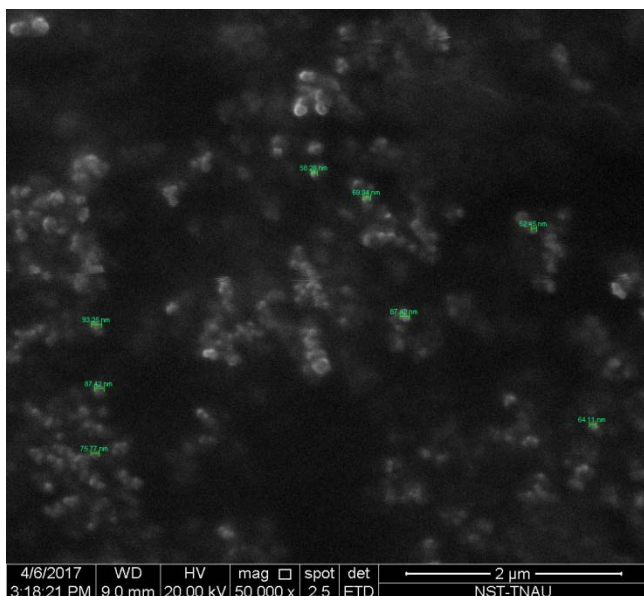


Plate 2 (a): FE-SEM images of sunflower leaf sprayed with nano ZnS @ 400 ppm

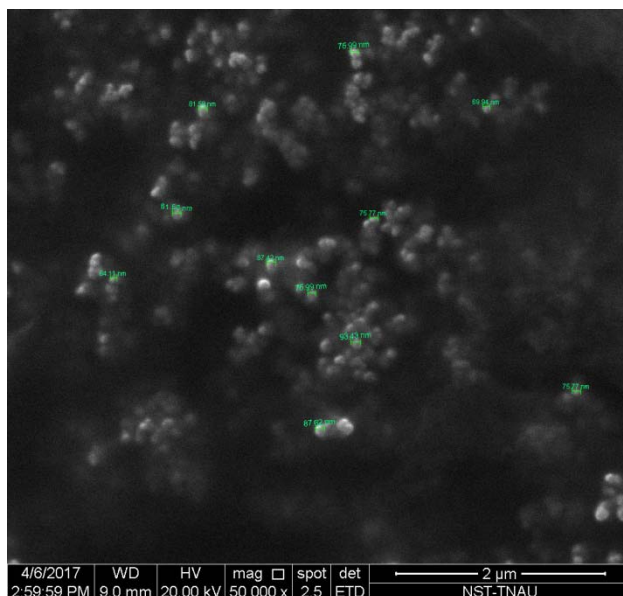


Plate 2(b): FE-SEM images of sunflower leaf sprayed with nano ZnO @ 1000 ppm

The FE-SEM images of sunflower leaf sampled after 24 hrs of spray with 400 ppm nano ZnS and 1000 ppm nano ZnO are shown in Fig 2 (a & b). The EDAX analysis of nano ZnS particles revealed the presence of zinc with weight per cent (0.47 %) and atomic per cent (0.10 %) and for 400 ppm nano ZnS also revealed the presence of zinc as weight per cent (0.46 %) and atom per cent (0.09 %).

The comparative absorption and deposition of zinc particles are depicted in Fig. 3 (a-d) indicated higher absorption of nano particles into stomatal aperture compared to conventional ZnSO₄. The EDX spectrum analysis revealed the presence of zinc element in leaf sample to an extent of 0.09 per cent by atomic weight. This clearly supported the fact that nano formulations were effective in reaching inner surface of leaf and enhanced the dry matter of photosynthetic surfaces. The bioaccumulation increased with application of ZnS nanoparticles when sprayed on foliage and effectively penetrated through stomatal pores. Similar results for ZnO nano particles were

reported by Khanm *et al.* (2018) in tomato. Usually the size of stomatal pores generally ranges from few nanometres to 30 μm in different crops. Fricker and Willmer⁽¹⁷⁾ opined that the formulation prepared at nano scale and sprayed on foliage could effectively be deposited on leaf surface and have made their entry into the leaf pores. Due to all these, nanoparticles are more efficient than conventional fertilizers.

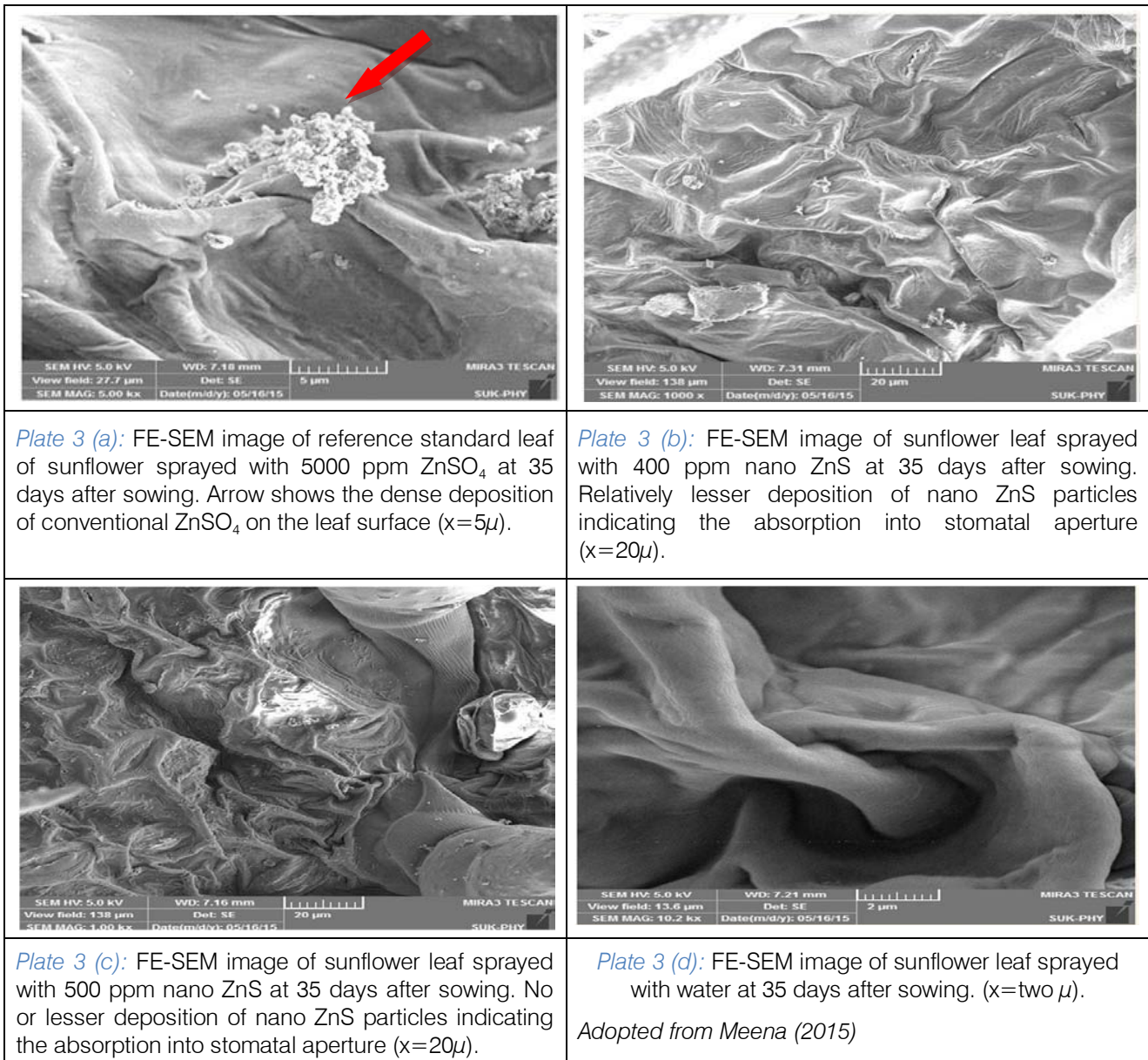


Plate 3 (a): FE-SEM image of reference standard leaf of sunflower sprayed with 5000 ppm $ZnSO_4$ at 35 days after sowing. Arrow shows the dense deposition of conventional $ZnSO_4$ on the leaf surface ($x=5\mu$).

Plate 3 (b): FE-SEM image of sunflower leaf sprayed with 400 ppm nano ZnS at 35 days after sowing. Relatively lesser deposition of nano ZnS particles indicating the absorption into stomatal aperture ($x=20\mu$).

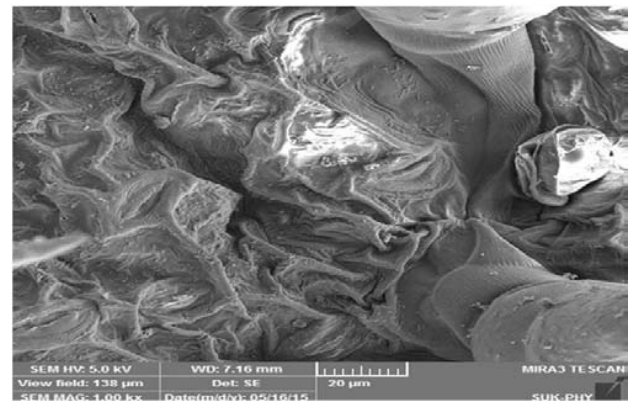


Plate 3 (c): FE-SEM image of sunflower leaf sprayed with 500 ppm nano ZnS at 35 days after sowing. No or lesser deposition of nano ZnS particles indicating the absorption into stomatal aperture ($x=20\mu$).

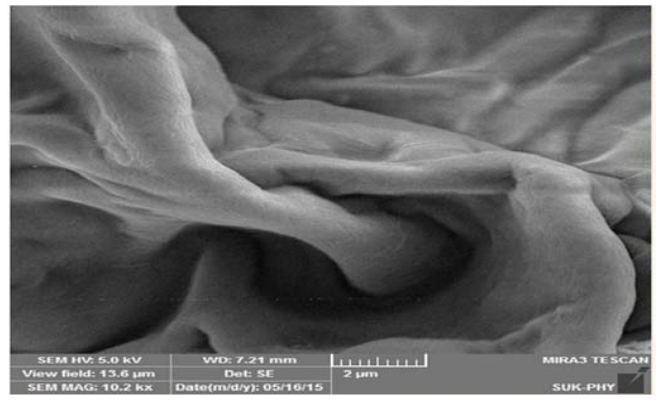


Plate 3 (d): FE-SEM image of sunflower leaf sprayed with water at 35 days after sowing. ($x=two\mu$).
Adopted from Meena (2015)

b) Above-ground growth

Foliar application of nano ZnS @ 400 ppm + boron @ 0.5 % recorded highest plant height (146.47 cm), number of green leaves (14.67) which were on par with nano ZnO @ 1,000 ppm + boron @ 0.5 % (Table 2). More availability of nutrient to the plants during initial growth period would have enhanced the growth on account of enhanced photosynthesis. Similar results as that of Zheng *et al* ⁽¹⁸⁾ was noticed with nano- TiO_2 treated spinach seeds that resulted in 73% more dry weight, three times higher photosynthetic rate and 45% increase in chlorophyll formation compared to the control over germination period of 30 days. Foliar application of nano ZnS @ 400 ppm + boron @ 0.5 % recorded highest leaf area ($555.62\text{ cm}^2\text{ plant}^{-1}$), leaf area index (0.377) which were on par with nano ZnO @ 1,000 ppm + boron @ 0.5 % (Table 2). The per cent increases over control were in the range 12-14 % for plant height;

20-26% for number of leaves; 35-36% for leaf area and 38-42% for total dry matter production. These results are in accordance with the findings of Meena and Kumar ⁽¹¹⁾. The leaf area and leaf area index are major indicators for determining the solar radiation interception, canopy photosynthesis which ultimately results growth and development rate of the crop. The results are in accordance with the findings of Hadiat and Salman ⁽¹⁹⁾ who reported that the shoot length, root length, leaf area, chlorophyll, carbohydrate and protein contents of the maize were increased significantly with increase in the concentration of silver nanoparticles from 20 to 60 ppm over control.

Significantly a higher total dry matter production ($19.91\text{ g plant}^{-1}$) was recorded with foliar applied nano ZnS @ 400 ppm + boron @ 0.5 % which was on par with nano ZnO @ 1,000 ppm + boron @ 0.5 % ($19.41\text{ g plant}^{-1}$). Both the treatments significantly

increased the dry matter production to an extent of 40 % over control. However, foliar application of nano Zn particles individually; and conventional ZnSO₄ in combination with boron resulted in dry matter production in the range 11.7 - 29.4%. Thus the present study revealed that foliar application of the individual nano micronutrient formulation in combination with boron showed significant effect on growth and yield attributes over sole application of nano formulation.

Crop response to foliar application of nano ZnS and ZnO generally depends on the initial sulphur and zinc status of the soil. Hence, in the present investigation, the response to foliar sprayed nano ZnS and ZnO was attributed to lower soil sulphur and zinc

level. The response of sunflower crop to nano ZnS and ZnO application might be due to more synthesis of chlorophyll leading to higher leaf area due to more availability of sulphur^(20, 7).

Yield attributes and yield also depends on growth attributes viz., plant height, leaf area, leaf area index and dry matter production per plant. However, significantly a lower dry matter was produced (13.67 g plant⁻¹) with control. Results of present investigation are in conformity with the findings of Raliya and Tarafdar⁽²¹⁾ who observed that ZnO NPs induced a significant improvement in cluster bean for plant biomass, shoot and root growth, root area and chlorophyll.

Table 2: Above ground growth parameters of sunflower as influenced by foliar application of green nano zinc particles

Treatment	Plant height (cm)	No. of green leaves	Leaf area (cm ² plant ⁻¹)	Leaf Area Index	TDMP (g plant ⁻¹)
T ₁ – Nano ZnS @ 400 ppm	142.73	12.33	533.59	0.361	17.58
T ₂ – Nano ZnS @ 400 ppm + boron @ 0.5 %	146.47	14.67	555.62	0.377	19.91
T ₃ – Nano ZnO @ 1,000 ppm	135.60	12.67	507.20	0.343	16.48
T ₄ – Nano ZnO @ 1,000 ppm + boron @ 0.5 %	144.68	14.00	552.84	0.374	19.41
T ₅ – ZnSO ₄ @ 5,000 ppm	132.7	12.00	432.98	0.316	14.49
T ₆ – ZnSO ₄ @ 5,000 ppm + boron @ 0.5 %	134.03	12.33	463.91	0.333	14.58
T ₇ – Water Spray (control)	129.00	11.67	409.72	0.300	14.06
S.Em. ±	0.44	0.44	2.05	0.001	0.14
C.D. at (p = 0.01)	1.83	1.84	8.64	0.006	0.59

c) Below ground growth

Our results demonstrated a significantly higher root growth due to foliar application of nano zinc formulations (Table 3). Root growth parameters enhanced due to foliar application nano ZnS @ 400 ppm +boron @ 0.5 % in root length (73%), root diameter (31%), root volume (87%), surface area (30%) and number of forks (93%) which were on par with

application of nano ZnO @ 1,000 ppm + boron @ 0.5 % for root length (71%), root diameter (27%), root volume (70%), surface area (27%) and number of forks (82%) over the control. Our results are in agreement with findings of earlier researchers who reported that ZnO nanoparticles induced a significant improvement in root traits in cluster bean⁽²¹⁾ and in tomato⁽⁶⁾; and in sunflower for ZnS nanoparticles⁽¹¹⁾.

Table 3: Root growth of sunflower as influenced by foliar application of green nano zinc particles

Treatment	Root length (cm)	Average diameter (mm)	Root volume (cm ³)	Surface area (cm ²)	No. of Forks
T ₁ – Nano ZnS @ 400 ppm	364.84	0.60	1.06	63.25	2,878.56
T ₂ – Nano ZnS @ 400 ppm + boron @ 0.5 %	382.59	0.68	1.25	66.29	3,395.42
T ₃ – Nano ZnO @ 1,000 ppm	335.73	0.56	0.96	62.30	2,626.14
T ₄ – Nano ZnO @ 1,000 ppm + boron @ 0.5 %	377.80	0.66	1.14	64.75	3,203.94
T ₅ – ZnSO ₄ @ 5,000 ppm	224.67	0.52	0.78	52.28	1,950.02
T ₆ – ZnSO ₄ @ 5,000 ppm + boron @ 0.5 %	295.66	0.54	0.84	56.88	2,123.31
T ₇ – Water Spray (control)	221.11	0.52	0.67	51.18	1,756.70
S.Em. ±	4.41	0.007	0.03	0.48	48.712
CD (p = 0.01)	18.57	0.03	0.14	2.02	205.07

d) Yield and yield attributes

Significant response of sunflower to combined application of nano zinc nutrients with boron over conventional source was seen on the seed yield (Table 4). Application of nano ZnS @ 400 ppm + boron @ 0.5% increased the seed yield from 7.06 g to 10.24 g plant⁻¹ resulting into 45 % increase; and was on par with nano ZnO @ 1,000 ppm + boron @ 0.5 % (9.88 g

plant⁻¹). This might be due partly to more availability of soluble forms of sulphur and zinc in ZnS nano-formulation. The results our earlier findings in sunflower⁽¹¹⁾ also demonstrated that application of nano ZnS @ 500 ppm at 55 DAS resulted in higher seed yield (5.27 g plant⁻¹) over rest of the treatments; and was on par with 400 ppm nano ZnS sprayed at 35 DAS (4.87 g plant⁻¹).

The average increase in seed yield owing to application of nano ZnS @ 400 ppm + boron @ 0.5 % and nano ZnO @ 1,000 ppm + boron @ 0.5 % over control were 45% and 40%, respectively. These increases in seed yield corroborate with the reports of workers. Meena ⁽¹²⁾ obtained higher seed yield of sunflower with foliar application of nano ZnS @ 400 and 500 ppm. Prasad *et al.* ⁽⁷⁾ observed that foliar application of nano ZnO at 15 times lower dose recorded 29.5 % and 26.3 % higher pod yield of groundnut when compared to the chelated ZnSO₄.

Foliar application of nano zinc sulphide with 400 ppm at 35 and 55 DAS + boron @ 0.5 % at 40 DAS also

recorded significantly higher yield attributes viz., head diameter (10.52 cm), head weight (15.96 g), stalk yield per plant (15.38 g), 100-seed weight (4.36 g), seed filling percentage (81.53) and harvest index (39.97 %) which were on par with nano zinc oxide with 1,000 ppm at 35 and 55 DAS + boron @ 0.5 %. The increments over control were in the range 4-45% for the yield attributes being higher for seed yield (45%); head diameter (37%) and stalk yield (33%). Nadi *et al.* ⁽²²⁾ reported similar results wherein foliar application of nano-iron at 6 g l⁻¹ during flowering stage increased grain yield faba bean.

Table 4: Yield and yield attributes of sunflower as influenced by foliar application of green nano zinc particles.

Treatment	Head diameter (cm)	Head weight plant ⁻¹ (g)	Seed yield plant ⁻¹ (g)	Stalk yield plant ⁻¹ (g)	Harvest index (%)	100 seed weight (g)	Seed filling percentage
T ₁ – Nano ZnS @ 400 ppm	9.14	14.22	8.78	14.69	37.40	4.02	80.43
T ₂ – Nano ZnS @ 400 ppm + boron @ 0.5 %	10.52	15.96	10.24	15.38	39.97	4.36	81.53
T ₃ – Nano ZnO @ 1,000 ppm	9.63	14.97	8.59	14.21	37.68	4.08	79.38
T ₄ – Nano ZnO @ 1,000 ppm + boron @ 0.5 %	10.06	15.90	9.88	15.07	39.59	4.26	80.11
T ₅ – ZnSO ₄ @ 5,000 ppm	8.32	14.00	7.33	12.22	37.51	3.90	78.37
T ₆ – ZnSO ₄ @ 5,000 ppm + boron @ 0.5 %	9.44	13.45	7.41	12.63	37.04	3.81	79.74
T ₇ – Water Spray (control)	7.66	13.16	7.06	11.54	37.96	3.67	78.67
S.Em. ±	0.10	0.06	0.09	0.14	0.50	0.03	0.190
C.D. at (p = 0.01)	0.46	0.27	0.42	0.59	2.11	0.11	0.80

e) Seed oil content and oil yield

The per cent seed oil content in control increased from 37.06 to 41.15 with the foliar application of nano ZnS @ 400 ppm + boron @ 0.5 %. This treatment also significantly increased oil yield (4.21 g plant⁻¹) compared to rest of the treatments to an extent of 59 and 42 % over control and ZnSO₄ @ 5,000 ppm, respectively. Further, foliar application of ZnO @ 1,000 ppm alone and in combination with boron @ 5 % also increased the seed oil content and oil yield to an extent of 23 and 42 per cent, respectively (Table 5). This increase in oil content is attributed to efficient fatty acid synthesis wherein, acetyl Co-A is converted into malonyl Co-A. This conversion is mediated by enzyme thiokinase, the activity of which depends on sulphur supply. Moreover, acetyl Co-A itself contains sulphur and sulphur hydroxyl group ⁽²³⁾. Hence the sulphur containing nano ZnS formulation might have accelerated this process. However, in depth investigation is needed to ascertain the exact mechanism.

Our finding that the percentage of oil in achenes is increased by application of beneficial nanoparticles corroborates these earlier results. Zareii *et al.* ⁽²⁴⁾ found that foliar application of iron nanoparticles during the reproductive growth stage significantly improved the oil percentage in safflower. Because of their very small

size, these particles offer a large contact surface per unit of mass and can pass through different protective barriers. Undoubtedly, nanoparticles compared to bulky particles interact better with intracellular processes, and this can partially explain their greater effectiveness. The present findings are consistent with the results of other research indicating that exogenous application of nanoparticles can significantly improve plant growth ^(8, 25, and 26).

Table 5: Oil content, oil yield, sulphur uptake and zinc uptake in sunflower as influenced by foliar application of green nano zinc particles

Treatment	Seed oil content (%)	Oil yield (g plant ⁻¹)	S uptake (mg plant ⁻¹)	Zn uptake (mg plant ⁻¹)
T ₁ – Nano ZnS @ 400 ppm	41.07	3.60	53.80	0.36
T ₂ – Nano ZnS @ 400 ppm + boron @ 0.5 %	41.15	4.21	54.40	0.39
T ₃ – Nano ZnO @ 1,000 ppm	37.95	3.26	37.00	0.35
T ₄ – Nano ZnO @ 1,000 ppm + boron @ 0.5 %	38.11	3.76	37.67	0.38
T ₅ – ZnSO ₄ @ 5,000 ppm	38.83	2.84	47.77	0.28
T ₆ – ZnSO ₄ @ 5,000 ppm + boron @ 0.5 %	38.85	2.88	45.67	0.29
T ₇ – Water Spray (control)	37.59	2.65	38.67	0.24
S.Em. ±	0.26	0.040	0.97	0.008
C.D. at (p = 0.01)	1.10	0.17	4.09	0.03

f) *Sulphur and Zinc uptake of sunflower*

Effect of foliar application of nano Zn particles exerted significant influence on sulphur uptake. Higher sulphur and zinc uptake was noticed in nano ZnS @ 400 ppm + boron @ 0.5 %. This was followed by ZnSO₄ treatments for uptake of sulphur and ZnO nanoformulation for uptake of zinc (Table 5). This might be due to higher biomass production leading to higher uptake of nutrients from soil and fertilizers encapsulated in nanoparticles will increase the uptake of nutrients⁽²⁷⁾. The uptake rate depends on the size and the surface properties of the nanoparticles. Nanoparticles could enter the xylem via the cortex and the central cylinder and may accumulate in the vacuole. Dietz and Hearth⁽²⁸⁾ reported that uptake rate depends on the size and the surface properties of nanoparticles.

IV. CONCLUSIONS

In the present investigation, the results showed that Zn nanoparticles (<100 nm) could enhance the growth and yield of sunflower plants. The FE-SEM images revealed the complete absorption of nano zinc sulphide and zinc oxide particles by leaves. Zinc, sulphur and boron are important nutrients for oil seed crops like sunflower and found to respond positively to foliar application. The results of the present study suggest that ZnS and ZnO in nano scale form are absorbed by plants to a larger extent compared to bulk ZnSO₄. Future *In vivo* studies to determine the toxicity of these NPs are necessary. The growth and yield attributes were increased due to application of nanoformulations of zinc. Thus, it can be concluded that foliar application of zinc sulphide @ 400 ppm at 35 and 55 days after sowing and boron @ 0.5 % at 40 DAS followed by application of nano zinc oxide @ 1,000 ppm at 35 and 55 DAS + boron @ 0.5 % at 40 DAS found optimum for sunflower crop for obtaining higher growth, yield and oil content.

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Conflicts of interest

Authors declare no conflicts of interest.

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Effect of Land Grabbing on Growth in Nigeria's Agricultural Sector (1980 -2015)

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Abstract- The issue of large scale land acquisitions for agricultural production by transnational corporations and foreign investors especially in sub-Sahara Africa has caused great concern in these Countries. This has given rise to the term land grabbing. This study investigated the effect of land grabbing on the per capita agriculture gross domestic product of the Country. Time series data were used for the study and the period span from 1980 to 2015. The per capita model and the trend model were used to estimate the per capita agriculture gross domestic product and its trend within the period. Also, the Augmented Dickey-Filler test for stationarity and the Johansen test for co-integration were performed to ensure that the variables were stationarity and that there is long run relationship between them. The vector error correction model was used to show the long run and short run relationships between the variables. The results show that the Country had an average per capita agriculture gross domestic product of N25 million for the period.

Keywords: *land grabbing, per capita, vector error correction.*

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Effect of Land Grabbing on Growth in Nigeria's Agricultural Sector (1980 -2015)

Simonyan J. B. ^α, Onyenweaku C. E. ^σ & Ibeagwa, O. B. ^ρ

Abstract- The issue of large scale land acquisitions for agricultural production by transnational corporations and foreign investors especially in sub-Sahara Africa has caused great concern in these Countries. This has given rise to the term land grabbing. This study investigated the effect of land grabbing on the per capita agriculture gross domestic product of the Country. Time series data were used for the study and the period span from 1980 to 2015. The per capita model and the trend model were used to estimate the per capita agriculture gross domestic product and its trend within the period. Also, the Augmented Dickey-Filler test for stationarity and the Johansen test for co-integration were performed to ensure that the variables were stationarity and that there is long run relationship between them. The vector error correction model was used to show the long run and short run relationships between the variables. The results show that the Country had an average per capita agriculture gross domestic product of N25 million for the period. The area of land used by foreign investors, domestic investment in agriculture and government capital expenditure on agriculture negatively influenced per capita agricultural gross domestic product in the long run. In the short run, only area of land used by foreign investors was significant and it negatively influenced per capita agriculture gross domestic product. The study recommended that policies that would regulate foreign investors' access to land for agricultural production so as to ensure that small holder farmers access to land is not jeopardized. It recommended stricter monitoring of government's spending in agriculture to ensure that funds are used for the purpose for which they were allocated.

Keywords: land grabbing, per capita, vector error correction.

I. INTRODUCTION

The global financial crises in the twenty-first century has contributed in large part to a change in focus from industrialization to agriculture. Several reasons have been adduced as being responsible for this shift and these ranging from fear of food insecurity within the developed world, the shift from fossil fuel to agrofuel especially in Europe, and new found economic opportunities for agricultural investors and speculators (Kachika, 2010; Graham *et al* 2009). The food price crisis which resulted from the financial crises of the early 2000s caused a dramatic spike in large-scale agricultural investments, primarily foreign, in the global

south for the purposes of food and biofuels production. Also, consumption targets in the European Union (EU) and financial incentives have been a key driving force for demand for investment in agrofuels (Cotula *et al.* 2009). The Renewable Energy Sources Directive also known as The EU *Directive* 2009/28EC which came into effect in April 2009 set new mandatory targets for member states. A minimum ten percent (10%) share of renewable energies, which in the end will be supplied mainly by agrofuels within the total consumption of fuel for transport in every member state by 2020 has stimulated increased interest and demand for agrofuel and hence land for agricultural production.

Speculation on land and other natural resources according to the Food and Agriculture Organization (FAO) (2013) has also been fuelled by the poor market performance of more traditional asset classes such as equity and bonds in the wake of the financial crisis that started in 2007. The need to meet up with world energy demand coupled with the fear of food insecurity among the developed nations has led to an inward search for alternative energy sources which agrofuels provide. This recourse to agriculture and large scale land acquisition as a viable, and dependable strategy and means for enhancing food security as well as meeting fuel needs, employment generation and wealth creation have brought intense pressure to bear on resources in the agricultural sector. The most important of which is land. Developing countries especially those in Africa and South America are under much pressure as demand for their lands for agricultural purposes is gradually increasing in response to this pressure.

According to Karlsson (2012), the global demand for agricultural land in 2008 was just about 4 million hectares (Ha). This figure rose within a space of one year to about 56 million hectares in 2009 with 70 percent of the increase from Africa alone. FAO reported that between 2007 and 2009, 20 million hectares of land were acquired by foreign investors in Africa (Hallam, 2009). The United Nations Conference on Trade and Development (UNCTAD) (2009) also reported that investors from countries in Europe including Italy, Norway, Germany, Denmark, the United Kingdom, and France form the bulk of those investing in agriculture. However, the Europeans are not the only group involved in land acquisition on the continent. Emerging economies in Asia are not left out. Kachika (2010)

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estimated that as of 2011, 70 percent of land grabs occurred in Africa and the main grabbers were China, the Gulf States, India and Korea. Vicol (2015) concurred to these other authors and further described the trend of recent large-scale land acquisitions in the global south which includes Africa by both foreign and domestic actors as highly significant.

Hallam further noted that the late 2000s witnessed a surge in foreign direct investment (FDI) into agriculture in developing countries and this was largely channelled towards primary agricultural production. According to UNCTAD (2014), FDI has been on the rise in those countries that are targets of Large Scale Land Acquisitions (LSLAs), especially since approximately 2004, and the primary sector has played a major role in this rise. Foreign Direct Investment (FDI) coming into the agricultural sector in developing countries is no doubt for the acquisition of land for production purposes. Foreign investors with the active connivance of indigenous governments on the continent pay so little to acquire such large expanse of land. Productive activities on these land is driven by the desire to produce for the home country of the investors. So, even though the local farmers are dispossessed of their land, the output from such land still does not contribute much to the total agricultural output in the host nation (Friis and Reenberg, 2010). It may be also be inferred that the returns of the investors do not seem to add to the income of the local farming communities neither do they contribute to strengthening food security in the host nation. Garlich and Liu (2010) reported that foreign investments in agriculture in some African countries have removed income opportunities from local farmers thereby plunging them into severe poverty. According to Lee and Neves (2009), most rural poor depend on agriculture or are otherwise dependent on natural resources in generating their livelihoods. Hanson (2009) corroborating this asserts that vast areas of land that may seem to be waiting for development are often providing important economic and social benefits for local communities. Thus, it is not just about bringing land into production but also the disruption of the livelihood and social structure of traditional communities who have for decades relied on their land for sustenance.

Despite the problems associated with it, FDI seems to be a blessing to the host nations. Since 1999 when Nigeria returned to civil rule, various governments have deployed strategies and policies aimed at attracting foreign direct investment into the country. Policies aimed at facilitating easier movement of capital into and out of the country have been used as incentives to bring in foreign investors. Shiro (2009) advances that with the enthronement of democracy in 1999, the government of Nigeria has taken a number of measures necessary to woo foreign investors into Nigeria. These measures includes the repeal of laws that are inimical to

foreign investment growth, promulgation of investment law, various overseas trips for image laundering by the president, among others. FDIs are seen as a healthy way for less-developed and developing nations to overcome their saving-investment gap. FDIs fill such gaps by bringing foreign investment into the country, as well as bridging gaps in management, technology, entrepreneurship and skills.

Investment in the agricultural sector which was hitherto driven by domestic investors has witnessed a steady rise in the amount of foreign investment being ploughed in. According to Hallam (2011), benefits arising from agricultural FDI should include capital inflows, technology transfers, leading to domestic productivity and production, quality improvement, employment creation, and forward and backward linkages. Most of these foreign investments in agriculture are used for the acquisition of land and farm machinery and equipment used for production and processing of produce from the farms.

Djokoto (2012) observed that agricultural FDI in Sub-Saharan Africa is mainly land based. Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC) (2013) gives an example of massive land deals to include that carried out by Biopalm Energy an Indian company which has invested about \$1,907.24 million to acquire a 200,000 hectare palm oil plantation in the south of Cameroon, as part of a joint venture with the National Investment Corporation of Cameroon. According Graham *et al* (2011) media reports in Nigeria indicate that in December 2008 Nigeria's Niger Delta Development Commission and UK based TRANS4 mation Agritech (T4M) signed a 305 million United States Dollars (\$305m) agreement for the establishment of 30,000 hectares of land for mechanized farming for rice and other agricultural products in the Niger delta. The case of the Zimbabwean farmers in Kwara State, Israeli Vegetable farmers in the Federal Capital territory and American rice and vegetables farmers in Anambra State are all cases in point in Nigeria, where FDI has shown massive improvement in investment portfolio of the nation.

The upsurge in large-scale land acquisitions in developing countries including Nigeria has raised concern, and given rise to the expression "land grabbing" which has now become an issue in most policy debate. Land grabbing according to Kachika (2010) is the contentious issue of large-scale land acquisitions; the buying or leasing of large pieces of land in developing countries, by domestic and transnational corporations (TNCs), governments, and individuals. It refers to large scale land acquisition – be it purchase or lease –for agricultural production by foreign investors (GRAIN 2008; Cotula *et al.* 2009). Global land grabbing according to Zoomers (2010) generally refers to large-scale, cross-border land deals or transactions

that are carried out by transnational corporations or initiated by foreign governments. Graham *et al.* (2011) defined land grabbing as taking possession of and/or controlling a scale of land for commercial/industrial or agricultural production which is disproportionate in size in comparison to the average land holding in the region. Although the practice is widespread and seem to have a global effect, there seem to be some intensity in South Sahara Africa, South east Asia and Latin America. Kachika (2010) reported that seventy percent (70 percent) of land grabs is concentrated in Sub-Saharan Africa. Other estimates of the scope of land acquisition, published in September 2010 by the World Bank, showed that over 46 million hectares in large-scale farmland acquisitions or negotiations were announced between October 2008 and August 2009 alone, with two-thirds of demanded land concentrated in Sub-Saharan Africa.

It appears that huge amount of FDI is being used to acquire large swathes of arable land for the purpose of agricultural production to meet the growing needs of the developed and a few newly emerging economies. The International Land Coalition (2012) cited in Lafrancesca (2013) reported that 134 million hectares of land has already been grabbed in Sub-Saharan Africa. Liverage (2010) cited reports from bodies like the International Land Coalition, Grain, Food Policy Research Institute (IFPRI) indicating that the targeted countries in Africa where land grabbing is prevalent include: Angola, Benin, the Congo, Ethiopia, Liberia, Madagascar, Mali, Mozambique, Nigeria, The Sudan, The United Republic of Tanzania and Zambia. This report brings the issue of land grabbing and its consequences nearer home. According to Costantino (2014), the land grabbing phenomenon is not distributed homogeneously across all countries, and the unevenness in its occurrence cannot apparently be explained adequately by the relative abundance of land in any of the target countries. So, even though Nigeria may seem to have abundant land for agriculture, the Country may not have escaped the land grabbing phenomenon. Furthermore, Kachika (2010) posited that land grabbing undermines the contribution of agriculture to the GDP in countries where the practice is prevalent. Thus, the import of this practice on the growth and development of these countries, especially Nigeria is dire. The practice undermines the policy of government that focuses on agriculture as a key sector for economy recovery and growth.

This study estimates the per capita agriculture gross domestic product; it also shows the trend in Per capita agricultural gross domestic product as well as the determinants of per capita agriculture gross domestic product.

II. METHODOLOGY

The study was conducted in Nigeria. The country is situated in tropical Sub-Saharan Africa along the Gulf of Guinea and is one of the largest countries on the continent. Nigeria lies between latitudes 4° and 14° north of the Equator and between longitudes 3° and 15° east of the Greenwich Meridian (Akpan, 2010). The country is bounded on the west by the Republic of Benin, on the east by the Republic of Cameroon, on the north east by the republic of Chad and on the North-west by the Niger Republic. The Atlantic Ocean forms the southern boundary of the country. Nigeria has a total land area of 923,768.622km² or about 92.4 million hectares, made up of land: 910,768 sq km and water: 13,000 sq km. The country's population is currently put at 167 million with an annual growth rate of 3.2 percent (National Population Commission NPC, 2015). The NPC had earlier put the country's population at 140,431,790 persons (NPC, 2006).

The climate of the country varies from equatorial in the south to tropical in the central and arid in the northern part of the country. Nigeria has only two seasons; the rainy season, which begins in April and ends in October; and the dry season, which lasts between October and March. Relative humidity is below 40 percent in the north to above 80 percent in the mangrove forest zone. Temperature varies between 27°C in the south to above 40°C in the North. The variations in climate also affect the vegetation. The vegetation of the country varies between savannah in the north and north central to swamp and rain forest in the south.

Agriculture is a major occupation in Nigeria. About 60 percent of the population is involved in agricultural production. The major food crops produced in Nigeria are: cassava, maize, rice, yams, various beans and legumes, soya, sorghum, ginger, onions, tomatoes, melons and vegetable. Cash crops produced in the country include: cocoa, cotton, groundnuts, palm oil and rubber. Nigeria has 19 million head of cattle, the largest in Africa. The sector contributed about 17.8 percent of the GDP of the country in 2015.

a) Data Sources

Data used for the study were secondary data and were generated from the Central Bank of Nigeria (CBN) publications, National Bureau of Statistics, FAOSTAT, Federal Ministry of Agriculture and Natural Resources. Data were collected on macroeconomic variables including: Gross Domestic Product (GDP), Agricultural Foreign Direct Investment (AFDI), Aggregate Agricultural Domestic Investment (ADAI), Total area of agricultural land, Capital accumulation in agriculture, National Output of Food, National Population, and Government capital expenditure on agriculture. The data generated for the study spanned from 1980 to 2015.

b) *Specification of model*

The per capita Agric. Gross Domestic Product

$$(PCAGDP) = \frac{AGDP_t}{N_t} \quad (1)$$

$$Y_{it} = b_0 e^{b_1 T} \quad (2)$$

Linearizing equation 3.4 by taking the log of both sides we have

$$\ln Y_{it} = b_0 + b_1 T + u_t \quad (3)$$

Where,

$\ln Y_{it}$ = natural log of Y { $Y_i = PAGDP_t$ }

b_0 = intercept

b_1 = slope coefficient

T = Time trend variable (years)

$$\ln PCGDP_t = b_0 + b_1 T + \mu_t \quad (4)$$

Where,

$PCGDP_t$ = Per capita agricultural GDP (Agricultural Gross Domestic product/population in agriculture)

T = Trend variable (1980-2015)

b_0 and b_1 = parameters to be estimated.

\ln = Natural logarithm

U_t = error term

Using time series data in econometric analysis of this nature it is necessary that we first test for the stationarity properties of the variables. The Augmented Dickey-Fuller ADF was used to test for stationarity in the data series. The ADF model as specified by Ayinde *et al* (2011) is given thus:

$$e_t = \Delta Y_{t-1} = (y_{t-1} - Y_{t-2}), \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3}). \quad (5)$$

The vector error correction model was used to establish the determinants of per capita agriculture gross domestic product short run and the long run relationships between the variables. The test for co-integration was first carried out using the Johansen Jesselis test before proceeding to vector error correction model.

Co-integration Test

According to Uremadu, Umezurike and Odili (2016) the Johansen Jesselis tests the null hypothesis that the number of distinct co-integrating vector is less than or equal to q against a general unrestricted alternatives $q = r$, this test is shown in the equation below:

$$\gamma \text{ trace } (r) = -T \sum_i^n r + 1 \ln (1 - \gamma t) \quad (6)$$

Where: T is the number of usable observations, and γt is the estimated eigenvalue from the matrix. The second statistical test is the maximum eigenvalue test ($\gamma \max$) that is calculated according to the following formula:

$$\gamma \max (r, r + 1) = -T \ln(1 - \gamma r + 1) \quad (7)$$

The test concerns a test of the null hypothesis that there is r co-integrating vector against the alternative of $r + 1$ co-integrating vectors.

The VECM as specified by Atanda *et al* (2013) is as follow:

$$\Delta \ln PCAGDP_t = \log \beta_0 + \beta_1 \Delta \log AALUFI_t + \beta_2 \Delta \log GEA_t + \beta_3 \Delta \log DIA_t + \beta_4 \Delta \log AFDI_t + \beta_5 ECT_{t-1} + vt \quad (8)$$

The variables $AALUFI_t$, GEA_t , DIA_t , $AFDI_t$ are as earlier defined. ECT_{t-1} is the error correction component and is the lagged estimated error series; vt are the random error terms.

III. RESULTS AND DISCUSSION

a) *Per Capita Agriculture Gross Domestic Product (PCAGDP)*

The PCAGDP of the Country was computed for the period under review, the result is presented in Table 4.2.

Table 4.2: PCAGDP for Nigeria 1980 -2015.

PCAGDP (Million Naira)	Frequency (No. of years)	Percentage
0.27 - 21.90	22	61.11
21.91 - 43.54	5	13.89
43.55 - 65.18	3	8.33
65.19 - 86.82	2	5.56
86.83 - 108.46	4	11.11
Total	36	100
Mean	28.1814	

The result in the table shows that the Country had an average PCAGDP of above ₦28 million Naira for the period under review. This represent the average agriculture output in Naira value per head of the Country and is an indication of the volume of activities in the agricultural sector within the period. The result also shows that the PCAGDP for most years within the period under review was less than ₦22 million. The PCAGDP of Nigeria compares favourably with countries like Ghana and Kenya which had average PCAGDP of ₦24.52 million and ₦20.20 Million respectively but is much lower than the PCAGDP of Malaysia and the United States of America which were ₦58 million Naira and ₦32 billion respectively for the period under review (FAOSTAT, 2017).

The low PCAGDP may be as a result of low capital investment in the sector. Low agricultural output in the Country has also been attributed to other factors including the use of low yielding crops and animal species, use of primitive implements, minimal usage of improved inputs like fertilizer and agrochemicals, fragmentation of agricultural land, inconsistencies in government policies and lack of competitiveness (Anyanwu *et al.*, 2010; Odetola and Etumnu, 2013). According to COMCEC (2013), suitability of ecological

conditions, sophisticated infrastructure, availability of natural resources, use of equipment and human capacity to carry out agricultural activity are key drivers of growth in the agricultural sector. The mismanagement of any of these factors or a combination of them may lead to underdevelopment and low output in the sector. Odetola and Etumnu (2013) identified low productivity as a major contributor to the slow or declining growth in Nigeria's agricultural sector. According to Iyoha and Oriakhi (2002) in Odetola and Etumnu (2013), slow growth in the agricultural sector of the country may also be attributed to slow growth in capital per worker. The relatively low PCAGDP of the Country may also be an

indictment of the poor implementation of numerous government policies, projects and programmes aimed at improving productivity and enhancing output and growth in the sector. According to Noko (2017), the poor performance of the agricultural sector in Nigeria may be attributed to the disincentive created by an unstable macroeconomic environment. The low value of output in agricultural sector may also be an indication of low living standard especially among the rural population who are mostly engaged in farming. It may also be an indication of food security challenges the country may be facing (Anyanwuet *al.*, 2010).

b) *Trend in Per Capita Agriculture Gross Domestic Product within the period also depicts slight fluctuations in the variable with time*

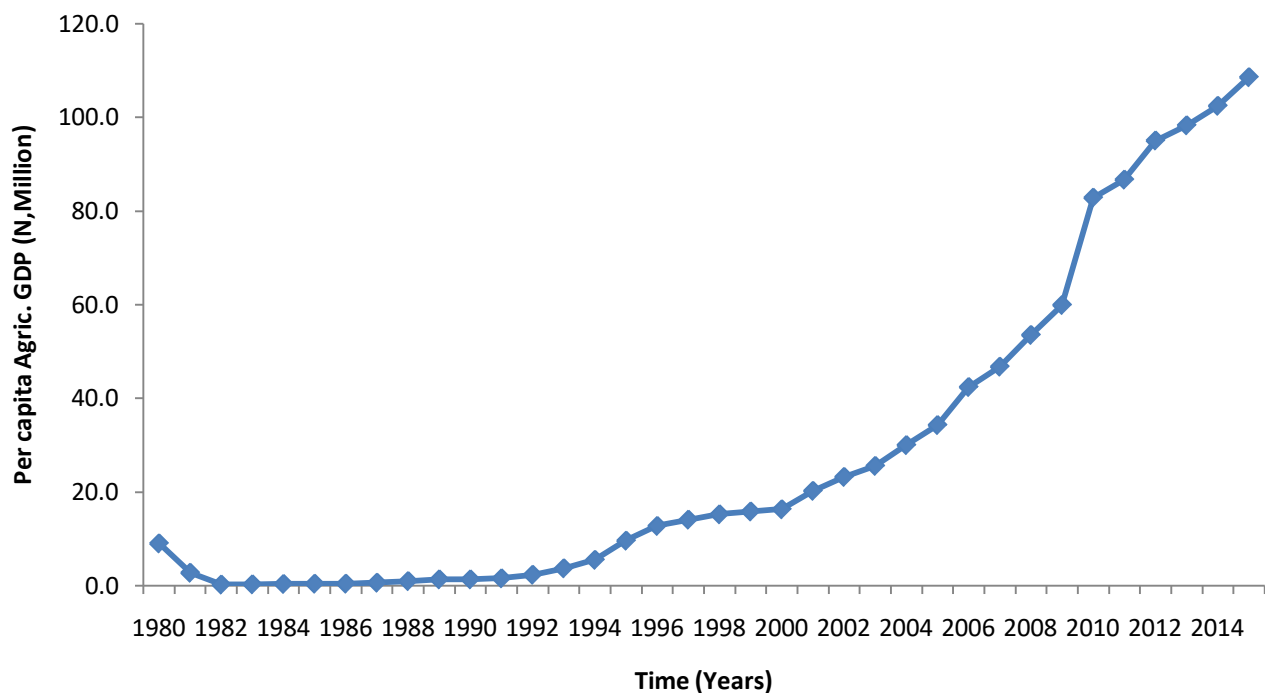


Figure 2: Trend in Per Capita Agriculture Gross Domestic Product in Nigeria 1980 to 2015

The trend shows that Per capita agriculture gross domestic product was low and remained stagnant throughout the 1980s to the early 1990s. This period coincides with the period of oil boom and the "Udorji award" which led to an unprecedented increase in earnings both to the Country and individuals, especially government workers. These led to a complete neglect of agriculture in the Country. Domestic investment in agriculture dropped drastically and foreign investment in the sector declined due to political instability. Despite these limitations, population was on the increase.

The introduction of the Structural Adjustment Programme (SAP) in the mid-1980s did little in shoring up domestic investment in the agricultural sector but this was not enough to encourage a massive rise in GDP. Population dynamics saw a mass movement of labour out of agriculture. Domestic investment orchestrated by

SAP encouraged PCAGDP to rise despite the mass movement of agricultural labour force. Growth in the sector therefore picks up. Growth in PCAGDP however picks up in the mid-1990s and continues albeit gradually into the next decade and this is reflected in the gradual increase in PCAGDP within the period as shown in the trend. The return to democracy and the pursuance of developmental programmes by government may be responsible for growth in the PCAGDP. Also, the influx of grants and developmental aid from foreign developmental partners may have contributed to this growth.

Due to the significance of the unit root in determining the co-integration, the series in the study were tested for unit root using the standard Augmented Dickey-Fuller (ADF) unit root tests. The tests were performed using E views 9.0 statistical package which

automatically selects the number of lagged dependent variables in order to correct for the presence of serial correlation (Asteriou and Hall, 2007). The standard ADF test was conducted for unit roots in the levels (for both constant without trend and constant with trend) and first difference (for both constant without trend and constant

with trend), given the automatically selected Schwarz information criterion, and the maximum lags, in order to determine the number of unit roots in the series of the variables. The result of the Augmented Dickey-Fuller unit root test is presented in Table 1.

Table 1: Result of Augmented Dickey-Fuller unit root test

Variables	With intercept			With intercept and trend		
	I(0)	I(1)	Order of Integration	I(0)	I(1)	Order of Integration
Agric. FDI	-0.03468	-10.0805***	I(1)	-1.264309	-10.05152***	I(1)
Domestic Investment in Agriculture	-0.82258	-5.48998***	I(1)	-1.288451	-5.492540***	I(1)
Govt. Capital Expenditure on Agric.	-1.92985	-5.45957***	I(1)	-0.922883	-5.322730***	I(1)
Area of Agricultural Land Used by Foreign Investors	-2.69333*	-6.62543***	I(1)	-2.376590	-6.795569	I(1)
Per capita Agric. GDP	-0.41524	-2.63980*	I(1)	-3.262063*	-5.093259***	I(1)

Source: Generated data from various issues of CBN, NBS and FAOSTAT (1980 -2015)

Note: With constant at level, critical value at 1% = - 3.633, and at 5% = -2.948; at first difference, critical value at 1% = - 3.639, and at 5% = -2.951. With constant and trend at level, critical values at 1% = -4.244 and at 5% = -3.544; at first difference, critical value at 1% = -4.253 and at 5% = -3.548. Asterisks * and ** represent 5% and 1% significance levels.

The result for the unit root test with constant for the logged variables shows that only Agriculture Partial Productivity of Capital was stationary at level, I(0), other variables were stationary at order one, I(1). PCAGDP was weakly stationary at first difference. On the other hand, the result for the unit root test with constant and trend determination in Table 3.2 shows that only API was stationary at level I(0), all other variables were stationary at order one, I(1). Therefore all the logged variables used for the study were integrated of order one, I(1) except for the API which was used at level, I(0). The

difference- stationary values for the variables found to be stationary at order one, I(1) were generated and used for analysis. The analyses in the study were therefore based on the unit root test of the logged variables with constant and trend.

To further show the long run and short run relationships between the independent variables in the model and the dependent variable, the vector error correction model was estimated. First Johansen cointegration test was conducted. The result is presented in Table 2.

Table 2: Johanson Cointegration Test

Trend assumption: Linear deterministic trend
Series: LOG(PCAGDP) LOG(AALUFI) LOG(AFDI) LOG(DIA) LOG(GCEA)
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.663	86.574	69.819	0.001
At most 1 *	0.473	50.634	47.856	0.027
At most 2	0.400	29.509	29.797	0.054
At most 3	0.284	12.665	15.495	0.128
At most 4	0.048	1.623	3.841	0.203

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Table 3: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.663	35.940	33.877	0.028
At most 1	0.473	21.125	27.584	0.269
At most 2	0.400	16.844	21.132	0.180
At most 3	0.284	11.042	14.265	0.152
At most 4	0.048	1.623	3.842	0.203

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

To consider the Null hypothesis that the variables are not co-integrated ($r=0$) against the alternative hypothesis of one or more co-integrating vectors ($r>0$). The result of the trace statistic indicates the value of TRACE equal to each number of the co-integrating vector: TRACE (0) = 86.754, TRACE (1) = 50.634, TRACE (2) = 29.509, TRACE (3) = 12.665 and TRACE (4) = 1.623. The trace test indicates 2 co-integrating equations at the 0.05 level as denoted by the significant sign (*) on the hypothesized number of co-integration equations at none and at most 1.

This implies that the null hypothesis that the variables are not co-integrated ($r=0$) was rejected at 0.05 level and the alternative hypothesis that there are one or more co-integrating vectors ($r>0$) was accepted judging from the MacKinnon (1999) p-values for none and at most 1 equations.

Similarly, the result of the Maximum Eigen statistic indicates that the value of Maximum Eigen value equal to each number of the co-integrating vector: Maximum Eigen value (0) = 35.394, Maximum Eigen value (1) = 21.125, Maximum Eigen value (2) = 16.844, and Maximum Eigen value (3) = 4.699852, Maximum Eigen value (4) = 11.042 and Maximum Eigen value (5) = 1.623. The Maximum Eigen value test indicates 1 co-integrating equation at the 0.05 level as denoted by the significant sign (*) on the hypothesized number of co-integration equations for none. This implies that the null hypothesis that the variables are not co-integrated ($r=0$) was rejected at 0.05 level and the alternative hypothesis that there are one or more co-integrating vectors ($r>0$) was accepted judging from the MacKinnon (1999) p-values for none equations which were less than 0.05%.

The results of the co-integration tests showed that there was co-integration in the foreign direct investment model with the trace test showing 2 co-integrating variables and the Maximum Eigen value test showing a co-integrating variable. Thus, the trace test and the Maximum Eigen value test showed slightly no disparity in their ability to account for all the outliers on the regression line. Once there is co-integrating vector, a long run relationship is concluded (Gujarati,

2004). According to Engle and Granger (1987), when a set of variables are $I(1)$ and are co-integrated then short-run analysis of the system should incorporate error correction term (ECT) in order to model the adjustment for the deviation from its long-run equilibrium. The error correction model (ECM) is therefore characterized by both differenced and long-run equilibrium models, thereby allowing for the estimates of short-run dynamics as well as long-run equilibrium adjustments process. This indicates that if the variables are co-integrated then they share a long-run relationship, which error correction model corrects. Therefore, the result of the co-integration test established that there exist a long run relationship among the variables that were co-integrated at order $I(1)$. The models were normalized on the variables in order to obtain the long-run parameter estimates. Since there is a long-run and short-run relationship, we will then proceed to estimate the parsimonious error correction model (ECM).

c) Parsimonious Error Correction Model

The Parsimonious Error Correction Model correction was used to establish the short run and long run relationships between the variables in the model. The result is resented in Table 5.

Table 4: Result of the Parsimonious Error Correction Model

Variable	Coefficient	Std. Error	t-statistics
Ln(AALUFI(-1))	-0.380	0.071	-5.362***
Ln(AFDI(-1))	0.0005	0.027	0.017
Ln(DIA(-1))	-0.702	0.051	-13.864***
Ln(GCEA(-1))	-0.150	0.0353	-4.276***
ECM (-1)	-0.834	0.097	-8.624***
D(Ln(AALUFI(1))	-0.213	0.058	-3.673***
D(Ln(AFDI(-1))	-0.007	0.041)	-0.159
D(Ln(DIA(-1))	0.066	(0.172)	0.382
D(Ln(GCEA(-1))	-0.063	0.046	-1.369
R-squared	0.804		
Adj. R-squared	0.760		
F-statistic	18.416***		

Source: Generated data from various issues of CBN, NBS and FAOSTAT (1980 -2015)

***= Significant at 1%; ** = significant at 5%. (-1) = 1 year lagged.

The result in Table 4.7 shows that the coefficient of multiple determinations (R^2) value was 0.804 which indicates that the explanatory variables jointly accounted for about 80.4 percent of the variations in the dependent variable $D(\ln(\text{PCAGDP}(-1)))$. The value of the F-statistics also indicates the robustness of the model.

The result shows that in the long run, $\ln\text{AALUFI}_{t-1}$, $\ln\text{DIA}_{t-1}$ and $\ln\text{GCEA}_{t-1}$ were significant at one percent and negatively influenced $\ln\text{PCAGDP}_{t-1}$. This implies that there is inverse relationship between each of these variables and PCAGDP_t . The result also shows that the value of PCAGDP_t falls by 0.38 percent for every one percent increase in AALUFI_t . This is indicative of the profound adverse effect of AALUFI_t on output and growth in the agricultural sector even in the long run. This relationship may be considered from the ability of foreign large scale land acquisition in displacing local small holder farmers from their land and thereby reducing their output even in the long run. According to Onyebinama (2004) in Nnamerenwa (2012) limited access to land limits the size and scale of the farm business. Land is one of the most important factors of production and has a direct relationship with output. A reduction in agricultural land area available to smallholder farmers who form the majority of producers in the agricultural sector therefore impinges negatively on their output and hence reduces overall output of the agricultural sector.

The negative relationship between $\ln\text{DIA}_t$ and $\ln\text{PCAGDP}_t$ in the long run is not in consonance with a *priori* expectation. This may however be ascribed to low returns on investment made in the sector by local investors. Nigeria's agriculture is still rain-fed and therefore very vulnerable to the vagaries of weather as well as attacks by diseases and pests, all of which could increase investment risks and drastically reduce output. According to Nnamerenwa (2012) and Ayinde, Ajewole, Ogunlade and Adewumi (2010), Nigeria's agriculture is rain dependent and adequate and timely rainfall is necessary for better agricultural output. Processors and other actors in the sector are also exposed to the risks of wide fluctuations in prices of inputs, unavailability of constant power supply, instability and inconsistencies in policies, and low capacity utilization all of which affect output adversely and reduces growth in the sector.

$\ln\text{GCEA}_t$ was negatively related to $\ln\text{PCAGDP}_t$. This implies that increase in GCEA_t will lead to a decrease in PCAGDP_t . This again is not in agreement with a *priori* expectation. A likely reason for this relationship may be massive diversion of funds and corruption which is rife in the public sector of the Country and which usually leads underperformance of Government's funding in almost all sectors of the economy. Also, the effect of the top-down syndrome in planning and implementation of capital projects in the agricultural sector tends to reduce the performance of

these projects and hence the output of beneficiaries of such projects.

The model also showed that the parameter estimate of the co-integrating error correction term (ECM (-1) which measures the speed of adjustment of the dependent variables to equilibrium after a deviation has occurred due to a change due to the explanatory variables in the model is 0.833. This is negative and lies between 0 and 1. Ehirimet *et al.* (2017), indicated that an ECM that is negative and significantly different from zero actually justifies long-run adjustment with a speed of less than 100%. The result therefore indicates that the stochastic error (residuals) processes generated and their movements with time in the model can be corrected and the speed of adjustment back to equilibrium in the long run was given as 83.3 percent.

Also in the short run, the area of land used by foreign investors $D(\ln(\text{AALUFI}(-1)))$ was significant at one percent and negatively related to $\ln\text{PCAGDP}_t$. The result shows that there is a 0.21 percent fall in PCAGDP_t for every 1 percent increase in AALUFI_t in the short run. This indicates the acuteness of the problem of large scale land acquisition as it relates to output and growth in the agricultural sector. The coefficients of DIA_t , AFDI_t and GCEA_t were not found to be significant in the short run.

IV. CONCLUSION AND RECOMMENDATION

The study analyzed the per capita agriculture gross domestic product (PCAGDP) for Nigeria from 1980 to 2015. It also described the trend in PCAGDP for the Country within the period and estimated the determinants of PCAGDP. The Augmented Dickey-Fuller Test was used to test the data series for stationarity. Johansen co-integration test was used to test co-integrating relationships among the variables in the model. Also, the vector error correction model was used to estimate the determinants of PCAGDP of the Country. study tested the time series data. The results show that the Country had an average PCAGDP of 25 Million Naira for the period. In the long run, area of land used by foreign investors, domestic investment in agriculture and government capital expenditure on agriculture negatively influenced PCAGDP; in the short run only area of land used by foreign investors was significant and negatively related to PCAGDP.

The study recommends policies that would regulate foreign investors' access to land for agricultural production so as to ensure that small holder farmers access to land is not jeopardized. Also, it recommends stricter monitoring of government's spending in agriculture to ensure that funds are used for the purpose for which they were allocated.

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Genetic Variability and Heritability Study of Hot Pepper (*Capsicum Annuum* L.) Genotypes in Wolaita, Southern Ethiopia

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Abstract- Genetic variability, heritability and genetic advance study was conducted using 55 hot pepper genotypes with the objectives to identify the extent of genetic variability explained by genotypes and to assess the magnitude of heritability (broad sense) and expected genetic advance. The experiment was conducted during 2016-2018 at three locations in Wolaita, Southern Ethiopia using RCBD with three replications. The result illustrated the existence of sufficient genetic variability in growth, yield and quality characters. The fresh fruit yield ranged from 3151.43kg/ha to 43002.86kg/ha with a difference of 39851.43kg/ha. Similarly, the oleoresin content and dry weight depicted range of 1.44-10.20% and 489.83-7652.85kg/ha, respectively indicating ample variability for further improvement and selection of superior genotype. The PCV in percent ranged from 33.44 (for oleoresin) to 8.50 (branch number) and GCV ranged from 32.15 to 7.21 for same traits which is an indication for broad genetic base and these traits are under the control of additive gene effects and, hence, there is a good scope for further improvement. Heritability (in broad sense) ranged from 60.39 (fruit number) to 92.39 (oleoresin content).

Keywords: genetic advance, heritability, hot pepper, variability, variety.

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Shumbulo Abrham

Abstract- Genetic variability, heritability and genetic advance study was conducted using 55 hot pepper genotypes with the objectives to identify the extent of genetic variability explained by genotypes and to assess the magnitude of heritability (broad sense) and expected genetic advance. The experiment was conducted during 2016-2018 at three locations in Wolaita, Southern Ethiopia using RCBD with three replications. The result illustrated the existence of sufficient genetic variability in growth, yield and quality characters. The fresh fruit yield ranged from 3151.43kg/ha to 43002.86kg/ha with a difference of 39851.43kg/ha. Similarly, the oleoresin content and dry weight depicted range of 1.44-10.20% and 489.83-7652.85kg/ha, respectively indicating ample variability for further improvement and selection of superior genotype. The PCV in percent ranged from 33.44 (for oleoresin) to 8.50 (branch number) and GCV ranged from 32.15 to 7.21 for same traits which is an indication for broad genetic base and these traits are under the control of additive gene effects and, hence, there is a good scope for further improvement. Heritability (in broad sense) ranged from 60.39 (fruit number) to 92.39 (oleoresin content). This indicated moderate to high heritability in all characters. In same manner, genetic advance as percent of the mean (GAM) varied from 12.13% (plant height) to 63.33% (oleoresin content). High heritability coupled with high GAM was observed for most of the characters indicating the predominance of additive gene action and hence direct phenotypic selection for improvement is useful with respect to these traits in hot pepper genotypes studied.

Keywords: genetic advance, heritability, hot pepper, variability, variety.

I. INTRODUCTION

Hot pepper (*Capsicum annum* L.), in the family Solonaceae ($2n = 24$), is an important spice and vegetable crop¹³. According to⁷ pepper production covers the lion share 74.63% of all the area under vegetables production and contributes 41.43 % yield to vegetable sector in Ethiopia. The crop has been produced for long periods of time in the country for coloring purposes, paprika and *capsicum* oleoresins for export market. It has wide indigenous applications in Ethiopian culture due its medicinal, nutritional and mainly for its pungency and color. Moreover, the crop has significant value in its household income generation

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and hence contributes for food security of rural community in Ethiopia²⁶.

The genotypic variation in the population is due to genetic differences among individuals for a particular character. On the other hand, phenotypic character is the observable difference present in individual due to the effects of both genotype and environment^{9, 23}. We must recognize that the variability observed in some characters is caused primarily by difference in the genes carried by the different individuals and that the remaining variability in the character is due primarily to differences in the environment to which individuals have been exposed^{2, 15}.

The presence of wide range of variability in any crop provides a better chance of selecting the desirable types²³. Detection of genetic variation and determination of genetic relationship between plant populations are important to develop efficient strategies for conservation and utilization of plant genetic resources. Improvement in any crop is proportional to the magnitude of its genetic variability present in germplasm¹⁷. For successful improvement program, plant breeders require basic information on crop variation, which are due to genotype, environment and genotype x environment interactions ($g \times e$)^{1, 12}.

Genetic variation in a crop population can be caused by domestication, segregation, germplasm collection, plant introduction, hybridization (intervarietal, distant, somatic), mutation, polyploidy, somaclonal variation and genetic engineering². According to^{11, 15} variability existing in a given set of germplasm is the sum total of heredity effects of the concerned genes, environmental influence and their interactions. This warrants the need to partition the observed variability into heritable and non-heritable components. These genetic parameters are measured as range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense and genetic advance as a percentage of mean^{4, 23, 32}.

The significance of heritability is that it generates information regarding the proportion of genotypic variance from the total phenotypic variance. Given a higher heritability for a given trait, it means selection becomes easier and simultaneously response to selection will be greater^{17, 18}. Previous studies have

been done to estimate variance components, heritability and genetic advance in various pepper characters⁹.

Heritability accompanied with genetic advance gives more relevant and useful information than heritability alone in predicting the effect of character for selecting the best individual among generations^{17, 18}. In addition,⁶ suggested that genetic coefficients of variation together with heritability estimates would give the best picture of genetic advance to be expected from selection. Therefore, traits that exhibited a high genotypic coefficient of variation, heritability and genetic advance as percent of the mean would be useful as a base for selection^{8, 9}.

Ethiopia has long history of producing hot pepper varieties for traditional house hold consumption, local and international markets in varieties of processed products such as oleoresins. Some scholars believe Ethiopia to be one of center of diversity in hot pepper germplasm due to diversity of cultivars growing in diverse agroecological zones in the country. In Ethiopia in general and in southern regions in particular, the crop is becoming high value cash crop and its demand is increasing from time to time. But to exploit the existing potential and to contribute for the growing demand of local, national and international markets, the attention given and research efforts done so far in the area is very low as compared to other crops. Thus, to address the existing critical gap for crop improvement the current research was designed with the following objectives:

1. To identify the extent of genetic variability explained by hot pepper genotypes studied.
2. To assess the magnitude of character heritability (broad sense) and expected genetic advances for selection.

II. MATERIALS AND METHODS

a) Description of the Study Areas

The field experiment was conducted at three different locations namely, Areka, Humbo and Wolaita Sodo university horticulture research and demonstration site in Southern Ethiopia for two years from 2016 to 2018.

b) Treatments, Experimental Design and Field management

The field experiment was done using 55 hot pepper genotypes out of which 45 were F₁ hybrids and the rest 10 were parental materials. Out of 10 parents, six were introduced from AVRDC (Asia) and four were Ethiopian released varieties. The 10 parents were crossed in half diallel mating design and produced the 45 F₁ hybrids.

The experimental design used at each location was RCBD with three replications. The continuous plots were used during field planting to minimize heterogeneity in soil variability. Seedlings were transplanted using plant spacing of 70 cm x 30 cm

between rows and plants, respectively. Each plot consisted of four row and ten plants per row that accommodated 40 plants in each plot. Thus, the plot area was 2.8m x 3.0m = 8.4 m². There was 1m distance between blocks and all other basic recommended horticultural practices were employed uniformly for all plots as per the recommendation of Melkasa Agricultural Research Center (MARC).

Table 1: Basic information of Hot pepper genotypes used during the experiment

Sr. No.	Genotype	Origin	Code
1	Melkaawaze	Ethiopia	G ₁
2	Marakofana	Ethiopia	G ₂
3	Melkashote	Ethiopia	G ₃
4	Melkazala	Ethiopia	G ₄
5	AVPP9813	Asian	G ₅
6	AVPP0206	Asian	G ₆
7	AVPP0514	Asian	G ₇
8	AVPP0512	Asian	G ₈
9	AVPP0105	Asian	G ₉
10	AVPP59328	Asian	G ₁₀
11-55	F ₁ -Hybrids	Cross/hybrids	G11- G55

c) Data Collected

Data were collected from representative randomly selected ten plants taken from central two rows of each plot for growth, yield and quality parameters.

Plant height [cm], Plant canopy width [cm], Stem diameter [cm], Branch number per plant, Number of fruits per plant, Fruit length [cm], Fruit width [cm], Fruit weight [g], Fruit wall thickness [mm], Number of seeds per fruit, Total Fruit yield [kg/ha], Total fruit dry weight [kg/ha], and Oleoresin content[w/w%].

d) Statistical Analysis

i. Estimation of variability parameters

The variance components were estimated from the mean square in the combined analysis of variance. Where:

$$\sigma^2_e \text{ (Error variance component)} = \text{MSe}$$

$$\sigma^2_{ge} \text{ (Variance component of GXE interaction)} = \frac{MS_{ge} - MSe}{r}$$

$$\sigma^2_g \text{ (variance component of genotype)} = \frac{MS_g - MS_{ge}}{re}$$

Phenotypic variance of the means for genotypes over locations and replications, σ^2_p , was estimated as:

$$\sigma^2_p = \sigma^2_g + \frac{\sigma^2_{ge}}{e} + \frac{\sigma^2_e}{re}$$

Where: σ^2_p -phenotypic variance

σ^2_g - genotypic variance

σ^2_{ge} - variance due to genotype by environment interaction

ii. *Coefficient of variation*

Genotypic and phenotypic coefficients of variation were calculated as the ratio of their standard deviation to the mean of the character expressed in percentage²⁸.

1. Phenotypic coefficient of variation

$$PCV\% = \frac{\sigma P_i}{\bar{X}_i} \times 100$$

2. Genotypic coefficient of variation

$$GCV\% = \frac{\sigma G_i}{\bar{X}_i} \times 100$$

where,

σP_i , and σG_i were the phenotypic, genotypic and environmental standard deviations for i^{th} characters, respectively.

\bar{X}_i = Mean of i^{th} character

iii. *Heritability and Expected genetic advance*

Heritability in broad sense (H) was calculated as the ratio of genotypic variance to the phenotypic variance³. The heritability estimates was calculated as follows:

$$H(h^2_b) = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

where,

$H(h^2_b)$ = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

In a typical experiment where g accessions are evaluated at L environments, with r replications per locations *Heritability* on genotypic mean basis can be expressed as:

$$\frac{\sigma^2_g}{\sigma^2_g + \frac{\sigma^2_{gL}}{L} + \frac{\sigma^2}{rL}}$$

Where: σ^2 = the experimental error variance

σ^2_{gL} = the genotype by environment interaction variance

σ^2_g = the total genotypic variance¹⁶.

iv. *Expected genetic advance*

Expected genetic advance was estimated as suggested by³.

$$GA = K \times \sigma p \times H$$

Where,

K = Selection differential expressed in standard unit (2.06 at 5% selection intensity)

σp = Phenotypic standard deviation calculated as square root of phenotypic variance

H = Heritability in broad sense

GA = Expected genetic advance

Genetic advance expressed as percentage of mean (GAM) = $\frac{\text{expected GA}}{\text{Grand mean}} \times 100$

For categorizing the magnitude of different parameters, the following limits were used:

PCV, GCV and ECV <10% = Low; 10-20% = Moderate; >20% = High²⁷;

Genetic advance (GA) <15% = Low; 15-30% = Moderate; >30% = High

Heritability <60% = Low; 60%-80% = Moderate; > 80% = High¹⁸.

III. RESULTS

a) *Variability Study*

Variability in means, ranges, genotypic variance (σ^2_g), phenotypic variance (σ^2_p), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2_b), genetic advance (GA) in absolute units and as percent of the mean (GAM) were employed to assess the variability existed on genotypes studied. The result illustrated significant ranges in variability in growth, yield and quality characters. The fresh fruit yield ranged from 3151.43kg/ha to 43002.86kg/ha with a difference of 39851.43kg/ha. Similarly, the oleoresin content and dry weight depicted range of 1.44-10.20% and 489.83-7652.85kg/ha, respectively which clearly indicates the existing variability in potential for breeding, further improvement and selection of superior genotype (Table 2).

The percentage values of PCV ranged from 33.44(for oleoresin) to 8.50(branch number) and GVC ranged from 32.15 to 7.21 for same traits. High PCV were recorded for traits oleoresin (33.44), fresh fruit yield (24.44), fruit number per plant (23.39) and dry weight (21.61) and that of high GCV were recorded for oleoresin (32.15) and fresh fruit yield (21.72) (Table 2). Moreover moderate PCV estimates were noticed by traits canopy width (11.01), stem diameter (11.30), fruit length (10.79), fruit diameter (11.88), skin thickness (10.81) and seed number per fruit (14.47) while moderate GCV values were recorded by fruit number (18.17), fruit diameter (10.85), seed number per fruit (12.62) and fruit dry weight (18.07) substantiating the variability in studied genotypes.

b) *Heritability and Genetic Advance*

Broad sense heritability ($H_b\%$) for traits ranged from 60.39 for fruit number per plant to 92.39 for oleoresin content. Results indicated that characters showed heritability greater than 60% which explained their moderate to high heritability. According to the current investigation traits with high heritability in order of magnitude were oleoresin content (92.39), fruit diameter (83.48), fruit length (80.96) and fresh fruit yield (78.94) (Table 2).

Genetic advance as percent of the mean (GAM) that could be expected from selecting the top 5% of the genotypes, varied from 12.13 % for plant height to 63.33% for oleoresin content. Traits with high GAM

values in the order of magnitude include oleoresin content (63.33), fresh fruit yield (39.80), dry fruit weight (31.18), fruit number per plant (29.13) and seed number per fruit (22.69) (Table 2).

Table 2: Variability and heritability of 12 traits studied for 55 hot pepper genotypes, 2016 to 2018

Traits	Mean	Min	Max	Range	σ^2_g	σ^2_p	GCV%	PCV%	H _{bs} (%)	GA	GAM
PH	54.38	17.33	115.20	97.87	15.53	23.57	7.25	8.93	65.87	6.60	12.13
CW	40.79	16.00	86.20	70.20	15.32	20.15	9.59	11.01	76.00	7.04	17.26
BN	5.46	2.00	10.10	8.10	0.15	0.22	7.21	8.50	71.87	0.69	12.61
SD	3.83	1.90	9.00	7.10	0.15	0.19	9.95	11.30	77.63	0.69	18.09
FN	40.61	6.75	174.00	167.25	54.47	90.19	18.17	23.39	60.39	11.83	29.13
FL	88.09	10.90	149.85	138.95	73.12	90.31	9.71	10.79	80.96	15.87	18.02
FD	13.66	8.45	32.21	23.75	2.20	2.63	10.85	11.88	83.48	2.79	20.46
TIC	1.43	0.48	3.27	2.79	0.02	0.02	9.17	10.81	72.03	0.23	16.06
SN	75.59	22.25	146.01	123.76	90.98	119.68	12.62	14.47	76.01	17.15	22.69
OL	5.53	1.44	10.20	8.76	3.16	3.42	32.15	33.44	92.39	3.50	63.33
YLD	11087.69	3151.43	43002.86	39851.43	5797002.14	7343179.28	21.72	24.44	78.94	4413.05	39.80
DW	2275.38	489.83	8142.68	7652.85	169111.81	241754.34	18.07	21.61	69.95	709.54	31.18

PH=Plant height; CW= Canopy width; BN=Branch number; SD=Stem diameter; FN= Fruir number; FL= Fruit length; FD= Fruit diameter; TIC= Pericarp thickness; SN= Seed number; OL= Oleoresin content; YLD=fresh fruit yield; DW= Dry weight.

IV. DISCUSSION

The current investigation confirmed the existence of sufficient genetic variability for many of the horticultural traits studied on 10 parents and 45 F₁ hybrids of hot pepper genotypes. In line with current findings, earlier authors Krishna *et al.*¹⁹; Vani *et al.*³¹; Ukkund *et al.*³⁰; Sharma *et al.*²⁵; Munshi *et al.*²² noticed almost same findings.

In the table 2, result revealed that the greater proportion of phenotypic variance was explained by genotypic variance and thereby contributed for high heritability of character confirms the greater contribution of genetic variability for phenotypic variability that further gives opportunity for selection and improvement. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters and the difference between PCV and GCV was narrow indicating the little influence of environment on the expression of these characters and considerable amount of genetic variation was observed for all the characters. These results were supported by earlier observations of Munshi *et al.*²², Krishnamurthy *etal.*²⁰, Sandeep *et al.*²⁴. In line with the current finding Vijaya *et al.*³² reported high PCV and GCV for dry fruit yield per plant followed by number of fruits per plant. Manju and Sreelathakumary²¹ reported the highest PCV and GCV for these characters. Again high estimates of PCV and GCV were reported for number of fruits per plant (40.50 and 37.77 %), dry fruit weight (40.75 and 37.77 %), and yield per plant (30.81 and 26.43%) by Janaki *et al.*¹⁷. This

indicates the existence of wide range of genetic variability, broad genetic base, less environmental influence and these traits are under the control of additive gene effects and hence, there is a good scope for further improvement of these characters through simple selection. Moreover, there were traits which depicted moderate PCV and GCV values like canopy width, stem diameter, fruit length, and fruit diameter. In line with the current finding, Sharma *et al.*²⁵ reported moderate PCV in pericarp thickness; Devi⁹ reported moderate PCV and GCV values for fruit length and width; Afroza *et al.*⁵ reported moderate PCV and GCV for fruit length, fruit diameter, flesh thickness and number of fruits per plant.

High heritability was observed in some traits like oleoresin content, fruit diameter, fruit length and fresh fruit yield that can be attributed to greater role of additive and additive x additive gene action, which can be exploited by following simple selection. Dhaliwal *et al.*¹⁰ noticed high heritability for red ripe fruit yield, plant height, fruit length, and fruit width indicating that these characters were less influenced by the environment and improvement by selection is relatively easier and rewarding. Krishna *et al.*¹⁹ reported same finding for fruit length, fruit number and fresh fruit yield. Yatung *et al.*³³ observed high heritability for all the characters ranged between 68.47 and 98.44%.

High heritability coupled with high genetic advance as per cent of mean was observed for most of the characters indicating the predominance of additive gene action and hence direct phenotypic selection for

improvement is useful with respect to these traits in hot pepper genotypes studied. Consistent with the current results, earlier workers noticed high heritability coupled with high genetic advance for fresh fruit yield, plant height, fruit length and fruit width (Dhaliwal *et al.*¹⁰); for all yield and quality related characters (Vijaya *et al.*³²; Gupta *et al.*¹⁴) for fruit diameter and average dry fruit weight; Suryakumari *et al.*²⁹ for number of seeds per fruit; (Krishna *et al.*¹⁹) for total fruit yield and fruit number.

V. CONCLUSION

The result illustrated significant ranges of variability in growth, yield and quality characters indicating ample variability for further improvement and selection of superior genotypes. The difference between PCV and GCV was narrow indicating the little influence of environment on the expression of these characters and considerable amount of genetic variation was observed for all the characters. Broad sense heritability explained moderate to high heritability in all characters. High heritability coupled with high GAM was observed for most of the characters indicating the predominance of additive gene action and hence direct phenotypic selection for improvement is useful with respect to these traits in hot pepper genotypes studied. Therefore, using different varieties at different agroecological regions is crucial to exploit the potential variability existing among hot pepper genotypes.

Significance statement

Ethiopia is endowed with diverse agroecology to accommodate varieties of hot pepper to grow for local and international markets. Thus, identifying and assessing the existing and newly introduced hot pepper varieties for yield and quality has significant importance for production and productivity in the area.

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Genetic Variability, Correlation and Path Analysis of Different Hill-Rice (*Oryza Sativa*) Genotypes

By N. Acharya, S. S. Acharya, A. Poudel & N. Neupane

Abstract- Rice (*Oryza sativa*), a staple food crop is central to the lives of people around the world. Present production of rice will not suffice rapidly increasing population as the area for production is decreasing. This necessitate to increase the productivity of rice through crop improvement. In order to identify suitable traits that contribute for crop improvement through the estimation of genetic variability, correlation and path coefficient analysis an experiment on eleven rice genotypes was conducted in randomized complete block design (RCBD) with three replications under irrigated condition at Institute of Agriculture and Animal science, Lamjung. Analysis of Variance revealed that genotypes under study differed significantly for all the traits under study which implies that genotypes constitute a pool of germplasm with adequate variability. The phenotypic coefficient of variation (PCV) values were higher than genotypic coefficient of variation (GCV), revealing lower influence of environment in character expression. High heritability coupled with high genetic advance and moderate GCV were observed for leaf area, number of effective tillers per m² and days to 50% flowering.

Keywords: correlation, GCV, genetic advance, heritability, path analysis.

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Genetic Variability, Correlation and Path Analysis of Different Hill-Rice (*Oryza Sativa*) Genotypes

N. Acharya ^α, S. S. Acharya ^σ, A. Poudel ^ρ & N. Neupane ^ω

Abstract- Rice (*Oryza sativa*), a staple food crop is central to the lives of people around the world. Present production of rice will not suffice rapidly increasing population as the area for production is decreasing. This necessitate to increase the productivity of rice through crop improvement. In order to identify suitable traits that contribute for crop improvement through the estimation of genetic variability, correlation and path coefficient analysis an experiment on eleven rice genotypes was conducted in randomized complete block design (RCBD) with three replications under irrigated condition at Institute of Agriculture and Animal science, Lamjung. Analysis of Variance revealed that genotypes under study differed significantly for all the traits under study which implies that genotypes constitute a pool of germplasm with adequate variability. The phenotypic coefficient of variation (PCV) values were higher than genotypic coefficient of variation (GCV), revealing lower influence of environment in character expression. High heritability coupled with high genetic advance and moderate GCV were observed for leaf area, number of effective tillers per m² and days to 50% flowering. Number of effective tillers per m² and panicle length had significant positive correlation with grain yield. The result of path coefficient analysis revealed that panicle length exhibited maximum positive direct effect on grain yield followed by number of effective tillers per m², days to 50% flowering and 1000-grain weight whereas number of un-effective tillers per m² exhibited maximum negative direct effect on grain yield. Therefore, result suggest these traits can be used for grain yield selection and improvement.

Keywords: correlation, GCV, genetic advance, heritability, path analysis.

I. INTRODUCTION

Rice (*Oryza sativa* L.) is an important annual, self-pollinated, diploid (2n=2x=24) cereal crop species. Rice is mainly grown on tropics, sub-tropics, semi-arid tropics, and temperate regions of the world. Globally, rice is grown on 163 million hectares in over hundred countries that produce more than 715 million tons of paddy rice annually (FAOSTAT, 2017). In Nepal, according to MoAD (2015/16) the rice crop was grown in 1.36 million hectares with the production of 4.29 million metric tons and productivity 3.15 tons/ha. Present production trend of rice will not be able to feed increasing population in depleting land resource availability. Therefore, there is a need for increase in production through increase in productivity which could be obtained through genetic improvement.

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a) Objectives

- To access the extent of correlation of traits with grain yield.
- To estimate direct and indirect effect of traits under study on grain yield.
- To study the genetic divergence in rice genotypes.

b) Hypothesis testing

- *Null hypothesis:* Rice genotypes give similar performance.
- *Alternative hypothesis:* Rice genotypes show significant difference in performance.

II. MATERIALS AND METHODS

The experiment was conducted at the field of Institute of agriculture and Animal Science, Lamjung Campus during kharif season under irrigated condition. For the experiment, 11 genotypes were studied which were laid in Randomized Complete Block Design (RCBD) with 3 replications. Pokhareli jethobudo was used as standard check against other 10 varieties. Seedling were transplanted after 25 days of seedling establishment in the plot of size 2 m² and plant geometry 20×20 cm. Fertilizers were applied as per general recommended dose for irrigated condition i.e 100:30:30 Kg/ha NPK where half dose of nitrogen, full dose of phosphorus and full dose of potash were applied as basal dose and split dose of nitrogen were applied after two weeding operation (i.e. 25 and 50 DAT).

Table 1: Genotypes used in the experiment

Sr. No.	Treatment	Genotypes
1	T ₁	khumal-9
2	T ₂	NR11050-B-B-B-1
3	T ₃	NR10676-B-5-3
4	T ₄	NR11153-B-B-18
5	T ₅	NR11100-B-B-15-2-1
6	T ₆	khumal-2
7	T ₇	khumal-11
8	T ₈	NR11105-B-B1-16-2
9	T ₉	Chainung-242
10	T ₁₀	khumal-6
11	T ₁₁	Jethobudho

Most of the data were recorded from five randomly selected hills in each plot whose mean values

were used for data analysis. Following characters were studied: plant height, leaf area, chlorophyll content, number of effective tillers/m², number of un-effective tillers/m², days to 50% flowering, panicle length, filled grains per panicle, grain yield, straw yield, 1000-grain weight. All data obtained for each character were subjected to analysis of variance. Various genetic parameters such as genetic variance, phenotypic variance, genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (H), genetic advance (GA) and genetic advance as percentage of mean (GAM) were computed.

Relationship between yield and yield components were analyzed using simple correlation analysis (Weber and Moorthy, 1952) and path analysis (Dubey and Lu, 1959). Data were entered in Microsoft-excel and analyzed via Microsoft-excel, R-packages and SPSS 16.0.

III. RESULTS AND DISCUSSION

a) Analysis of variance

The analysis of variance exhibited the presence of significant difference among the tested genotypes for all the characters indicating the existence of variability.

Table 2: Mean performance of hill rice genotypes.

Genotype	Plant Height	Leaf Area	Chlorophyll Content	Effective Tillers	Un-effective Tillers	Panicle Length
01.khumal-9	144.88 ^{ab}	41.97 ^b	34.50 ^{ab}	180.00 ^f	30.00 ^{bc}	24.89 ^{de}
02.NR11050-B-B-B-B-1	150.78 ^{ab}	52.19 ^a	34.25 ^{ab}	220.00 ^e	76.67 ^a	31.26 ^a
03.NR10676-B-5-3	149.11 ^{ab}	32.47 ^{cd}	33.42 ^b	310.00 ^a	31.67 ^{bc}	25.32 ^{cde}
04.NR11153-B-B-18	148.75 ^{ab}	32.53 ^{cd}	33.32 ^b	226.67 ^{de}	40.00 ^{bc}	26.15 ^{cd}
05.NR11100-B-B-15-2-1	147.63 ^{ab}	42.16 ^b	33.30 ^b	250.00 ^c	38.33 ^{bc}	27.96 ^b
06.khumal-2	146.29 ^{ab}	41.85 ^b	30.15 ^c	243.33 ^{cd}	40.00 ^{bc}	26.25 ^c
07.khumal-11	105.99 ^c	28.86 ^d	36.85 ^a	191.67 ^f	56.00 ^{ab}	22.22 ^g
08.NR11105-B-B1-16-2	142.74 ^b	32.75 ^{cd}	33.49 ^b	178.33 ^f	11.67 ^c	24.47 ^{ef}
09.Chainung-242	114.33 ^c	28.56 ^d	36.39 ^a	171.67 ^f	53.33 ^{ab}	23.36 ^g
10.khumal-6	144.33 ^b	28.76 ^d	35.18 ^{ab}	280.00 ^b	51.67 ^{ab}	28.33 ^b
11.Jethobudho	162.55 ^a	36.60 ^{bc}	34.31 ^{ab}	215.00 ^e	63.33 ^{ab}	25.67 ^{cde}
F-test	***	***	**	***	*	***
LSD (5%)	17.29	6.78	2.52	20.05	30.93	1.22
CV%	7.17%	10.99%	4.34%	5.25%	40.55%	2.74%
Grand Mean	141.58	36.25	34.11	224.24	44.79	25.62

Significance codes: 0 '***', 0.001 '**', 0.01 '*'

Table 3: Mean performance of hill rice genotypes

Genotype	Flowering	TGW	Filled Grain	Straw Yield	Grain Yield	Harvest Index
01.khumal-9	91.33 ^{efg}	29.23 ^a	109.33 ^c	6888.89 ^{ab}	5250.00 ^{bc}	43.68 ^{bc}
02.NR11050-B-B-B-B-1	103.33 ^b	22.57 ^{cde}	162.20 ^a	5938.89 ^{ab}	5651.66 ^{abc}	48.61 ^{bc}
03.NR10676-B-5-3	94.33 ^{cde}	21.00 ^e	132.60 ^{bc}	7029.17 ^a	6056.25 ^{ab}	46.13 ^{bc}
04.NR11153-B-B-18	94.00 ^{cde}	26.43 ^{abc}	142.07 ^{ab}	6583.33 ^{ab}	5683.33 ^{abc}	46.28 ^{bc}
05.NR11100-B-B-15-2-1	96.67 ^{cd}	25.30 ^{abcd}	133.20 ^{bc}	6429.17 ^{ab}	6799.17 ^a	51.30 ^b
06.khumal-2	94.00 ^{de}	25.47 ^{abc}	124.53 ^{bc}	6877.78 ^{ab}	6129.17 ^{ab}	47.17 ^{bc}
07.khumal-11	88.33 ^g	27.53 ^{ab}	130.20 ^{bc}	3383.33 ^c	5005.55 ^{bc}	59.50 ^a
08.NR11105-B-B1-16-2	98.33 ^c	21.13 ^{de}	164.33 ^a	5894.44 ^{ab}	5037.92 ^{bc}	46.01 ^{bc}
09.Chainung-242	87.00 ^g	28.07 ^{ab}	114.40 ^c	5645.83 ^b	4258.33 ^c	43.07 ^c
10.khumal-6	92.33 ^{def}	24.07 ^{bcd}	123.20 ^{bc}	6877.78 ^{ab}	6337.78 ^b	47.73 ^{bc}
11.Jethobudho	134.33 ^a	20.87 ^e	115.27 ^{bc}	6527.78 ^{ab}	5065.28 ^{bc}	43.56 ^{bc}
F-test	***	**	**	***	*	**
LSD (5%)	3.99	4.02	23.91	1160.85	1316.4	6.92
CV%	2.40%	9.56%	10.64%	11.01%	13.87%	9.52%
Grand Mean	97.64	24.7	131.94	6188.763	5570.404	43.31

Significance codes: 0 '***', 0.001 '**', 0.01 '*'

b) Genetic variability

Estimates of phenotypic variance (σ^2_p) and Genotypic variance (σ^2_g), phenotypic coefficient of variation (PCV) and genotypic coefficient of variation

(GCV), heritability (h^2), genetic advance (GA) and genetic advance as a percentage of mean (GAM) are shown in Table.

Table 4: Estimates of variability, heritability, genetic advance and genetic advance as a percentage of mean

Traits	σ^2g	σ^2p	GCV	PCV	h^2	GA	GAM
PH	237.83	340.93	10.89	13.04	0.70	26.48	18.71
LA	51.05	66.91	19.71	22.57	0.76	12.86	35.47
CHL	2.46	4.65	4.60	6.32	0.53	2.35	6.89
EFF	1902.67	2041.67	19.45	20.15	0.93	86.74	38.68
UNEFF	208.23	538.03	32.22	51.79	0.39	18.49	41.29
PL	6.07	6.58	9.48	9.87	0.92	4.87	18.76
DF	166.70	172.20	13.22	13.44	0.97	26.17	26.80
FG	264.40	461.40	12.32	16.28	0.57	25.36	19.22
TGW	7.13	12.71	10.81	14.44	0.56	4.12	16.69
SY	641874.33	1392033.33	13.57	19.98	0.46	1120.71	18.98
GY	335694.00	933095.00	10.40	17.34	0.36	715.89	12.85

PH=Plant Height, LA=Leaf Area, CHL= SPAD reading, EFF= Effective numbers of tillers m^2 , UNEFF=Number of un-effective tillers m^2 , PL= Panicle Length, DF= Days to 50% flowering, SY= Straw yield, TGW= 1000-Grain Weight, FG=Number of Filled Grains per Panicle, GY=Grain Yield

The GCV value were ranged from 4.60 for chlorophyll content to 32.22 for un-effective tillers per m^2 whereas values for PCV ranged from 6.32 for chlorophyll content to 51.79 for number of un-effective tillers per m^2 . The values of PCV were higher than the values of GCV indicating the influence of environment in the expression of traits. Number of un-effective tillers per m^2 was found to have high GCV and plant height, leaf area, effective number of tillers per m^2 , days to 50% flowering, number of filled grains per panicle, 1000-grain weight, straw yield and grain yield were found to have moderate GCV which signifies that the direct selection through phenotype observation is effective. Chlorophyll content and panicle length were found to have the low GCV whose direct selection may not be rewarding. Similar results were obtained by Rashid et al. (2017), Umesh et al. (2015), Dhanwani et al. (2013), Sumanth et al. (2017), Islam et al. (2017). The result for grain yield was supported by Binda et al. (2017) and for number of un-effective tiller per m^2 by Limbani et. Al (2017).

The heritability estimates vary from 0.97 to 0.36 for days to 50% flowering and grain yield respectively. According to Robinson et al. (1949) the heritability estimates were categorized as low medium and high. Among the traits studied grain, chlorophyll content, number of un-effective tiller per m^2 , 1000-grain weight, number of filled grains per panicle and straw yield showed moderate heritability whereas plant height, leaf area, panicle length, days to 50% flowering density showed high heritability. Above results were in agreement with results obtained by Alam et al. (2014), Konate et al (2016) and Limbani et al. (2017).

GAM ranges from 38.68 for effective number pf tillers per m^2 to 6.89 for chlorophyll content. GAM was also categorized to low, medium and high where chlorophyll content was found to have low GAM indicating non-additive gene action and selection for this trait is not rewarded. Plant height, panicle length, filled grains per panicle, 1000-grain weight, harvest index,

straw yield and grain yield, leaf area, number of un-effective tiller per m^2 , number of effective tillers per m^2 , days to 50% flowering were found to have moderate to high GAM suggesting additive gene action whose selection will be beneficial for crop improvement. The result was similar to the finding of Akinwale et al. (2011), Binda et al. (2017), Limbani et al. (2017) and Dhanwani et al. (2013).

c) Correlation coefficient analysis

The correlation coefficient among yield and yield components are presented in the table.

Table 5: Correlation between yield and yield component

	PH	LA	CHL	EFF	UNEFF	PL	DF	SY	TGW	FG	GY
PH	1										
LA	0.507	1									
CHL	-.628*	-0.45	1								
EFF	0.443	-0.003	-0.379	1							
UNEFF	-0.072	0.26	0.368	0.005	1						
PL	.626*	.685*	-0.334	0.444	0.39	1					
DF	.623*	0.262	-0.129	0.011	0.339	0.226	1				
SY	.801**	0.276	-.621*	0.504	-0.277	0.463	0.205	1			
TGW	-0.59	-0.105	0.287	-0.438	0.002	-0.353	-.617*	-0.273	1		
FG	0.153	0.273	-0.191	.00031	-0.106	0.384	-0.016	-0.161	-0.49	1	
GY	0.506	0.324	-0.553	.797**	-0.109	.623*	-0.069	0.487	-0.216	0.128	1

PH=Plant Height, LA=Leaf Area, CHL= SPAD reading, EFF= Effective numbers of tillers m², UNEFF=Number of un-effective tillers m², PL= Panicle Length, DF= Days to 50% flowering, SY= Straw yield, TGW= 1000-Grain Weight, FG=Number of Filled Grains per Panicle, GY=Grain Yield

*** Correlation is significant at 0.05 level (2-tailed)

** Correlation is significant at 0.01 (2-tailed)

The result showed that effective number of tillers per m² (.797**) and panicle length (.623*) had a significant and positive correlation with grain yield. Other traits showed non-significant correlation with the grain yield. Plant height (0.506), leaf area (0.324), straw yield (0.487), numbers of filled per panicle (0.128), showed a positive and non-significant correlation with grain yield. Chlorophyll content (-0.553), number of un-effective/m² (-0.109) days to 50% flowering (-0.069) and 1000-grain

weight (-0.216) showed non-significant and negative correlation with grain yield. This result is in agreement with the results of Ekka et al. (2011), Babu et al. (2012), Konate et al. (2016), Abarshahr et al. (2011) and Ukaoma et al. (2013).

d) Path coefficient analysis

The path coefficient analysis for grain yield is presented in the table.

Table 6: Path coefficient analysis of yield attributing traits of hill rice genotypes

	PH	LA	CHL	EFF	UNEFF	PL	DF	SY	TGW	FG
PH	-0.416	-0.211	0.261	-0.184	0.030	-0.260	-0.259	-0.333	0.245	-0.064
LA	-0.024	-0.048	0.022	0.000	-0.012	-0.033	-0.013	-0.013	0.005	-0.013
CHL	0.142	0.102	-0.226	0.086	-0.083	0.076	0.029	0.140	-0.065	0.043
EFF	0.417	-0.003	-0.356	0.942	0.005	0.418	0.010	0.475	-0.413	0.000
UNEFF	0.069	-0.250	-0.353	-0.005	-0.959	-0.374	-0.325	0.266	-0.002	0.101
PL	0.758	0.830	-0.405	0.538	0.473	1.211	0.274	0.561	-0.427	0.465
DF	0.452	0.190	-0.094	0.008	0.246	0.164	0.726	0.149	-0.448	-0.012
SY	-0.493	-0.170	0.383	-0.311	0.171	-0.286	-0.126	-0.616	0.168	0.099
TGW	-0.372	-0.066	0.181	-0.276	0.001	-0.222	-0.389	-0.172	0.630	-0.309
FG	-0.028	-0.050	0.035	-0.000057	0.019	-0.071	0.003	0.030	0.090	-0.184
	0.506	0.324	-0.553	0.797	-0.109	0.623	-0.069	0.487	-0.216	0.128

PH=Plant Height, LA=Leaf Area, CHL= SPAD reading, EFF= Effective numbers of tillers m², UNEFF=Number of un-effective tillers m², PL= Panicle Length, DF= Days to 50% flowering, SY= Straw yield, TGW= 1000-Grain Weight, FG=Number of Filled Grains per Panicle, GY=Grain Yield

The result showed that panicle length had highest, positive and direct effect on grain yield followed by number of effective tillers per m², days to 50% flowering and thousand grain weight. Plant height, leaf area, chlorophyll content, straw yield, filled grains per panicle showed negative direct effect on grain yield. As number of effective tillers per m² and panicle length had significant positive correlation with grain yield along with high positive and direct effect indicating that the selection for these traits was likely to bring about an overall improvement in grain yield directly. Although

1000-grain weight, days to 50% flowering had negative correlation with grain yield but they exhibited positive effect directly to the grain yield. Highest indirect effect of leaf area was observed via panicle length followed by effective tiller via panicle length. The results were in confirmation with Ekka et al. (2011), Archana et al. (2018), Ashok et al. (2016), Gayathri and Padmalatha (2018), Basavaraja et al. (2013) and Rahman et al. (2014).

IV. CONCLUSION

Grain yield has lower heritability than other yield attributing traits. So, direct selection for grain yield will not be effective. As, correlation of grain yield with effective numbers of tillers/m² and panicle length was observed significantly positive and exerted high positive direct effect on grain yield they could be used as selection criteria for improvement of grain yield. NR10676-B-5-3 was found to be best for grain yield and yield attributing traits. Therefore, this genotype can be subjected to further trial.

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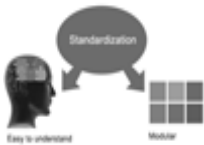
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The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.



FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELECTRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow [here](#).



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.



- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

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Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.



CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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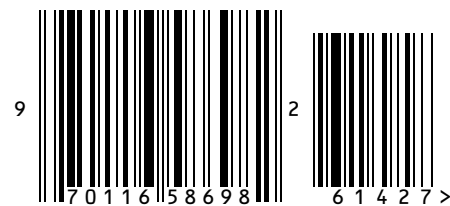
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