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Journal of Science and Sustainable Development (JSSD)

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- To contribute to the pool of scientific information by providing (creating) more access for researchers to have their original scientific work relevant to the need of the country and the world at large.

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All portions of the manuscript must be typed **double-spaced** and all pages numbered starting from the title page.

The **Title** should be a brief phrase describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author along with E-mail and P.O.Box address.

The **Abstract** should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The abstract should be 200 to 250 words in length. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.

Following the abstract, about 3 to 5 **key words** that will provide indexing references should be listed.

A list of non-standard **Abbreviations** should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelt out and introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Standard abbreviations (such as ATP and DNA) need not be defined.

The **Introduction** should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and Methods should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used.

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Results should be presented with clarity and precision. The results should be written in the past tense when describing findings in the author(s)' experiments. Previously published findings should be written in the present tense. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the results but should be put into the discussion section.

The **Discussion** should interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

The **Acknowledgments** of people, grants, funds, etc should be brief.

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double-spaced throughout, the captions. Each table should be numbered consecutively in Arabic numerals. Tables should be self-explanatory without reference to the text. The same data should not be presented in both table and graph forms or repeated in the text.

Figure: Figure captions should be typed in numerical order. Graphics should be prepared using applications capable of generating high resolution GIF, TIFF, JPEG or PowerPoint before pasting in the Microsoft Word manuscript file. Use Arabic numerals to designate figures and lower case letters for their parts e.g. (Figure 1).

References: In the text, a reference identified by means of an author‘s name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author‘s name should be mentioned, followed by ’et al‘. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like ’a‘ and ’b‘ after the date to distinguish the works.
Examples:

Abayomi (2000), Agindotan et al. (2003), (Kelebeni, 1983), (Usman and Smith, 1992), (Chege, 1998; Chukwura, 1987a,b; Tijani, 1993,1995), (Kumasi et al., 2001)

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Examples:

Moran GJ, Amii RN, Abrahamian FM, Talan DA (2005). Methicillinresistant *Staphylococcus aureus* in community-acquired skin infections. Emerg. Infect. Dis. 11: 928-930.

Chikere CB, Omoni VT and Chikere BO (2008). Distribution of potential nosocomial pathogens in a hospital environment. Afr. J. Biotechnol. 7: 3535-3539.

Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing *Escherichia coli* in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

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Short Communications are limited to a maximum of two to three figures/table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100-150 words; (2) Results and Discussion should be combined into a single section.

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RESEARCH PAPER

Communicating Local Economic Development Approach for Poverty Alleviation in Ambo Town, West Shewa, Oromia, Ethiopia

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Abstract

Local Economic development as approach to development is a prominent strategy to tackle unemployment and poverty in urban areas. Thus, the objective of the study was to assess and communicate the extent to which municipal Local Economic development initiatives contribute towards improving the livelihood of communities in Ambo Town for sustainable local economic development. Both quantitative and qualitative research methods were employed in this study. Accordingly, data were collected from 152 participants through questionnaire, interview and observation; and analyzed using descriptive statistics, content analysis and description. The study revealed that local economic development has had a marginal impact on poverty alleviation due to a myriad of factors which reinforce and interact with each other thereby trapping entrepreneurs and residents in poverty. Local economic development approach, in most cases, to the development project planning and decision makings are in top-down which do not target all the segments of the poor in a meaningful way. Local economic development serves as an important strategy to boost local economies to address the high levels of poverty, unemployment and inequalities facing majority population. Participatory development process is crucial to properly translate the local economic development policy into meaningful practice so that there is a significant impact on alleviating poverty program.

Keywords: Local Economic Development, Poverty Alleviation; Unemployment

Introduction

Development is a multi-dimensional concept; it could refer to the human development, economic development, sustainable development and territorial development or other type of development. It requires the involvement of different disciplines. Varied ways and activities are needed to bring about development and maintain and increase development. Many national approaches to development have been unsuccessful to satisfy the local needs as well as to tackle local economic difficulties and challenges, and, thus, have failed to improve people`s quality of life in a context of increasing globalization (Swinburn, 2006). Accordingly, poverty remains rampant and continues to compromise available opportunities to majority of the world's poorest people.

However, the rise of the use of Local Economic Development (LED) strategies as a tool for development can be seen in international development policy. Global economic factors have forced many governments to realign their strategies of development and these governments have used LED as an effective tool for development (Helmsing, 2001; World Bank, 2002). LED looks development as more holistically and shifts away from basic economic and materialistic thinking towards that which bases development on the attitudes of people and their interpretation of their needs. It is rooted in bottom-up, people-centered development literature rather than top-down, centralized thinking. This means that local economic development is primarily understood as a process whereby either local governments or community based organizations, or both, are responsible for coordinating the use of existing resources and to establish partnerships with one another and with the private sector to boost the local economy in order to improve the lives of the local people living in the area. LED is also connected to decentralization with regards to the delegation of power to lower levels of government, particularly in terms of economic activity, in order to ensure the financial viability and sustainability of local areas.

Hence, a wide range of strategic focus areas for LED now include inter alia, property development, place marketing for inward investment, Small, Medium and Micro Enterprise (SMME) development, investment facilitation, improving the local business investment climate, encouraging local business, institutional development, upgrading skills and training, investment in business sites and premises, and cluster upgrading (Rogerson, 2003; Harrison et al., 2008). In addition, LED plays an important part in local democratic literature since it is connected to ideas of citizen inclusion and voice, and the valuing of local knowledge, expertise and resources. LED integrates the economic measures and humane aspects of development but goes on further to focus on development at a micro level. It is a conscious process wherein small communities assisted by better developed institutions work toward improving standards of social and economic life (Jeppe 1980).

In line with the current global trend of streamlining the role of the state, the governments of Ethiopia have devolved power to grassroots institutions with a view to enhance development through decentralization. But in reality, such devolutions have in many cases been quite inefficient to achieve the development goal. The need to empower the local people responds to the growing recognition that local people in developing countries lack control over resources and opportunity to participate in decision making processes. For instance, the dominant paradigm of neo-liberalism limits economic possibilities and, ultimately, human flourishing for the vast majority of people. This market economy reinforces and perpetuates conditions of wealth inequality, poverty, environmental injustice, and health, gender and racial disparities. The contemporary local economic development approach; thereof, has been projected as a viable alternative development strategy capable of unleashing the development potentials of territories and making localities and their enterprises or economic ventures competitive in the global scene. Thus, municipalities have been tasked and have the responsibility to ensure that they fulfill the governmental constitutional developmental mandate of coordinating local economic initiatives despite challenges in their respective localities. In different words, municipalities have always played a role in local economic development. They employ people from local area, purchase goods and services, develop infrastructure and regulate the development of land and donors' grants directed to local community. These activities have significant impact on the local economy.

The study was conducted from a context where the poverty alleviation, unemployment and job creation serves as the strategic intent of the Ethiopia government through local municipalities’ development. Resources are expected to be channeled towards the support of small and medium enterprises (SMMEs), thus creating sustainable livelihoods for individuals and communities. The direct participation of local communities in the mainstreams of their local economies is crucial in making this strategy work effectively. Accordingly, the local economic development approach has been promoted in Ethiopia since 2009 mainly by international development agencies. Since then, there have also been national efforts to institutionalize the LED approach and also up-scale LED initiatives in different towns across the country. This study, thus, was carried out to assess the contribution of Local Economic development initiatives towards improving the livelihood of communities in Ambo Town.

Research Methods

Description of the Study Area

The research was conducted in Ambo town of West Shoa Zone in Oromia regional state of Ethiopia. The geographical (astronomical) location of the Ambo Town is approximately between 8º 56'30’’ N - 8º 59'30’’ N latitude and between 37º47'30" E - 37º 55'15" E longitude (topographic map sheet obtained from Ethiopian Mapping Agency and topographic surveyed map). Ambo town is located 110 km far away West of Addis Ababa.

Research Design

The research design is the overall plan for obtaining answers to the questions being studied and for handling some of the difficulties encountered during the research process. It normally specifies which of the various types of research approach adopted and how the researcher plans to implement scientific controls to enhance the interpretability of the results (Polit & Hungler, 1999). For the purpose of this study, both qualitative and quantitative methodologies which imply the application of mixed methods were used. This is basically due to the manifold advantage of such an approach. According to Creswell et.al (2007), the use of both qualitative and quantitative approaches in combination provides a better understanding of research problems that either approach alone. Generally, the descriptive research design is used to conduct the study.

Study population

Research population is expected to cover the stakeholders that could be useful strategy and carry out LED. They are individuals, community groups, firms and/or organizations in the public private and not-for-profit sectors (World Bank, 2002). In this research, the population includes municipal government structures working at different level, targeted communities, cooperative unions` representatives, SME representatives, private developers, professional associations, youth groups, and nongovernmental organizations.

This study employed purposive sampling to select the Ambo municipality. Purposive sampling lies in selecting information thus enabling researchers to target and engage only those respondents likely to have the required information and are willing to share (Berg, 2001).

To determine the sample size, Yemane formula is used. Yemane (1967) provides a simplified formula to calculate sample sizes.

$$n = \frac{N}{1+N\ (e)^2}$$

where n = sample; N = population; e= standard error

n = 16815/(1+16815(0.08)2

= 16815/108.6

= 154.83 or 155

The study adopted a confidence level of 92% and the margin of error of 8%.

Source of data and data collection tools

Both primary and secondary data were collected for the study. Concerning the primary data, information was gathered from the sample respondents. These are identified as beneficiaries of the project and chosen on the basis of the simple random sampling technique. As to the secondary data, information were collected from both authorized and non-authorized sources such as reports, project documents, manuals, research papers, newspapers, bulletins, posters, billboards, professional journals, etc.

Data Collection Tools

To gather very useful information for the research, the researcher used three data collection instruments. These are questionnaire (both open ended and close-ended), semi-structured interview and participant observation by the researcher. This helped to triangulate the data collected. To collect data from the respondents, 155 questionnaire papers were administered and 152 were collected. As most of target populations were not familiar with the English language, the questionnaire was prepared in English and translated in Afan Oromo to collect reliable data.

Methods of Data Analysis

The purpose of data analysis is to reduce data into intelligible and interpretable form so that the relation of research problems can be studied and tested. Interpretation takes the result of analysis, makes inferences pertinent to the research thesis and draws conclusions from relations (Kerlinger, 1986). Accordingly, depending on the nature of the LED, , the essential data were collected from respondents and the participants through questionnaires, interview and observation. Before grouping the obtained information from the instruments, checking was done to be sure that all data are relevant to the research. Then, the researcher reviewed all the responses and checklist information to recognize the similarities and differences of the data. So far, similar expressions and common patterns were sorted and recorded. Finally analysis and presentation be clearly described.

Accordingly, the quantitative data were analyzed using the Statistical Package for Social Scientists (SPSS) software updated version 20 at the time of analysis. To make the analysis procedural the questionnaires were coded and entered to the SPSS for statistical analysis. Descriptive statistics was the main statistical technique used during analysis as it describes those variables. Content analysis was the major analytical technique for qualitative data.

Results and Discussion

LED initiatives contribution towards the livelihoods of local communities

There are divergent views on the implementation of LED as a poverty alleviation tool to Ambo Town in particular and Ethiopia in general. From the interviews different views of LED emerge, even though it is a statutory requirement in most countries. Firstly, town and regional planners view LED as a means of enhancing the space economy of an area. In common terms which feature from this line of thought is developing corridors, nodes, economic hubs, infrastructure provision, and movement networks. From this perspective LED is concerned with designing and building infrastructure in long-term. Thus, through such approaches Ambo municipal economy can be mainstreamed and ultimately the global economy through anchor projects such as the UNDP and World Bank projects.

Economists and personnel from the SMEs support unit within the municipality, viewed LED is concerned with promoting business enterprises through business support activities. From this point of view, LED is mainly concerned with enhancing the competitive advantage of enterprises and letting the market dictate is central. LED; therefore, acquires an economic growth focus wherein with economic growth it is assumed that there will be trickled down effects and alleviate poverty. One; therefore, wonders how different LED is from previous economic development strategies or is it just the same outworn presumption repackaged.

Though LED is pro-poor, from the interviews with local community and some others municipality sectors, LED is scarcely viewed as a poverty alleviation tool. Instead, it is described as a wealth creation tool for some wealth people and family of officials. One community member or household confirmed that LED usually supports the wealth as- "Government created a number of jobs to minimize unemployment in the town through SMEs development. However, most shops here in our town organized through SMEs belong to official families or business owners." With this line of thought LED approach in Ambo Town; therefore, mainly geared to SME‘s at an advanced stage of development disregarding those at lower segment. Thus, LED is conceived as not achieving its objective of being pro-poor, since it finds it is not managing to reach the poor in a meaningful way.

Major Activities of LED initiatives

Different LED stakeholders work in different fields at variant levels depending on the specialty of the institution itself and availability of grants. Institutions can contribute in all different society daily life fields and efforts are needed to establish the proper tool to distribute the grants and capitals on effective fields relevant to the institutions. However, the respondents be aware of the implementation of the activities differently. Table 1 illustrates the activities of LED initiatives undertaken in Ambo Town.

Table 1: Activities of LED initiatives

Activities	n	Response	
		No	Yes
Infrastructure construction	152	76(50)	76 (50)
Humanitarian service	152	113 (74)	39(26)
Profit Making	152	103(68)	49(32)
Awareness creation/ communication	152	15(10)	137(90)
Environmental protection	152	37(24)	115 (76)

As the data in Table 1, 76 (50%) of the respondents responded that stakeholders participated in infrastructure construction. About 39 (26%) of the respondents responded that LED stakeholders provide humanitarian services, while 49 (32%) of the respondents stated that stakeholders do profit making. On different hand, almost all, 137 (90%) of the respondents confirmed that stakeholders provide awareness creation activities, and 115 (76%) stated that stakeholders provide environmental protection activities.

LED should exercise its functions in a way that it has maximum impact on the social and economic development of the local community by meeting the basic needs and interest. Through service delivery and regulations, local governments could exert a lot of influence on the social and economic well-being of local communities. The reasons how and the extent to which LED initiatives could curb the problem of the grassroots community and improve the leaving standards of the community is summarized in Table 2.

Extent of municipal LED initiatives contribute towards quality life

Table 2: Contribution of LED towards quality life of the respondents

S. No	Reasons for LED projects	Level of contribution										Mean
		Very Weak		Weak		Middle		High		Very High		
		n	%	n	%	n	%	n	%	n	%	
1	Poverty alleviation	-	-	-	-	12	7.9	88	57.9	52	34.2	**4.26**
2	Job creation and unemployment reduction	-	-	-	-	4	2.6	80	52.6	68	44.7	**4.42**
3	Skills development	-	-	-	-	32	21.1	47	30.9	73	48	**4.27**
4	Community development	-	-	-	-	12	7.9	66	43.4	74	48.7	**4.41**
5	Seize economic opportunities	-	-	41	27	37	24.3	44	28.9	30	19.7	**3.41**
6	Networking of stakeholders	-	-	1	0.7	10	6.6	83	54.6	58	38.2	**4.3**
7	Others (please clarify)											

Table 2 depicts that almost all, 140 (92.1%) participants responded as LED initiatives contribute for poverty alleviation with high 88 (59.9%) and very high 52 (34.2%) rate. In light of poverty alleviation, most respondents also agreed that their standards of living is improved immensely with the income derived and the products sold, giving them something to take home to support their families. On top of this, some of the respondents indicated that they were able to improve their houses, buy TV sets and furniture (Sofa). With regard to job creation and unemployment reduction of LED projects, 80 (52.6%) rated that LED initiatives contribute to the high level and 68 (44.7%) rated very high. It is only 4(2.6%) of the participants responded that LED initiatives create job and minimize unemployment at middle rate. In fact poverty is multidimensional. It is not only based on income alone but includes basic needs and human capabilities. With regard to income indicators, there is a high level of unemployment in Ambo Town. From observation, the unemployment level looks significantly higher than the national average points out to the lack of an economic base and industrial base to absorb the unemployed. Even though there was a change in government and municipal policy to alleviate poverty in Ethiopia, interview respondents point out that their levels of poverty have not changed significantly for the better.

From Table 2, one can deduce that LED initiatives would help entrepreneurs/ community members with the skill they want to acquire. On top of this, most of the respondents revealed during interview that before forming SMEs and joining LED target projects, they did not acquire the skill in any of the tasks they were doing in their projects at a moment. Most of the respondents pointed out that they acquired skills and abilities such as sewing, curving and metal work, wood work pottery and fattening. Respondents confirmed that they gained more experiences and managerial skills from their respective projects by holding official positions such as chairperson, treasurer and secretary. More skills gained by the respondents after joining LED activities include leadership, organizing, bookkeeping and project management.

As to community development contribution to LED initiatives, the survey data confirmed that 66 (43.4%) of the respondents rate as high and 74 (48.7%) respondents rate as very high (Table 2). The balance 12 (7.9%) responded that LED contribute at middle level to community development. As Jones and Inaba (1997) state, community-based development provides the opportunity to define and measure the social problem in a community, neighborhood or household. Thus, the emerging of this idea as an alternative approach to poverty alleviation takes the community as a unit of solution to the process at large. It is generally based on the belief that problems in communities have solutions in communities and the people should participate in matters that affect them at the community level (UNDP, 2000).

For LED to be successful there should be a coherent planning process involving all stakeholders within the local area. The process takes place over time, involving all sections of the community and covers all matters that affect quality of life in a local area, particularly those that need most support (Sekhampu, 2010). Table 3 shows that a total of 10488 projects were implemented by different stakeholders in the last five years in Ambo Town and were giving benefit for the community from developed LED projects. In total, 79055 household members got job and got advantage from the proceeds and rewards brought along by the community projects. Therefore, community projects have made a difference in the livelihoods of the communities involved by providing some form of employment.

The interview data shows, in the 2017/2018 Integrated Development Plan (IDP) of the Ambo municipality, LED is one of the main objectives for the municipality. A new LED strategy has been compiled, taking into account all the principles of a modern strategy and is currently being implemented.

Table 3 Number of project implemented and employee benefiting from the projects

	n	*Min.*	*Max.*	*Mean*	*Sum*	*Std. Deviation*
No of projects implemented	152	3	402	69.00	10488	76.918
Budget your institution fund for projects (ETB in Million)	152	.40	36.00	12.48	1897.37	10.20993
No of jobs created in last five years	152	3	3000	520.10	79055	684.909
No of people employed at the institution	152	5	408	60.90	9257	60.447

LED Strategies

LED in Ambo municipal manifests itself at a local government level, being informed by both national and regional policy. Ambo municipality has been grappling with the concept of LED for a few years now and have been consistent in their endeavor to produce LED strategies that will guide economic development within the municipality. The primary focus in these LED strategies is creating a favorable environment for employment opportunities to occur and for attracting investments.

Job creation needs to be the focus of most LED strategies and projects. Linked to job creation is the issue of income improvement. The overarching goal of LED is to create jobs and income, and therefore it is crucial to involve employment promotion measures and organizations in a given LED effort. Employment creation and poverty alleviation, however, is also a distinct activity with its own delivery structure, and it is usually addressed as part of social policy. This, in turn, leads to something which is often a major confusion in LED: the distinction between economic development (business promotion) and community development (employment creation, poverty alleviation). Sometimes these activities get mixed up, and as a result usually neither economic nor social objectives are achieved. As a result of focus group discussion, Ambo municipal and other stakeholders hardly ever give assistance in terms of skills development, training entrepreneurship on business management, marketing and sales, branding and packaging, record keeping and financial management and technical operations. Studies on LED strategies reveal that the most critical business skill gaps for entrepreneur are: business plan writing; business management, branding and packaging, record keeping and financial management, technical operation and advertising (eThekwini municipality, 2007). Thus, there is a great need for the SME‘s to engage in training and equip them with skills to run viable business enterprises in LED strategies. Equipping small business with these skills through training will promote invention, innovation and diffusion of ideas and will assist small enterprises to grow is an important. This growth of SMEs would be in terms of income, market share and assets since it has impacts on poverty reduction and livelihoods development.

The purpose of institutional capacity building is to enable institutions perform their mandated functions effectively and efficiently. It is possible to identify two kinds of institutions (technical/sector and coordinating) as far as the LED implementation is concerned. Those institutions which have economic technical functions and those which play the key coordinating and management functions of LED. Based on information gathered, the Ambo municipality indicates that there are different stakeholders involved in LED initiatives, playing a variety of roles, as prescribed by the terms of agreement between stakeholders and on the capacity and capability of each stakeholder. The municipality is the implementer, planner and coordinator of LED activities, whilst other stakeholders, such as private businesses and government departments, like Economic Development and some international NGOs, play the role of funding, implementing and planning, with the communities of Ambo Town and the local municipality as the recipients of LED outcomes

Conclusion

The study revealed that there were LED projects that were mean to help communities to alleviate poverty in the study area. Some of these projects promote SMEs and job creation up on which more people rely on. They are the source of income and creating access to food security too. However, the municipal has no LED unit which organizes and mobilizes local community members to form groups in order to start cooperatives and small businesses. Thus, LED is not yet well embedded in municipal structures. This indicates that Ambo municipality loss capacity and means that would help local development activities more effective. The municipality should work critically on job creation, employability and SMEs financial stability dealing with micro finance institutions and in collaboration with other stakeholders. Entrepreneur development trainings with the focus on business management, marketing and sales, branding and packaging, record keeping and financial management and technical operations should be given by the municipality and NGOs.

The data also revealed that despite the fact that LED approach to the development plan should be generally a bottom-up one, most project planning and decisions in Ambo municipal are made still in top-down ways in the study area . In different words, project activities are more centralized. This will enable a more focused local economic development strategy which is to be achieved through a participatory approach. The merits of a participatory approach are that, the community own and design their development goals by involving all stakeholders. LED strategy planning and implementation should be a participatory process that allows an opportunity to all stakeholders involved to actively take part in all activities. LED requires more talented and skilled personnel to direct its activities, such as designing a monographic study and strategic plan for municipal council members. Besides, identification of economic poles that are very competitive in terms of quality, quantity, price, delivery, better services, regular supply and guaranteed markets is an important job.

Generally, LED requires municipality local governors to become more strategic, creative, and ultimately influential in the way they give proper service for the community. They have a crucial role as policymakers, as thinkers, innovators and as institutions of local democracy. The local official capacity and resource limitations had negative effect to move the LED initiative forward. Besides, the majorities of the projects as the data revealed were initiated and funded by municipality and members claimed to be not receiving any direct support from stakeholders.

References

Baylis,J. and Smith, S. (2005): The Globalization of World Politics An introduction to international relations. New York: Oxford University Press

Berg, B.L. (2001) Qualitative Research, Message for the Social Sciences. 4th Edition. Boston: Allin and Bacon.

Chibba, M. (2009). "Governance and Development." World Economics 10(2): 79-108.

Cohen, et al, (2000). Research Methods in Education (5th Edition). London: Routledge Falmer.

Creswell et.al (2007). Qualitative Inquiry and Research Design: Choosing Among Five Approaches (2nd ed.). USA: Sage Publications Inc.

eThekwini Municipality (2007). Smme Strategy for the eThekwini Municipality income.

Green, E. (2010). "Patronage, district creation, and reform in Uganda." Studies in comparative international development 45(1): 83-103.

Helmsing, B. (2001). Partnerships, Meso-institutions and Learning. New local and regional economic development initiatives in Latin America. Institute of Social Studies. The Hague: Netherlands.

Hussein, M. K. (2004). Decentralisation and Development: The Malawian experience. Africa Development. 29(2): 106-133.

Jones, F. and Inaba, M. (1997). “Measurement in Transitional Situations: The Social Development paradigm and Its Nuances”. Regional Development Dialogue(RDD), 18 (1)

Kerlinger, F.N. (1986) Foundations of Behavioral Research. Orlando:. Holt, Rinehart and Winston publishers.

Koponen, J. (2004). Development Intervention and Development Studies. Development Intervention: Actor and Activity Perspectives. T. Kontinen. Helsinki, University of Helsinki.

Pilot, D. F., & Hungler, B. P. (1999). Nursing Research: Principles and Methods. Phildelphia: JB Lippincott Company.

Rogerson, C.M. (2003). Towards pro-poor local economic development: The case for sectoral targeting in South Africa, Urban Forum.

Sekhampu, T.J. (2010). An investigation into the economic sustainability of Kwakwatsi. NWU: Vaal campus. Vanderbijlpark. Unpublished PhD thesis).

Swinburn, G. 2006. Local Economic Development: A Primer. Developing and implementing local economic development strategies and action plans. The World Bank: Washington,D.C

UNDP (2000) Overcoming Human Poverty: UNDP Poverty Report 2000, New York: United Nations Publications

World Bank, (2002), Local Economic Development: Quick References, Washington, DC

Yamane T., 1967. Statistics: An Introductory Analysis: Harper and Row: N. Y.

Ziai, A. (2012). "Postcolonial Perspectives on 'Development'." ZEF Working Paper Series (103).

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RESEARCH PAPER

Optimal Breast Feeding Practice and Associated Factors among Mothers of Children aged 6-23 months in Dandi District, West Shewa, Ethiopia.

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Abstract

Optimal feeding of infants and young children means exclusive breastfeeding from birth to about six months, followed by an introduction of complementary foods drawn from the local diet at about six months. However, the status of optimum breastfeeding practice in low-income countries like Ethiopia varies from place to place. The aim of this study was to assess optimum breastfeeding practice and associated factors among mothers of children aged 6-23 months in the study area. The study was conducted at Ginchi Town, Dandi District, West Shoa Zone Ethiopia. A community-based cross-sectional study was conducted from June 1-10, 2018 G.C. Systematic random sampling followed by a Simple random sampling technique was used to reach a study subject. A structured questionnaire was used to collect the data. Data were coded and entered into Epi-data version 3.1 and exported to SPSS version 21 for further analyses. Binary logistic regression was used to check the association between dependent and independent variables. In multivariate logistic regression, those variables with a p-value of less than 0.05 were selected as factors associated with optimal breastfeeding. A total of 216 mothers of children aged 6-23months were voluntarily responded, making a response rate of 100%. This study found that 81.9% of mothers have practiced optimum breastfeeding practice. There was a significant association between monthly income and optimum breastfeeding. Mothers who had a monthly income of greater than >1000birr were less likely to practice optimum breastfeeding as compared to mothers who had a monthly income of <500birr (AOR = 0.332, 95% CI: 0.122 - 0.901, p-value < 0.05). Optimum breastfeeding practice among the study subjects in the study area was below widely accepted "Universal coverage" of 90%. Therefore the town and district Health office should work to enhance optimum breastfeeding practice.

Keywords: Breastfeeding, Child, Infant, Ethiopia

Introduction

Breast milk is safe, feasible, and unique food for infants that has no equivalent substituent. It is well known that natural breast milk has many health benefits for the child, like protection against infectious disease (Gartner, 2005), neurocognitive development of the child (Gomez et al., 2004), protection of chronic disease in later life (Arenz et al.,2004) and protection of inflammatory bowel disease (Linda et al., 2005; Klement, et al.,2004). Different studies revealed that there was scientific evidence that highlights the importance of the first 2–3 years of life for later success in school. Studies in high as well as low and middle-income countries (LMICs) show that growth in the first 2 years of life predicts years of schooling and income in adulthood (Adair et al., 2010; De Vries et al., 2007; Gertler et al., 2014).

Worldwide about 823,000 children's life will be saved, if appropriate breastfeeding is practiced

(Walters et al., 2016). In developing countries, suboptimal breastfeeding contributes to 45% of neonatal infectious deaths, 30% of diarrheal deaths and 18% of acute respiratory deaths among under five years of age children (Öberg et al.,2011). Similarly, studies have documented the long term beneficial effects of breastfeeding on chronic diseases like Overweight, diabetes mellitus, and cancer prevention (Kelishadi & Farajian, 2014). Longer breastfeeding duration was associated with a 13 percent reduction in the likelihood of overweight and/or obesity prevalence and a 35 percent reduction in type-2 diabetes incidence (Victora et al., 2016). Even in developed countries, none breastfed children had increased incidence of ear infection, gastroenteritis, pneumonia, obesity, type I and type II diabetes and leukemia as compared to the breastfed child (Stuebe, 2009). Similarly, Systematic reviews by World Health Organization (WHO) confirmed the long term effects of breast milk in controlling blood pressure, type-2 diabetes, serum cholesterol, overweight and obesity, and intellectual performance (Horta & Victora, 2013).

Optimal feeding of infants and young children means exclusive breastfeeding from birth to about six months, followed by the introduction of complementary foods drawn from the local diet at about six months (WHO, 2014). World health organization recommends all infants should be breastfed within one hour after birth and exclusively breastfed from birth until 6 months of life and thereafter, infants should be introduced to nutritionally adequate and safe complementary foods with continued breastfeeding for up to 2 years or beyond (WHO, 2014). However, no more than 35% of infants worldwide are exclusively breastfeeding during the first four months of life (UNICEF, 2010). Recent studies showed that less than 40% of children less than six months of age are exclusively breastfed and about 70% of infants are sub-optimally breastfed in developing countries, which is a major contributor to infant mortality rate (Cai et al.,2012).

There were many factors that affect optimal breastfeeding practice. Mothers' knowledge, attitude, and skills towards breastfeeding were commonly depicted by scholars (Hector et al., 2005). Besides, Economical and familial factors and insufficient maternity leave were also indicated (Mkhize et al., 2017). Similarly, the job condition of the mother, insufficient breast milk, health condition of the nipple of the breast, and stress was among factors that affect optimal breastfeeding practice (Al-Shoshan et al., 2007; Ella et al.,2016).

In Ethiopia currently, only 58% of children are exclusively breastfed, whereas 17% of infants 0-5 months consume plain water, 5% consume non-milk liquids or other milk, and 11% consume complementary foods in addition to breast milk. Five percent of infants under age 6 months are not breastfed at all (EDHS, 2016). Meanwhile, 24% of infant death in Ethiopia is due to poor breastfeeding practices (Ministry of Health Ethiopia,2011). Therefore, this study will have significant input in the formulation of appropriate strategies to promote optimal breastfeeding practice in the study area and the region at large.

Methods and materials

The Study Area and Period

The study was conducted at Ginchi Town, Dandi District, West Shoa Zone Ethiopia. Ginch town is found at 80 km to the west of Addis Ababa, capital of Ethiopia. The total population of Ginchi Town is 26,294 among which 13,492 were male and 12,802 were females and 1499 were children aged 6-23 months. Administratively, Ginchi town is structured as two urban Kebeles. The study was conducted from June 1-10, 2018 G.C.

Study design, study population and sample size determination

A community-based cross-sectional study design was utilized in this study. Randomly selected mothers of children aged 6- 23 months in the randomly selected households of the town were study subjects. Sample size (n) was determined by using single population proportional formulae (n = (Zα/2)2 pq/d2), using a prevalence rate of 82.2% from the previous study (Zenebu et al., 2015) at 95% confidence interval, considering non-response rate of 10% and correction formula, the minimum required sample size was estimated to be 216.

Sampling procedure and Data collection

Systematic random sampling followed by a Simple random sampling technique was used to reach a study subject. First households with children aged 6-23 months were identified from the family folder of the health extension workers found in each Kebele. In kebele 01 and 02 there were 896 and 603 children aged 6-23 months respectively. Using proportional allocation 128 and 87 study subjects were selected every 7th interval (k=7) from each kebele respectively. Then a simple random sampling technique was used to select the first household. Data were collected by trained data-collectors using well-structured questionnaires that address the objective of the study.

Operational definitions

Optimal breastfeeding: exclusive breastfeeding up to six months and starting complementary feeding at six months.

Data Quality Control

Data quality was ensured during data collection, coding, entry, and analysis. Originally the questionnaire was prepared in the English language and then translated to Afan Oromo language for easy management, then translated back to English to maintain the quality of data and consistent information. The translated version was pre-tested on 10% of the study sample in nearby towns through trained data collectors and supervisors. Completeness of the questionnaire was checked to ascertain whether all questions are properly filled or not on spot.

Data processing and analysis

Data were coded and entered into Epi-data version 3.1 and exported to SPSS version 21 for analyses. Frequency, mean and standard deviations from descriptive statistics and analytic statistics such as bivariate and multivariable logistic regression analysis were computed to determine the effect of various factors on the outcome variable. Variables having a p-value of less than or equal to 0.3 on binary logistic regression was the candidate for multiple logistic regressions. Statistical significance was declared at $p<0.05$. The strength of the association between independent and dependent variables was assessed using the adjusted odds ratio at a 95% confidence interval.

Results

A total of 216 mothers of children aged 6-23 months had responded, making a response rate of 100%.

Socio-demographic characteristics of respondents

The mean age of the mothers was 26 +4.7 years. The age range of children considered in this study was 6-23 months, which is an optimal recommended age range for breastfeeding. The mean age of the children was 12.23 + 6.22 months. Half of the respondents were orthodox (Table 1.)

Maternal health service utilization

Majority of the respondents 207(95.8%) have visited health institution for ANC and about 183 (84.7%) mothers delivered their youngest child at a health institution while only 33(15.3%) delivered at home. About 208 (96%) of the respondents had at least one ANC follow up for the current child whereas 168 (78%) had postnatal care service utilization.

Breastfeeding practice

According to this study, the majority of mothers 169 (78.2%) started the initiation of breastfeeding within an hour of delivery and 89% of mothers were exclusively breastfed their children for six months. In general, this study found that 81.9% of mothers have practiced optimum breastfeeding while 18.1% apply non-optimum breastfeeding practice.

Table 1. Socio-demographic characteristics of respondents, Ginchi town, Ethiopia.2018

Variables(n=216)	Category	Number	Percent
Age of mothers	<20	12	5.6
	20 – 29	147	68.1
	30 – 39	57	26.4
	Total	216	100
Age of child (months)	6 -12 month	100	46.3
	13-24 month	116	53.7
	Total	216	100
Marital status	married	216	100
Religion	Orthodox	108	50.0
	Muslim	16	7.4
	protestant	87	40.3
	other	5	2.3
	Total	216	100
Ethnicity	Oromo	197	91.2
	Amhara	12	5.6
	others	7	3.2
	Total	216	100
Maternal Occupation	Employed	43	19.9
	unemployed	173	80.1
	Total	216	100
Monthly house hold income(ETB)	< 500	30	13.9
	500 – 1000	48	22.2
	>1000	138	63.9
	Total	216	100
Educational status of a mother	Illiterate	36	16.7
	Read and write	38	17.6
	Up to secondary school	102	47.2
	College and University	40	18.5
	Total	216	100

Table 2. Distribution of respondents by their breastfeeding practice, Ginchi town, Ethiopia, 2018

Variables (n=216)	Category	Number	Percent
Initiation of breast feeding	Within 1hr	169	78.2
	After one hour	47	21.8
Currently breastfeeding	Yes	205	94.9
	No	11	5.1
Frequency of breast Feeding	<8 times	70	32.4
	8-12	128	59.3
	>12	15	6.9
Exclusive breastfeeding	<6month	20	9.3
	Up to 6months	192	89
	>6month	4	1.7
Start complementary Feeding	<6 month	24	11.1
	=6 month	177	81.9
	>6month	15	7
Optimal Breast-Feeding practice	Not optimum	39	18.1
	optimum	177	81.9

Factors associated with optimal breastfeeding practice

There was a significant association between monthly income and optimum breastfeeding. Mothers who had a monthly income of greater than >1000birr were less likely to practice optimum breastfeeding as compared to mothers who had a monthly income of <500birr (AOR = 0.332, 95% CI: 0.122 - 0.901, p-value < 0.05 (See table 3).

Table 3. Bivariate and multivariate logistic regression analysis factors associated with optimal breastfeeding practice, 2018

Variable(N=216)	Optimum	Not optimum	COR(95% CI)	AOR(95% C.I)
Religion				
Orthodox	89(82%)	19(18%)	1	1
Muslim	11(69%)	5(31%)	0.32(0.05,2.050)	2.357(0.484,11.481)
protestant	73(84%)	14(16%)	0.682(0.085,5.448)	1.121(0.479,2.619)
Others	3(60%)	2(40%)	0.288(0.44,1.882)	9.279(0.887,97.025)
Ethnicity				
Oromo	163(83%)	34(17%)	1	1
Amhara	7(58%)	5(42%)	3.422(1.026,11.434)	3.247(0.749,14.072)
0ther	6(86%)	1(14%)	0.799(0.093,6.853)	0.371(0.026,5.268)
Monthly income				
<500	19(63%)	11(37%)	1	1
500-1000	44(92%)	4(8%)	0.157(0.44,0.556)	0.115(0.30,0.447)*
>1,000	113(82%)	25(18%)	0.382(0.162,0.903)	0.332(0.122,0.901)*
Place of Delivery				
Home	23(70%)	10(30%)	1	1
HI	153(84%)	30(16%)	0.451(0.195,1.044)	0.483(0.179,1.306)

Postnatal Care				
Yes	133(80%	34(20%)	1	1
No	43(88%)	6(12%)	0.546(0.215,1.388)	0.545(0.184,1.609)
Initiation of Breast feeding				
Immediately	142(84%)	27(16%)	1	1
After 1hr	34(72%)	13(28%)	2.011(0.94,4.3)	2.215(0.916,5.359)
Start Complimentary feeding				
Nothing	72(77%)	22(23%)	1	1
Water/ tea	27(84%)	5(16%)	0.606(0.209,1.762	0.466(0.104,2.084)
Cow milk	62(89%)	8(11%)	0.422(0.176,1.016)	0.293(0.073,1.178)
Adult food	11(69%)	5(31%)	1.488(0.466,4.745)	1.474(0.259,8.372)

Discussion

The analysis of this study found that majorities of the respondents 177 (81.9%) have optimum breastfeeding practice. This finding is comparable with the previous study conducted at Ambo woreda which revealed 82% exclusive breastfeeding practice (Zenebu et al., 2015). However, the finding of this study is higher than the study conducted at Goba District (71.3%) Southeastern part of the country (Setegn et al., 2012) and Kamba District (40.6%) Southern part of the country (Getahun et al.,2017). The discrepancy of the finding may be due to socio-demographic differences in the area and the length of the study period.
It is known that early initiation of breastfeeding after birth is one among interventions practiced to reduce neonatal morbidity and mortality (Edmond et al., 2006; Jones et al.,2003). Meanwhile, the finding of this study shows that early initiation of breastfeeding was about 78.2%, which is slightly higher than previous studies conducted in Southern and Northern parts of Ethiopia. The study conducted in the Southern Nation Nationalities Region of Ethiopia revealed that 50% of mothers reported that they had initiated breastfeeding in the first one hour. Whereas study from the Northern part of the country shows that 60% of mothers had reported early initiation of breastfeeding within one hour after delivery (Horii et al.,2011; Teka et al.,2015).

As to the level of exclusive breastfeeding in the area, this study found that about 89.4% of mothers were exclusively breastfeeding their children for the first six months. This figure is higher than the national report which shows only about 58% exclusive breastfeeding practice (EDHS, 2016). The discrepancies may be due to study design, sample size, and other socio-demographic factors. The national study includes the study subjects from all parts of the country and it uses different sampling techniques, whereas this study relies only on a specific area, Ginchi town. Similarly, this study found that about 88.9% of mothers had started complementary feeding at six months of age. This report is also higher than the studies reported somewhere else (Horii et al., 2011).

According to the results of this study, household income was associated with optimal breastfeeding practice. Mothers whose monthly income range from 500-1000 Ethiopian birr (AOR=0.11 (0.30, 0.45)) was less likely to breastfeed their children compared to those who get <500 Ethiopian birrs. Similarly, mothers who earn>1000Ethiopian birr (AOR = 0.33(0.12, 0.90)) monthly income were less likely to breastfeed their children compared to those who get <500Ethiopian birr. Similar to this finding, a study conducted in Ethiopia East Gojjam revealed that mothers whose average monthly household income is lower were more likely to practice exclusive breastfeeding than mothers whose average monthly household income was higher (Tewabe et al., 2016). This can be explained by the fact that the higher the income the mother earns the higher the probability of finding other feeding options like mixed feeding and formula.

Place of delivery is another factor that is found to be associated with breastfeeding practice. The study conducted in Bahir Dar (Northern Ethiopia) revealed that the place of delivery was significantly associated with optimum breastfeeding practice (Demilew et al.,2017). However, in our study, the place of delivery has no significant effect on optimal breastfeeding. This may be due to the absence of difference in either providing counseling or health education on the benefits of breastfeeding for mothers who delivered at home or health institutions. Similarly, maternal occupation is also reported somewhere else as factors that have an association with optimal breastfeeding (Tewabe et al., 2016; Weber et al.,2011). According to those studies mothers who were working at the government office were less likely to breastfeed their infants as compared to mothers who were not employed by the government. Conversely, our study found no association between maternal occupation and optimal breastfeeding practice. This may be due to the majority of our study subjects were unemployed.

Conclusion

Optimum breastfeeding practice among the study subjects in the study area was below widely accepted "Universal coverage" of 90% coverage. Therefore the town and district Health office should work to enhance optimum breastfeeding practice.

Declaration

Ethics approval and consent to participate

The study was reviewed and approved by Ambo University College of Medicine and Health Sciences Department of Public Health. Public health department issued Ethical approval on May 25, 2018. Consent was obtained from mothers of children, before collecting any information. Finally, information collected from each study participant was kept confidential.

Consent to publish

Both authors have read the content of the manuscript and had a common understanding regarding the finding of the study. They also have an agreement to publish it under this journal.

Availability of data and materials

All data regarding this study is available and it can be sent upon request from Corresponding Author.

Competing interests

The authors also declare that there are no other financial or non- financial competing interests.

Author's contribution

KT and GB conceptualized the research question, analyzed and interpreted the findings, conduct final report writing, and prepare the manuscript.

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Reference

Adair, L. (2010). Weight gain in the first two years of life is an important predictor of schooling outcomes in pooled analyses from five birth cohorts from low and middle income countries. J Nutr, 140, 348-354.

Adair, L., & Dahly, D. (2005). Developmental determinants of blood pressure in adults. Annu. Rev. Nutr., 25, 407-434.

Al-Shoshan, A. A. (2007). Factors affecting mother's choices and decisions related to breastfeeding practices and weaning habits. Pakistan journal of nutrition, 6(4), 318-322.

Arenz, S., Rückerl, R., Koletzko, B., & von Kries, R. (2004). Breast-feeding and childhood obesity a systematic review. International journal of obesity, 28(10).

Cai, X., Wardlaw, T., & Brown, D. W. (2012). Global trends in exclusive breastfeeding. International breastfeeding journal, 7(1), 12.

De Vries, L. (2007). Does breastfeeding influence risk of type 2 diabetes in later life? A quantitative analysis of published evidence. Breastfeeding Review, 15(2), 29-30.

Demilew, Y. M., Tafere, T. E., & Abitew, D. B. (2017). Infant and young child feeding practice among mothers with 0–24 months old children in Slum areas of Bahir Dar City, Ethiopia. International breastfeeding journal, 12(1), 26.

EDHS. (2016). Health Survey Central Statistical Agency. Addis Ababa, Ethiopia.

Edmond, K. M., Zandoh, C., Quigley, M. A., Amenga-Etego, S., Owusu-Agyei, S., & Kirkwood, B. R. (2006). Delayed breastfeeding initiation increases risk of neonatal mortality. Pediatrics, 117(3).

Ella, R. E., Ndep, A., & Akpan, M. (2016). Factors affecting exclusive breastfeeding practice in rural communities of Cross River State, Nigeria. International Journal of Humanities Social Sciences and Education, 3(4), 101-110.

Gartner, L. M., Morton, J., Lawrence, R. A., Naylor, A. J., O'Hare, D., Schanler, R. J., & Eidelman, A. I. . (2005). Breastfeeding and the use of human milk. . Pediatrics, 115(2), 10.

Gertler, P., Heckman, J., Pinto, R., Zanolini, A., Vermeersch, C., Walker, S., . . . Grantham-McGregor, S. (2014). Labor market returns to an early childhood stimulation intervention in Jamaica. Science, 344(6187), 998-1001.

Getahun, E. A., Hayelom, D. H., & Kassie, G. G. (2017). Exclusive Breast Feeding Practice and Associated Factors in Kemba Woreda, Southern Ethiopia, a Community Based Cross-Sectional Study. International Journal of Science, Technology and Society, 5(4), 55.

Gomez-Sanchiz M, C. R., Rodero I, Baeza JE, Gonzalez JA. . (2004). Influence of breast-feeding and parental intelligence on cognitive development in the 24-month-old child. . Clin Pediatr, 43(8), 8.

Hector, D., King, L., Webb, K., & Heywood, P. (2005). Factors affecting breastfeeding practices. Applying a conceptual framework. New South Wales public health bulletin, 16(4), 52-55.

Horii, N., Guyon, A. B., & Quinn, V. J. (2011). Determinants of delayed initiation of breastfeeding in rural Ethiopia: programmatic implications. Food and nutrition bulletin, 32(2), 94-102.

Horta, B. L., & Victora, C. G. (2013). Long-term effects of breastfeeding. Geneva: World Health Organization, 74.

Jones, G., Steketee, R. W., Black, R. E., Bhutta, Z. A., & Morris, S. S. (2003). How many child deaths can we prevent this year. The Lancet, 362(9377), 6.

Kelishadi, R., & Farajian, S. (2014). The protective effects of breastfeeding on chronic non-communicable diseases in adulthood: A review of evidence. Advanced biomedical research, 3.

Klement, E., Cohen, R. V., Boxman, J., Joseph, A., & Reif, S. (2004). Breastfeeding and risk of inflammatory bowel disease: a systematic review with meta-analysis. 80(5), 1342-1352. American journal of clinical nutrition, 80(5), 10.

Mkhize, Z. P. (2017). The current infant feeding practices and related factors of Indian and Zulu mothers with 0-9 month old infants attending well baby clinics in Durban-North.

Öberg, M., Jaakkola, M. S., Woodward, A., Peruga, A., & Prüss-Ustün, A. (2011). Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. The Lancet, 377(9760), 139-146.

Setegn, T., Belachew, T., Gerbaba, M., Deribe, K., Deribew, A., & Biadgilign, S. (2012). Factors associated with exclusive breastfeeding practices among mothers in Goba district, south east Ethiopia: a cross-sectional study. International breastfeeding journal, 7(1), 17.

Stuebe, A. (2009). The risks of not breastfeeding for mothers and infants. Reviews in obstetrics and gynecology, 2(4), 222.

Teka, B., Assefa, H., & Haileslassie. (2015). Prevalence and determinant factors of exclusive breastfeeding practices among mothers in Enderta woreda, Tigray, North Ethiopia: a cross-sectional study. International breastfeeding journal, 10(1), 2.

Tewabe, T., Mandesh, A., Gualu, T., Alem, G., Mekuria, G., & Zeleke, H. (2016). Exclusive breastfeeding practice and associated factors among mothers in Motta town, East Gojjam zone, Amhara Regional State, Ethiopia, 2015: a cross-sectional study. International breastfeeding journal, 12(1), 12.

UNICEF. (2010). A successful start in life: Improving breastfeeding in West and Central Africa. New York: UNICEF.

Victora, C. G., Bahl, R., Barros, A. J., França, G. V., Horton, S., Krasevec, J., . . . Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. The Lancet, 387(10017), 475-490.

Walters, D., Kakietek, J. J., Eberwein, J. D., Pullum, T., & Shekar, M. (2016). Breastfeeding in the 21st century. The Lancet, 387(10033), 2087.

Weber, D., Janson, A., Nolan, M., Wen, L. M., & Rissel, C. (2011). Female employees' perceptions of organisational support for breastfeeding at work: findings from an Australian health service workplace. International breastfeeding journal, 6(1), 19.

WHO. (2014). Global strategy for infant and young child feeding. The optimal duration of exclusivebreastfeeding. 2001. Fifty-Fourth World Health Assembly. Document A, 54.

Zenebu, B. B., Belayneh, K. G., Alayou, G., Ahimed, A., Bereket, C., Abreham, A., . . . Keno, T. (2015). Knowledge and practice of mothers towards exclusive breastfeeding and its associated factors in Ambo Woreda West Shoa Zone Oromia Region, Ethiopia. Epidemiology: Open Access, 5(1).

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RESEARCH PAPER

Assessing Crop Response to Zinc Fertilization: a Meta-Analysis

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Abstract

Several studies on effects of Zinc fertilization on cereals yield and their Zinc content on soils with various soil properties and using different Zn fertilization strategies have been conducted. Nevertheless, studies that summarized the studies in the form of meta-analysis as to what extent the crop Zn content and grain yield could be improved as result of Zn fertilization were limited. Hence, the objective of this study was to evaluate the response of cereal crops to Zinc fertilization across selected soil properties and Zinc fertilization startegies from large number of published studies through a meta-analysis. Fourty-two field experiments, from 27 peer-reviewed published articles were included in the analysis. MetaWin v 2.1 was used for the analysis and effect sizes estimated by using the natural logarithm of response ratio method. Cumulative analyses of each study showed a positive and significant effect of Zn fertilization over no Zn fertilization on Zn content and grain yield of agricultural crops. The average Zn content and grain yield of crops across studies is found to be 12.6; 20.4 mg/kg, and 3526; 4370kg/ha, respectively for no Zn vs Zn applied treatments; corresponding to approx. 62% and 24% increase in Zn content and grain yield as result of Zn application. In general, in Zn deficient areas, Zn biofortification through Zn fertilization of the soils can be used to improve crop Zn content and grain yield significantly. Moreover, other factors such as application methods, soil pH, SOM, and P should be managed integratively for successful Zinc biofortification.

Keywords: Zinc, biofortification, cereals, fertilizer, meta-analysis, yield

Introduction

Zinc (Zn) is a micronutrient which is very useful for healthy growth and reproduction of plants and nutrition of human being. Zn plays key role as structural constituent or regulatory co-factor in various enzymes of biochemical pathways involved in carbohydrate metabolism, photosynthesis and conversion of sugars to starch by plants (Ahmad et al., 2012). Zn is also required for the regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants, such as high light intensity and high temperatures (Cakmak, 2000). It is also vital for metabolism of proteins and auxins, maintaining integrity of biological membranes and those related to infection by certain pathogens (Alloway, 2004). Moreover, adequate supply of this micronutrient can also increase agricultural productivity through increased crop yields (Hossain et al., 2008). However, Zn deficiency in soils of many parts around the world is one of the major challenges in crop production.

Zn deficiency is the most widespread micronutrient deficiency in the world, and it's estimated that about 50% of agricultural soils used for growing cereals in the world have low levels of available Zn (Alloway, 2004). This is a common feature in tropical and temperate climates, in particular for acid and alkaline soils (Cakmak et al., 1996) because of low Zn availability and high Zn fixation under such conditions (Donner et al., 2010). Zn deficiency can cause heavy yield losses. For example, heavy yield loss was reported in Bangladesh, China, Turkey, India, Iraq, Pakistan (Alloway, 2004), and Africa (Kang and Osiname, 1985). Moreover, it is also known to cause human health problems in regions where crops are grown on Zn deficient soils and are their staple food (Cakmak et al., 2010).

Several soil factors can cause deficiency of total Zn content and Zn availability to plant uptake. Weathered parent material, nature of clay minerals, alkaline pH, soil organic matter (SOM), sandy texture, calcareousness, intensive cultivation, agronomic practices such phosphorus application, soil available Zn and nutrients (potassium and Iron) (Huang et al., 2019) are considered to be the major factors associated with the occurrence of Zn deficiency (Alloway, 2009). Genetic biofortification (crop improvement for Zn efficiency) and agronomic management (fertilizer application) of Zn are the two most commonly used strategies to overcome such Zn deficiency problems (Cakmak, 2008). While the genetic biofortification is likely to be the most cost-effective strategy and its research and development is underway (Noulas et al., 2018), using Zn fertilization strategy is a promising intervention to improve Zn contents in grains or diets.

Several studies on effects of Zn fertilization on crops (cereals) yield and their Zn content on soils with various soil properties and using different Zn fertilization strategies have been conducted. Nevertheless, studies that quantitatively estimated, or summarized the studies in the form of meta-analysis, to what extent the crop Zn content and grain yield could be improved as result of Zn fertilization are limited. Meta-analysis, which focuses on contrasting and combining results from different studies, is very useful to estimate the average response of agricultural crops to Zn fertilization across a large number of studies varying cropping systems, climatic conditions, agro-ecosystem properties and fertilizer strategies. It's also important to test whether the response is significantly affected by aforementioned issues. Moreover, it's also resource and time efficient. Information (quantitative), obtained from meta-analysis is very useful for researchers and policy makers. Hence, the objective of this study was to evaluate the response of cereal crops to Zinc fertilization across selected soil properties and Zinc fertilization startegies from large number of published studies through a meta-analysis.

Materials and Methods

Data collection/literature search

Scientific databases were searched in May 2019 using Scopus, Web of science, CAB-abstract and Google Scholar and the keywords "Zinc" in combination with "fertilizer," "fertilization," "availability," "uptake," "Africa," "Asia," over the period 1960 to 2019. In addition, a more general (without keyword "fertilizer") and crop focused search was done using the keywords "zinc" in combination with the crops "wheat," "cereal, "maize," or "rice." Following the general search, articles were screened based on certain criteria: field experiments (no pot/greenhouse, aqueous) experiments conducted in areas with comparable soil properties such as Zn content, soil pH and soil organic matter (SOM) or tropics and sub-tropics in general; studies that focused on effect of Zn fertilizer rates, Zn form and application methods on the crop Zn uptake, content and grain yield; studies that showed replication of treatments, and experiments that reported a measure of variance such as standard deviation (SD), standard error (SE) or at least ANOVA tables, LSD were retained for further analysis.

However, in an attempt to obtain sufficient data that would allow to use the meta-analysis approach, studies which did not report the SD or SE values were also included by using an arbitrary SD value based on coefficient of variation which is 1.25 times the average CV (CVav) in the other studies (taking into account crop specific differences). Then, the SD was calculated as: SD = 1.25 * CVav * mean. When data were not presented as tables, a freeware digitizing software for data extraction from graphs (GetData Graph Digitizer version 2.22) was used.

Mean crop responses in grain yield and Zn concentration of experimental and control groups with their SD and replicates (n), from the screened studies were collected. When only SE was reported, SD was calculated as SD= SE* sqrt (N). Data were subdivided into various subgroups related to factors that could affect the concentration in or uptake of Zn by cereal crops. The factors included were: location (country), basic fertilization (with N, P, and K), soil characteristics (Zn content, clay content, pH and soil organic matter), fertilizer properties (Zn species, application form [liquid, granular, foliar]), fertilizer rate, and crop properties (crop species, crop variables [grain yield and Zn content], crop part). The response variables used were grain yield (kg ha-1) and Zn content (mg Kg-1) of the agricultural crops, and the analysis was conducted for these variables separately.

For the independent variables such as soil Zn and soil pH, data was collected only from studies that used the frequently used extraction techniques: DTPA-extractable Zn and pH-H2O, respectively. Furthermore, the soil Zn data was grouped into three (<0.5, 0.5-1.5 and >1.5mg kg-1) based on literatures (Alloway, 2009). Similarly, pH was categorized based on USDA soil pH classification into <6.5 (acidic), 6.5 to 7.3 (Neutral) and >7.4 (Alkaline). Overview of the publications used for this meta-analysis study is provided below (table 1).

Table 1. Overview of the publications used for the meta-analysis.

S/N	Reference	Crop	Soil pH	Soil Zn (mg kg^{-1})	SOM (%)	P (kg ha^{-1})	Zn Application method	Continent
1.	Abunyewa and Mercer-qurshie, 2004	Maize	5.1	1.64	1.72	137	Soil	Africa
2.	Bereket et al., 2011	Teff	7.53	0.68	1.89	90	Soil	Africa
3.	Bharti et al., 2013	Wheat	8.1	-	0.6		Soil, Seed + Foliar	Asia
4.	Biljon et al., 2013	Maize	4.1-6.1*	2-5.3*	0.34	45	Soil	Africa
5.	Chiezey, 2014	Maize	5-5.4*	0.9-1.9*	0.34	59	Soil	Africa
6.	Dwivedi and Srivasta, 2014	Rice + Wheat	7.01	0.57	1.77	-	Soil	Asia
7.	El-Attar et al., 1982	Wheat	8.1	3.49	1.7	60	Soil	Africa
8.	Ezik et al., 2008	Wheat	7.8	0.1	2.1	68	Soil	Asia
9.	Guo et al., 2016	Rice	5.6-7.7*	0.6-2.3*	-	75	Soil, Foliar, Soil +Foliar	Asia
10.	Gupta et al., 1991	Wheat	8.3	0.42	0.55	60	Soil	Asia
11.	Hossain etal 2008	Maize	8.2	0.58	1.44	63	Soil	Asia
12.	Kalayci et al., 1999	Wheat	7.6	0.1	2.6	68		
13.	Mao et al., 2014	Wheat	8.12-8.21*	0.73-0.78*	1.21-1.36 *	100	Foliar	Asia
14.	Mathur and Lal, 1991	Wheat	8	0.42	0.27	40-60	Soil	Asia
15.	Mehla, 1999	Rice	8.3	0.85	0.55	60	Soil	Asia
16.	Nayyar and Takkar, 1980	Rice	10.4	0.56	1.33	-	Soil	Asia

17.	Rafique et al., 2015	Pea	8.1-8.3*	0.28-0.42*	3.4-4.9*	100	Soil	Asia
18.	Sankhyan and Sharma, 1997	Maize	5.4	0.68	1.33	39-78	Soil	Asia
19.	Sharma and Katyal, 1986	Wheat	8.4	0.3	0.77	57	Soil	Asia
20.	Sharma et al., 1982	Rice	9	0.4	0.3	57	Soil, Seed, Foliar	Asia
21.	Singh and Abrol, 1986	Rice	10.45	0.38	0.33	-	Soil	Asia
22.	Tariq et al., 2002	Maize	8	0.25	1.38	90	Soil	Asia
23.	Yerokun and Chirwa, 2014	Maize	7.2	0.8	2	-	Soil, Foliar	Africa
24.	Yilmaz et al., 2008	Wheat	7.8	0.1	2	68	Soil, Foliar, Seed, Soil + Foliar	Asia
25.	Yoshida et al., 2012	Rice	7.9	-	1.68	67	Soil, Seed, Foliar	Asia
26.	Zhang et al., 2012	Wheat	5.7-8*	0.4-1.59*	-	100	Soil	Asia
27.	Zhao et al., 2014	Wheat	7.98	0.6	1.38	120	Soil, Foliar, Soil +Foliar	Asia

Meta-analysis

Meta-analysis is an analytical technique designed to summarize the results of multiple studies. A meta-analysis (performed using MetaWin programme) can be used to estimate the average response of agricultural crops to Zn fertilization across a large number of studies varying in cropping systems, climatic conditions, agro-ecosystem properties, fertilizer strategies (timing, dose, Zn species), and to test whether the response is significantly affected by aforementioned issues. Background information on meta-analysis can be found in the study of (Gurevitch and Hedges, 1999; Rosenberg et al., 2000; Gurevitch and Hedges, 2001). The current meta-analysis focuses on the averaged effects across the groupings involved. Based on this general meta-analysis, it is possible to identify the most important factors controlling the efficiency of Zn fertilizers quantitatively. This analysis helps to identify the relevant agro-ecosystem properties affecting the efficiency of Zn fertilizers as an agronomic fortification strategy.

Effect size calculation

Standardized mean difference, Pearson's correlation coefficient, and the log response ratio are the effect size metrics used in soil science and ecological meta-analyses studies (Gurevitch and Hedges, 1999). In this this study, the commonly used natural log of response ratio was used as it estimates the proportionate change due to experimental manipulation (Zn fertilization in this study), and it was calculated by using treatment mean and control mean, their standard deviations (SD), variance and sample size (N) with MetaWin v2.1 software (Gurevitch and Hedges, 1999; Rosenberg et al., 2000; Gurevitch and Hedges, 2001). Finally, cumulative effect size is calculated for each study which represents the overall magnitude of the effect present in the studies, and this value is considered to be significantly different from zero if its confidence limits do not bracket zero (i.e. the effect size is significant at P=0.05) (Rosenberg et al., 2000).

Data exploration

The funnel plot and Normal quantile functions of the MetaWin software were used for exploring the distribution of data and detecting potential publication bias. Scatterplots of effect size vs. sample size or variance, respectively, were checked to test for potential publication bias. Publication bias was tested by using Rank correlation test of Kendall's Tau and Spearman rank order. The Fail-Safe number was calculated by using Rosenthal's Fail-Safe (Alpha =0.05) and Orwin's Fail-Safe method. Finally, the meta-analysis, based on random-effects model, was conducted by using MetaWin version 2.1.

Result and Discussion

Dataset description

A total of 90 studies published between 1960 and 2019 were identified and collected, of which 27 studies included reliable and quantitative data for this meta-analysis. A total of 1, 032 studies or observations (n = 1032) from 42 field experiments published in 27 peer reviewed papers where the effect of Zn fertilization was tested in comparison with an unfertilized control have been collected.

Most of these experiments were performed in zinc deficient arable ecosystems in the Asian continent including India, China, Turkey, Pakistan, and Bangladesh. These regions are shown to be Zn-deficient by soil analysis with 70% of the arable land is Zn deficient in India (Singh et al., 2008), 49% in China (Zou et al., 2008), 14% in Turkey (Cakmak, 2008), and 15% in Pakistan (Yoshida and Akira, 2012). About 89% of the observations were derived from experiments conducted in Asia, and the remaining 8% and 3% from Africa and South America, respectively. All of the experiments were conducted on cereal crops (wheat, maize, rice, barley and Teff), of which wheat comprises 76.5%, rice 15%, maize 8%, barley and teff 0.5% of observations. Most of the Zn concentration were reported for grain and shoot. Afterwards, the data was split into grain yield and Zn concentration so as to study Zn fertilization effect on the two factors separately.

About 60% of observations had initial soil Zn content of <0.5 mg kg-1 indicating that majority of the studies were conducted on Zn deficient soils with Zn concentration lower than widely accepted critical Zn concentration of 0.5 mg kg-1 (Sims and Johnson, 1991); 23% had 0.5-1 mg kg-1 and only 7% had >1 mg kg-1. The soil pH ranged from 4.1 to 10.5 of which 8% have pH values below 5.5, 69% with pH values between 7.0 and 8.0, and about 22.5% with pH values above 8 indicating that the experiments were conducted on Alkaline/calcareous soils. About 10% of the soil organic matter (SOM) had < 0.5%, 25% had 0.5 to 1.4%, 35% had 1.5 to 2.5%, 25% had >2.5% soil organic matter content, and the remaining 5% didn't include information on SOM. Summary of basic statistics for some soil properties where the studies were conducted is provided in Table 2.

The most common Zn fertilizers used in these experiments are based on Zinc sulphate (ZnSO4.7H2O) (88%) followed by Zinc oxide (ZnO) 4.5% of the observations. The fertilizer dose ranges from 0.44 to 120 kg ha-1 (assuming a soil density of 1400 kg m-3 and a soil layer of 10 cm for up-scaling). Application dose of Zn fertilizers 15-25 kg ha-1 comprises the majority of the observations (62%), whereas <15 kg ha-1 and >25 kg ha-1 comprises 28.5% and 9% of the observations, respectively. Majority of the studies used Nitrogen fertilizers and Phosphorus fertilizers optimum for the crops and the region.

Table 2. Dataset description (basic statistics) of some soil properties where the experiments were conducted

Soil variables	Range	Median	SD	Most common
DTPA-Zn (mg kg^{-1})	0.1-5.3	0.12	0.56	<0.5
Soil pH (pH-H_2O)	4.1-10.4	7.8	1.03	7-8
SOM (%)	0.27-2.6	2.1	0.82	1.5-2.5

Based on the suggested data exploration and publication bias testing methods no obvious bias could be detected (Plots provided in Appendix). Even though there is publication bias the high number of Fail-Safe number (see supplementary materials), compared to the number of observations in this study, gives us confidence that the results are reliable (Ros et al., 2016). A threshold of >5*n+10, where n is the number of observations included in the current study, was set by Gurevitch and Hedges (Gurevitch and Hedges, 2001) indicating that fail-safe numbers above the threshold, results are reliable even when there is significant publication bias.

Crop responses: Zinc content and grain yield

The study showed a positive and significant effect of Zn fertilization over no Zn fertilization. The cumulative analyses of each study (the middle point of each horizontal line) where the response ratio (plotted on X-axis) and its confidence interval remained above zero (zero being no effect of Zn fertilization. Note that this value is supposed to be 1 but changed to 0 because we used natural logarithm of response ratio (ln R) (fig.1).

The average Zn content and grain yield of crops across studies is found to be 12.6; 20.4 mg/kg, and 3526; 4370kg/ha, respectively for no Zn vs Zn applied treatments. This corresponds to approx. 62% and 24% increase in Zn content and grain yield as result of Zn application.

The independent variables (Zn fertilization and soil properties) considered influence the response variables i.e. Zn concentration in the plant parts and also grain yield (herein after referred together as ‘crop responses’) with an overall effect size of 0.35.

Zn fertilization: Zn fertilization had an effect size of 0.48 and 0.22 for Zn concentration and grain yield which means that Zn fertilization has improved the Zn concentration and grain yield of crops grown in Zn fertilized soils by 62% and 25% compared to their counterparts grown on Zn unfertilized soils (Fig.2A, 2B). The Zn concentration is also shown to be more responsive to Zn fertilization than grain yield as it had higher effect size. Application of optimum Zn rate i.e. 15-25 kg ha-1 resulted in highest effect size for both dependent variables (fig.3B; fig.4A). Increasing Zn application rate (up to 25 Kg ha-1) increased crop zinc content; however, application rate of >25 kg Zn ha-1 didn’t result in any better performance.

Alloway (2004) suggested that optimum fertilizer regimes that will restore yield (due to Zn deficiency) and also enrich grains with Zn need to be investigated thoroughly. This meta-analysis, based on the analyzed papers, shows that Zn fertilization of 15-25 kg ha-1 on soils with low Zn and alkaline soils would result in highest Zn content and grain yield of crops.

Zn fertilization in soils with low Zn content is also shown to restore yield loss due to Zn deficiency of soils. Application of Zn fertilizers in Zn deficient soils is crucial to avoid stagnant yield and increase crop productivity. It was indicated that a reduction in yield by approx. 28% for maize when Zn was omitted from the fertilizer treatments (Ahmad et al., 2012). The current meta-analysis also showed the possibility of increasing crop yield by applying Zn fertilizers. Moreover, Zn application could also help increase Zn concentration in roots, leaves and stems through application of Zn-fertilizers. For example, root Zn concentration could be increased with 5 to 50%, and leaf concentration up to 70% (Ahmad et al., 2012).

The current meta-analysis confirmed these observations where Zn fertilizer application could increase crop Zn content (averaged over grains, leaves, stems, straw) by 62%. Increasing the Zn concentration in the shoot and grains of crops in Zn deficient areas is very important because limited (dietary) Zn intake increases the incidence of various diseases in children aged < 5 years (WHO, 2005) especially in developing countries where cereals are staple food.

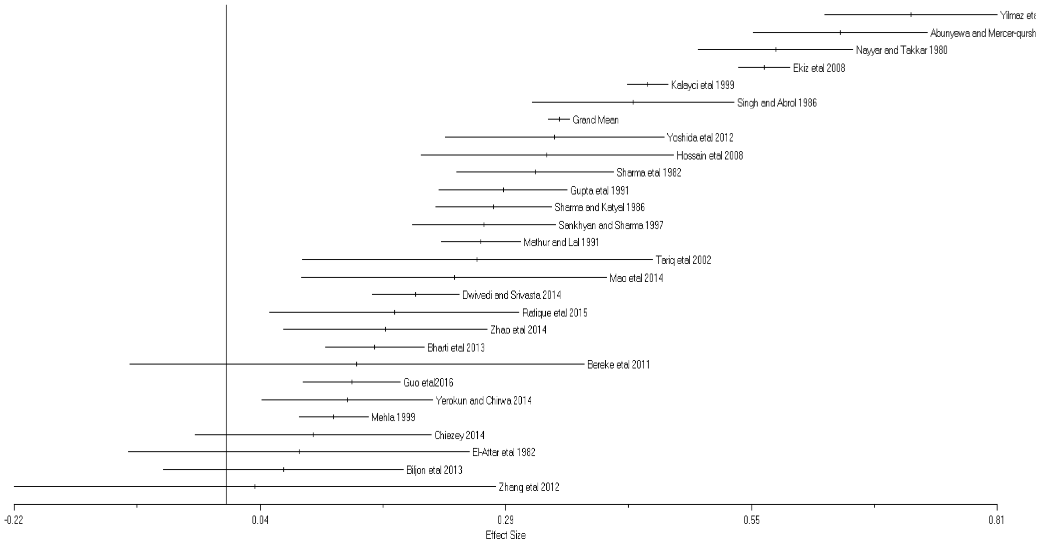

Figure 1. Forest plot of the cumulative effect size and confidence limits for each study (cumulative summary analyses). The cumulative effect size represents the overall magnitude of the effect present in the studies; this value is considered to be significantly different from zero if its confidence limits do not bracket zero (i.e. the effect size is significant at P=0.05). The vertical line (X=0) indicates the point of No response.

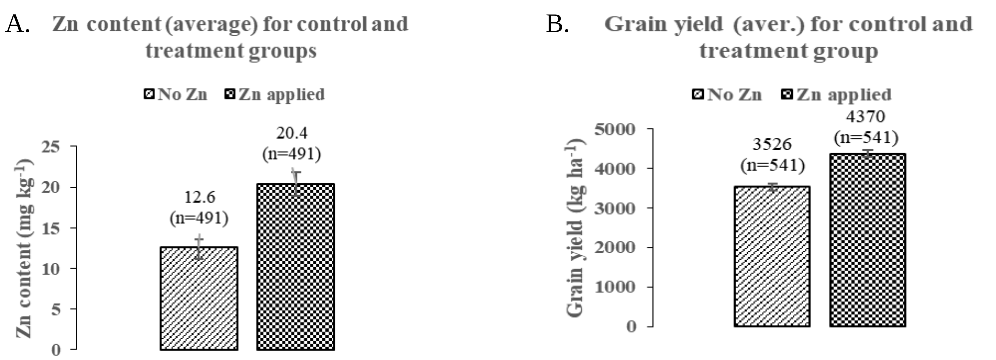

Figure 2. Average response of crops to Zn fertilization interms of Zn content (A) and grain yield (B). Error bars indicate 95% confidence interval.

In cases where soil Zn application is used to ameliorate Zn deficiency problems or as a biofortification strategy it's important to conduct periodic soil or plant analysis for Zn content. This is because after the use of zinc fertilisers, there is normally a period of several years that the residual effect of the applied zinc adsorbed in the soil is still providing an adequate supply to successive crops (Alloway, 2004). Therefore, in areas where Zn is applied (in to soil) continuously, soil analysis may help to implement cost effective Zn fertilization and also to make sure that Zn doesn't accumulate in undesirably high concentrations in the soil.

Soil Zn: Soil Zn influenced the response of crops to Zn fertilization with the highest effect size for low soil Zn content (<0.5 mg kg-1) (fig 3C; fig.4B). Crop responses increased as the soil Zn content decreased indicating the importance of Zn fertilization of low soil Zn for Zn biofortification of crops. In other words, Zn fertilizer application on soils with low soil Zn content as low as 0.5 mg kg-1 may increase the Zn concentration and grain yield of crops by as much as 48% and 22%, respectively. However, this may depend on the crop species as crops differ in their relative sensitivity to Zn deficiency. For instance, maize and rice are categorized as highly sensitive whereas wheat has low sensitivity (although this is also intra-specific) to Zn deficiency (Alloway, 2004).

The slightly high crop response in Zn rich soils (soil Zn > 1.5) was unexpected and might be related to the limited number of observations (n=36) and hence, higher uncertainty for this category.

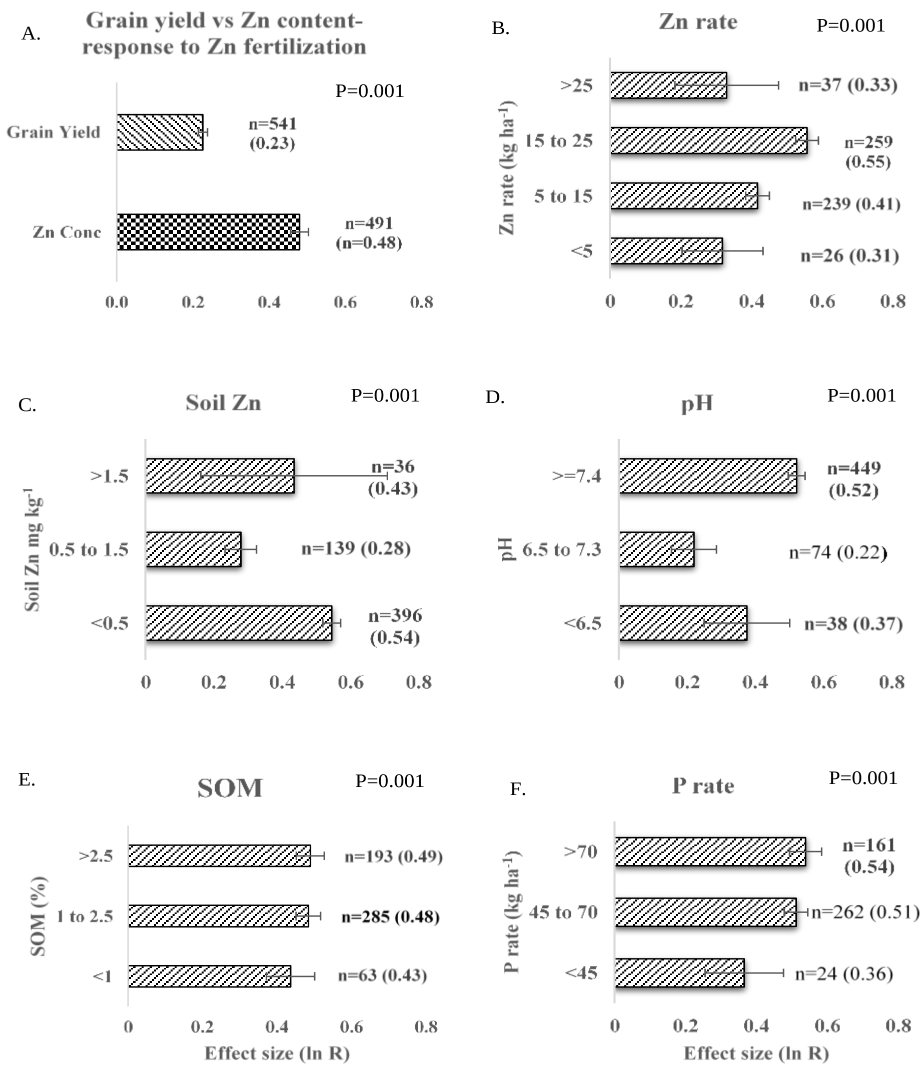

Figure 3. Averaged effect of: Zn fertilization on grain Zn concentration vs grain yield (A), rates of Zn fertilization (B), soil factors (C to E) and P application (F), on the crops' Zn concentration response to Zn fertilization. n=number of studies; numbers in brackets are the effect sizes; Error bars indicate 95% confidence intervals.

Soil pH: The study also showed that the pH level of the soil could influence the response of crops to zinc fertilization with the highest effect size observed for alkaline, calcareous soils than acidic or neutral soils (fig.3D; fig.4C). Zn concentration and grain yield can be influenced by Zn uptake of the crops and Zn availability in the soil which in turn is controlled by many soil factors including soil pH. Soil pH plays a decisive role in reducing Zn availability to plant roots by stimulating absorption to soil particles (e.g. clay minerals and Fe/Al oxides) (Alloway, 2009). Zn solubility decreases as pH increases which again results in reduced Zn uptake. In general, Zn fertilization in alkaline soils resulted in more crop response which might be due to reduced availability of Zn for uptake is compensated by Zn applied from external source. This implies that application of optimum Zn rates in alkaline/calcareous soils would improve the Zn content of the crops.

Soil Organic matter (SOM): Crop response to Zn fertilization generally increased as the SOM content increased with highest effect size (0.48) for 1-2.5% SOM category (fig.3E; fig.4D). This implies that soils of at least 1% organic matter content are needed to achieve sufficient crop response to Zn application. Improved crop responses with increased SOM can be explained by the fact that efficient uptake of Zn from soil solution by plant roots depends on the growth condition of the crop. Soils with good organic matter content may promote better growing condition for crops, and consequently uptake and content would be higher. Moreover, improved SOM content through long-term application of organic matter is reported to reduce concentration of toxic heavy metal Cadmium but not Zn in crops, typically wheat (Gruter et al., 2019). However, Alloway (2009) indicated that relatively higher soil organic matter content (>3%) would also be associated with Zn deficiency in crops. Actually, the current work also confirms this where Zn concentration didn't increase (or even slightly lower) at SOM >2.5% compared with 1 to 2.5% SOM range.

Phosphate fertilization: P application didn't result in significantly reduced Zn content of the crops although higher applications (>70kg ha-1) didn't result in significantly higher Zn contents either (fig.3F; 4E). P typically is known to counteract the Zn availability in the soil and uptake by the crops, but this occurs when the P is applied in over dose and continuously during successive (e.g. four) cropping seasons causing elevated soil P concentrations (measured as Olsen-P) (Chen et al., 2017). The same authors indicated that increase in Zn with P application can be related to a general deficiency in plant nutrients e.g. P in the soil. In case of stresses because of P, an increase in P at first may cause the plant to grow better, have a better root system and be more effective at liberating Zn uptake. A plant will do strong efforts to maintain minimum Zn for its physiological requirements, and eventually be limited in biomass production because of low Zn. Therefore, the current study is not in contrast with previous finding. On the other hand, P-induced reduction in crop Zn contents may be attributed to a combination of several processes, including reduced plant-availability of Zn in the rhizosphere, reduction in Zn uptake per unit of root weight, decreasing mycorrhizal colonization, diminished root-to-shoot translocation of Zn, and yield-induced dilution effect (Chen et al., 2017).

The increase in Zn concentration, which is likely due to improved uptake, with P application could explain increase in yield with P application (fig.4E). Phosphorus may stimulate Zn uptake predominantly by enhancing Zn concentration in soil solution and by increasing metabolic Zn absorption by plant roots.

Zn uptake increased with P (P2O5) application, or in other words, P application didn't influence (negatively) the Zn uptake of crops.

Application Method: Applying Zn fertilizers in soil at sowing followed by foliar application (spray) i.e. Soil + Foliar application had the highest effect size for both crop Zn content and grain yield (fig. 5A, B). The 'soil + foliar' method is a multiple Zn fertilizer application where Zn is applied at the beginning or sowing of seeds (to the soil) and later during the vegetative growth stage through spray on the leaves (foliar). The higher crop response with this method might be because zinc is immobile in plants (Ahmad et al., 2012), and its deficiency could occur at any of the vegetative, flowering or seed development stage. Therefore, continuous supply of Zn might have helped the crops to overcome deficiency during various crop growth stages. Moreover, foliar spray is also best to supply Zn when crop root activity is limited at any of the growth stages. In general, frequent supply of Zn throughout the crop growing season would help to better manage Zn deficiency in crops.

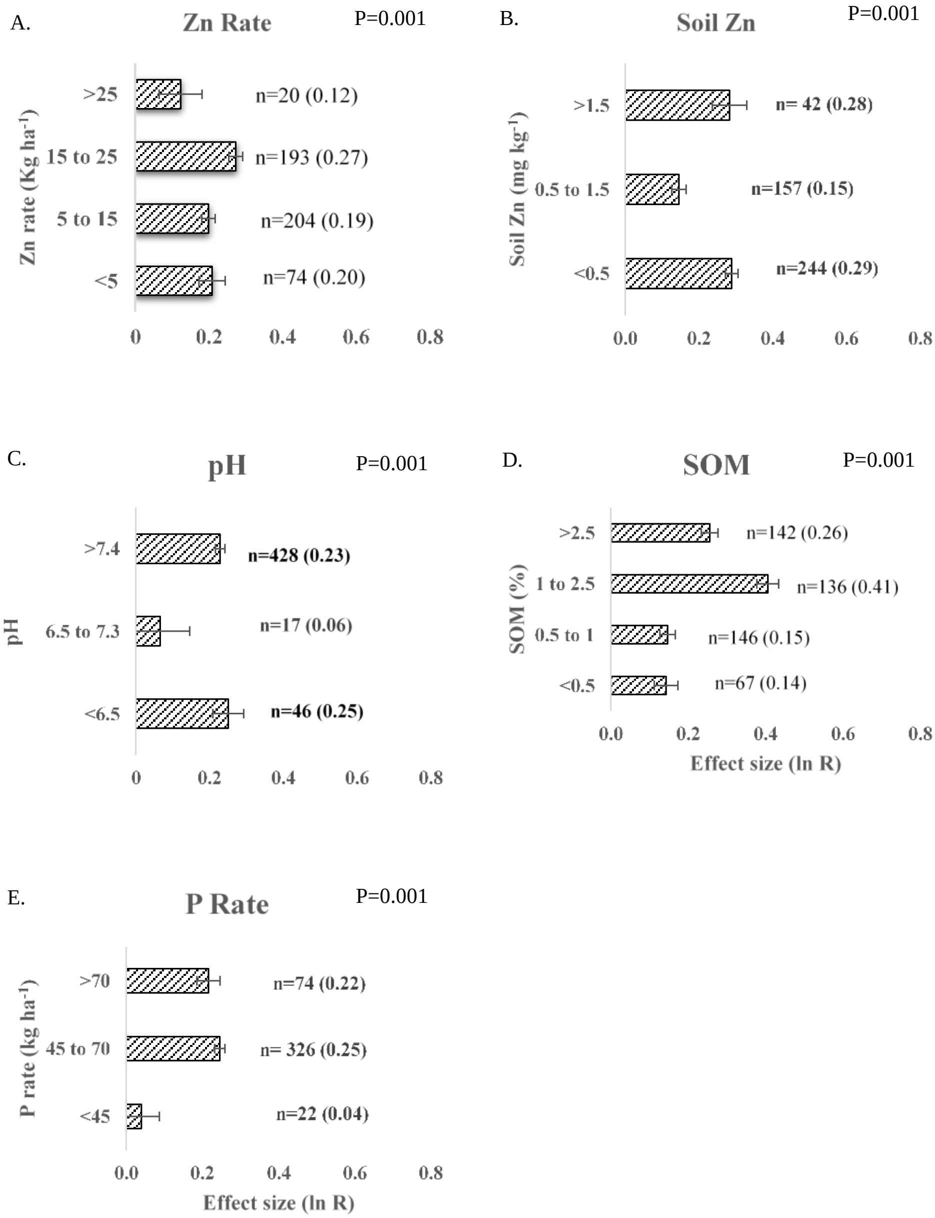

Figure 4. Averaged effect of rates Zn fertilization (A), soil factors (B to D) and P application (E), on the crops' yield response to Zn fertilization. n=number of studies; numbers in brackets are the effect sizes; Error bars indicate 95% confidence intervals.

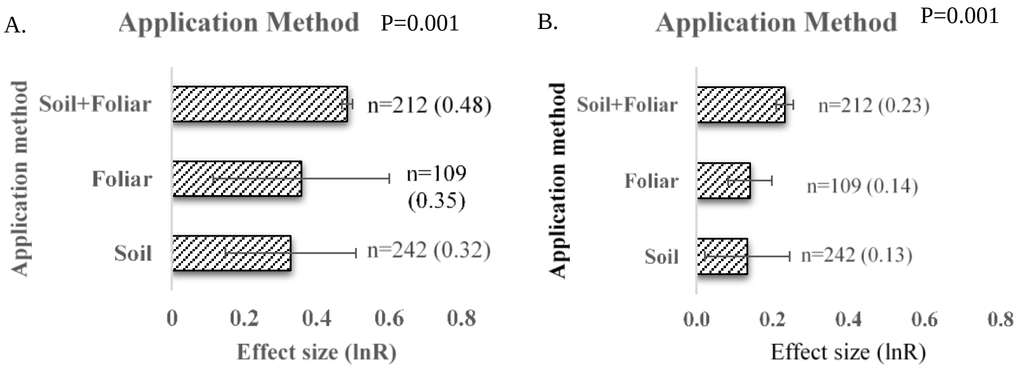

Figure 5. Averaged effect of Zn application methods on crops' response to Zn fertilization interms of Zn content (A), grain yield (B). n=number of studies; numbers in brackets are the effect sizes; Error bars indicate 95% confidence intervals.

This study showed the high influence of Zn fertilization and soil characteristics, and hence relevance of their consideration for tackling the Zn deficiency problems. However, since Zn deficiency can also be caused and aggravated by other factors it would be more effective to implement integrated strategies by combining one or more of the following interventions recommended in previous studies: Zn biofortified or Zn efficient crops, Zn fertilization, using more effective application method, choosing appropriate cropping systems that doesn't deplete already low soil Zn and agronomic management of fertilizers (N & P) and soil properties (Huang et al., 2019; Cakmak, 2009; Chaundry et al., 1977; Guo et al., 2019; Graham et al., 2011; Vitousek et al., 2009).

Conclusion

This meta-analysis study showed that Zn fertilization had positive and significant impact, over control (no Zn fertilization), interms of improving crop Zn content and grain yield. All the independent variables considered had high and comparable effect sizes towards improving crop Zn content with Zn fertilizer application, Soil Zn, soil pH, SOM and P application had high and relevant influence on the dependent variables: Zn content of the crop and total grain yield. This implies that all of them are important parameters to consider for effective Zn deficiency management in Zn deficient areas. Zn doses of 15 to 25 kg ha-1 is shown to produce the highest effect size of crop response to Zn fertilization and might be sufficient in Zn deficient areas to improve both Zn content and grain yield of arable crops. Zn doses higher than 25 kg ha-1 doesn't (significantly) increase crop response anymore.

Authors' contribution

This work was carried out in collaboration between both authors. Author Zewdneh Zana Zate designed the study, extracted data, performed the statistical analysis, wrote the protocol and the first draft of the manuscript, and finalized the revised version. Author Bikila Olika Fufa helped in the literature search and provided inputs for overall improvement of the study. Both authors read and approved the final manuscript.

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Conflict of Interest

The authors indicate that there is no conflict of interest.

References

Abunyewa, A. A., & Mercer-Quarshie, H. (2004). Response of maize to magnesium and zinc application in the semi-arid zone of West Africa. Asian Journal of Plant Science, 3(1), 1-5.

Ahmad, W., Watts, M. J., Imtiaz, M., Ahmed, I., & Zia, M. H. (2012). Zinc deficiency in soils, crops and humans: A Review (Review). AGROCHIMICA, 56(1), 75-89.

Alloway, B. J. (2004). Zinc in soils and crop nutrition. Brussels, Belgium: International Zinc Association.

Alloway, B. J. (2009). Soil factors associated with zinc deficiency in crops and humans. Environmental geochemistry and health, 31(5), 537-548.

Bereket H., Stomph, T. J., & Hoffland, E. (2011). Teff (Eragrostis tef) production constraints on Vertisols in Ethiopia: farmers' perceptions and evaluation of low soil zinc as yield-limiting factor. Soil Science and Plant Nutrition, 57(4), 587-596.

Biljon, J. V., Wright, C. A., Fouche, D. S., & Botha, A. D. P. (2010). A new optimum value for zinc in the main maize producing sandy soils of South Africa. South African Journal of Plant and Soil, 27(3), 252-255.

Cakmak, I. (2000). Role of zinc in protecting plant cells from reactive oxygen species. New Phytol, 146, 185–205.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification. Plant and Soil, 302(1–2), 1–17.

Cakmak, I., Pfeiffer, W. H., & McClafferty, B. (2010). Biofortification of durum wheat with zinc and iron. Cereal Chemistry. https://doi.org/10.1094/CCHEM-87-1-0010

Cakmak, I., Yilmaz, A., Kalayci, M., Ekiz, H., Torun, B., Ereno, B., & Braun, H. J. (1996). Zinc deficiency as a critical problem in wheat production in Central Anatolia. Plant and soil, 180(2), 165-172.

Chaudhry, F. M., HussainA, F., & Rashid, A. (1977). Micronutrient availability to cereals from calcareous soils. Plan and Soil, 47(1), 297–302.

Chen, X., Zhang, Y., Tong, Y., Xue, Y., Liu, D., Zhang, W., Shi, X. (2017). Harvesting more grain zinc of wheat for human health. Scientific Reports, (June), 1–8. https://doi.org/10.1038/s41598-017-07484-2

Chiezey, U. F. (2014). Field Performance of Quatity Protein Maize With Zinc and Magnesium Fertilizers in the Sub-Humid Savanna of Nigeria. Journal of Agricultural Science, 6(3), p84.

Donner, E., Broos, K., Heemsbergen, D., Warne, M. S. J., McLaughlin, M. J., Hodson, M. E., & Nortcliff, S. (2010). Biological and chemical assessments of zinc ageing in field soils. Environmental pollution, 158(1), 339-345.

Dwivedi, R., & Srivastva, P. C. (2014). Effect of zinc sulphate application and the cyclic incorporation of cereal straw on yields, the tissue concentration and uptake of Zn by crops and availability of Zn in soil under rice–wheat rotation. International Journal of Recycling of Organic Waste in Agriculture, 3(2), 1-12.

Ekiz, H., Bagci, S. A., Kiral, A. S., Eker, S., Gültekin, I., Alkan, A., & Cakmak, I. (1998). Effects of zinc fertilization and irrigation on grain yield and zinc concentration of various cereals grown in zinc deficient calcareous soils. Journal of plant nutrition, 21(10), 2245-2256.

El Attar, H., El Halfawi, M., & El Haddad, E. (1982). Response of maize to farmyard manure and zinc. In Organic materials and soil productivity in the Near East: papers presented at the FAO/SIDA Workshop on the Use of Organic Materials for Improving Soil Productivity in the Near East, held in Alexandria, Egypt, 9-18 October 1978. (pp. 221-224).

Fageria, N. K., Dos Santos, A. B., & Cobucci, T. (2011). Zinc nutrition of lowland rice. Communications in Soil Science and Plant Analysis, 42(14), 1719-1727.

Graham K. MacDonald, Elena M. Bennett, Philip A. Potter, and N. R. (2011). Agronomic phosphorus imbalances across the world's croplands. Proceedings of the National Science Academy of the United States of America., 3086–3091.

Grüter, R., Costerousse, B., Mayer, J., Mäder, P., Thonar, C., Frossard, E., … Tandy, S. (2019). Long-term organic matter application reduces cadmium but not zinc concentrations in wheat. Science of the Total Environment, 669, 608–620. https://doi.org/10.1016/j.scitotenv.2019.03.112

Guo, J. X., Feng, X. M., Hu, X. Y., Tian, G. L., Ling, N., & Wang, J. H. (2019). Effects of soil zinc availability, nitrogen fertilizer rate and zinc fertilizer application method on zinc biofortification of rice. The Journal of Agricultural Science (2016), 584–597. https://doi.org/10.1017/S0021859615000441

Gupta, V. K., Potalia, B. S., & MEHLA, D. (1991). INFLUENCE OF SOURCES AND MODE OF ZINC APPLICATION ON YIELD AND UPTAKE OF ZINC BY WHEAT IN ARIDISOLS. ANNALS OF ARID ZONE, 30(3), 209-211.

Gurevitch, J., & Hedges, L. (1999). Statistical issues in ecological meta-analysis. Ecology, 80, 1150–1156.

Gurevitch, J., & Hedges, L. (2001). Meta-analysis: combining the results of independent experiments. In: Scheiner SM, Gurevitch J (eds) Design and Analysis of Ecological Experiments. Oxford University Press, 347–369.

Hossain, M. A., Jahiruddin, M., Islam, M. R., & Mian, M. H. (2008). The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbean-rice system. Plant and Soil, 306(1–2), 13–22.

Huang, T., Huang, Q., She, X., Ma, X., Huang, M., Cao, H., Wang, Z. (2019). Grain zinc concentration and its relation to soil nutrient availability in different wheat cropping regions of China. Soil and Tillage Research, 191(June 2018), 57–65.

Imtiaz, M., Alloway, B. J., Khan, P., Memon, M. Y., Siddiqui, S. U. H., Aslam, M., & Shah, S. K. H. (2006). Zinc deficiency in selected cultivars of wheat and barley as tested in solution culture. Communications in soil science and plant analysis, 37(11-12), 1703-1721.

Kalayci, M., Torun, B., Eker, S., Aydin, M., Ozturk, L., & Cakmak, I. (1999). Grain yield, zinc efficiency and zinc concentration of wheat cultivars grown in a zinc-deficient calcareous soil in field and greenhouse. Field Crops Research, 63(1), 87-98.

Kang, B. T., & Osiname, O. A. (1985). 5. Micronutrient problems in tropical Africa. Fertilizer research, 7(1-3), 131-150.

Mao, H., Wang, J., Wang, Z., Zan, Y., Lyons, G., & Zou, C. (2014). Using agronomic biofortification to boost zinc, selenium, and iodine concentrations of food crops grown on the loess plateau in China. 14(2), 459–470.

Mathur, G. M., & Lal, F. (1991). EFFECT OF ZINC NITROGEN AND PHOSPHORUS ON THE YIELD AND UPTAKE OF ZINC BY WHEAT IN LOAMY SAND SOIL. ANNALS OF ARID ZONE, 30(3), 213-216.

Mehla, D. S. (1999). Effect of frequency of zinc application on yield of rice (Oryza sativa) and wheat (Triticum aestivum) in rice-wheat sequence. Indian Journal of Agronomy, 44(3), 463-466.

Nayyar, V. K., & Takkar, P. N. (1980). Evaluation of various zinc sources for rice grown on alkali soil. Zeitschrift für Pflanzenernährung und Bodenkunde,143(5), 489-493.

Noulas, C., Tziouvalekas, M., & Karyotis, T. (2018). Zinc in soils, water and food crops. Journal of Trace Elements in Medicine and Biology. https://doi.org/10.1016/j.jtemb.2018.02.009

Potarzycki, J., & Grzebisz, W. (2009). Effect of zinc foliar application on grain yield of maize and its yielding components. Plant Soil Environ, 55(12), 519-527.

Rafique, E., Yousra, M., Mahmood-ul-hassan, M., Sarwar, S., Tabassam, T., & Choudhary, T. K. (2015). Zinc Application Affects Tissue Zinc Concentration and Seed Yield of Pea (Pisum sativum L.). Pedosphere, 25(2), 275–281. https://doi.org/10.1016/S1002-0160(15)60012-1.

Ros, G. H., Rotterdam, A. M. D. Van, & Bussink, D. W. (2016). Selenium fertilization strategies for bio-fortification of food : an agro-ecosystem approach. Plant and Soil, 404(1–2), 99–112. https://doi.org/10.1007/s11104-016-2830-4

Rosenberg, M., DC, Adams., & J, Gurevitch. (2000). METAWIN: Statistical Software for Meta-analysis, Version 2. Sinauer Associates, Sunderland, MA, USA.

Sankhyan N.K., Sharma C.M. (1997): Effect of phosphorus and zinc fertilization on grain yield and uptake by maize (Zea mays L.). Indian Journal of Agricultural Science, 67: 63–66.

Schulte, E. E. (1992). Soil and applied zinc (Vol. 2528). University of Wisconsin--Extension.

Sharma, B. D., & Katyal, J. C. (1986). Evaluation of amounts, methods and sources of zinc application to wheat in flood plain soils. The Journal of Agricultural Science, 106(01), 41-44.

Sharma, B. D., Takkar, P. N., & Sadana, U. S. (1982). Evaluation of levels and methods of zinc application to rice in sodic soils. Fertilizer research, 3(2), 161-167.

Singh, D., Behera, S. K., Dwivedi, B. S., Singh, S., Kumar, K., & Rana, D. S. (2008). Distribution of fractions of zinc and their contribution towards availability and plant uptake of zinc under long-term maize (Zea mays L.)-wheat (Triticum aestivum L.) cropping on an Inceptisol. Australian Journal of Soil Research, 46(1), 83–89.

Singh, M. V., & Abrol, I. P. (1986). Transformation and movement of zinc in an alkali soil and their influence on the yield and uptake of zinc by rice and wheat crops. Plant and soil, 94(3), 445-449.

Tariq, M., Khan, M. A., & Perveen, S. (2002). Response of maize to applied soil zinc. Asian Journal of Plant Sciences.

Vitousek1 P.M., R. Naylor2, T. Crews3, M. B. David4, L. E. Drinkwater5, E. Holland6, P. J. Johnes7, J. Katzenberger8, L. A. Martinelli9, P. A. Matson10, G. Nziguheba11, D. Ojima12, C. A. Palm11, G. P. Robertson13, P. A. Sanchez11, A. R. Townsend14, F. S. Z. (2009). Nutrient imbalances in agricultural development. AAAS, 1519–1520.

WHO (2005). Available at http://www.who.int/nut.

Yerokun, O. A., & Chirwa, M. (2014). Soil and foliar application of Zinc to maize and wheat grown on a Zambian Alfisol. African Journal of Agricultural Research, 9(11), 963-970.

Yilmaz, A., Ekiz, H., Torun, B., Gultekin, I., Karanlik, S., Bagci, S. A., & Cakmak, I. (1997). Effect of different zinc application methods on grain yield and zinc concentration in wheat cultivars grown on zinc-deficient calcareous soils. Journal of Plant Nutrition, 20(4-5), 461-471.

Yoshida, S., & Akira, T. (2012). Zinc deficiency of the rice plant in calcareous soils. Soil Science and Plant Nutrition, 15(2).

Yoshida, S., McLean, G. W., Shafi, M., & Mueller, K. E. (2012). Effects of different methods of zinc application on growth and yields of rice in a calcareous soil, West Pakistan. Soil Science and Plant Nutrition, 16(4), 147-149.

Zhang, Y.-Q., Sun, Y.-X., Ye, Y.-L., Karim, M. R., Xue, Y.-F., Yan, P., … Zou, C.-Q. (2012). Zinc biofortification of wheat through fertilizer applications in different locations of {China}. Field Crops Research, 125, 1–7. https://doi.org/10.1016/j.fcr.2011.08.003

Zhao, A., Tian, X., Cao, Y., Lu, X., & Liu, T. (2014). Comparison of soil and foliar zinc application for enhancing grain zinc content of wheat when grown on potentially zinc-deficient calcareous soils. Journal of the Science of Food and Agriculture, 94(10), 2016–2022. https://doi.org/10.1002/jsfa.6518

Zou, C., Gao, X., Shi, R., Fan, X., & Zhang, F. (2008). Micronutrient deficiencies in crop production in China. Micronutrient Deficiencies in Global Crop Production, 127–148.

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RESEARCH PAPER

Genetic divergence among Ethiopian linseed (*Linumusitatissimum* L) genotypes

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Abstract

Knowledge of genetic divergence of traits in any crop population is important for the continued improvement of the crop as well as for its development in the agricultural system. The study was designed to assess genetic diversity of traits in linseed (Linumusitatissimum L) genotypes evaluated at Ambo University Gudar campus during 2019 cropping season. The experiment was conducted using simple lattice design with two replications consisted fifty six genotypes. Using Euclidean distance value (D2) the studied genotypes were grouped into seven different clusters. Among the clusters cluster III and IV consisted largest number of genotypes while cluster VI and VII consisted small number of genotypes. Maximum inter cluster genetic divergence (D=71.64) was revealed between cluster II and VI, while minimum genetic divergence (D=19.74) was manifested between cluster V and VI. Whereas maximum (11.85) intra clusters distance was manifested for cluster V, while minimum (7.14) intra cluster was revealed for cluster VII. Genotypes in cluster II revealed highest mean value for seed yield per hectare. Principal component analysis (PCA) showed that the first four principal components accounted for 75.96 of the total variation, of which nearly 53.08 % was contributed by the first two principal components (PCA1 and PCA2). Therefore the result of this study suggests existence of genetic divergence for seed yield and other agronomic traits in the studied linseed genotype, which should be exploited in linseed breeding program.

Keywords: cluster, Genetic divergence, Genotypes, principal component

Introduction

Linseed (Linumusitatissimum L., 2n=30) belongs to family linaceae and the genus Linum is one of the earliest crop cultivated for its seeds and fibre. Almost every part of the linseed plant is utilized commercially either directly or after processing (Paul et al., 2017).Among the oilseed crops, linseed contributes an important share to Ethiopian economy. Linseed covered 0.64% (about 80,353.74 hectares) of the grain crop area and 0.30% (about 879,116.55 quintals) of the grain production (CSA, 2017).

Ethiopia is the fifth world producer in linseed and considered as a centre of diversity (Vavilov, 1926). It is known for its high quality oil, and its use as a raw material for agro-industries. Linseed is grown for oil production and shows high variability in flower color, plant height, flowering and maturity periods, and capsule size and wilt resistance (Biru and Dareje, 2014)

Despite of its contribution to local oil industry and hard currency earning, average productivity of linseed in Ethiopia during 2016/17 cropping season was 10.94 quintals per hectare (CSA, 2017), but in developed country greater than 15 q/ha (FAO, 2018).

Among various production constraints limiting productivity of linseed, was limited access to improved varieties is the major that is the reason why Less than 10 percent of Ethiopian farmers only utilize improved seeds (FAO/WFP, 2010).

Genetic diversity is crucial to success in any crop breeding and it provides information about the quantum of genetic divergence and serves a platform for specific breeding objectives (Bindroo and ManthiraMouthy, 2014). Therefore understanding the genetic diversity of linseed (Linumusitatissimum L.) is important for the continued improvement of this crop as well as for its development in the agricultural system. Germplasm characterization is an important link between the conservation and utilization of plant genetic resources. The diversity among genotypes can be assessed based on morphological characterization thus; the genetic diversity is referred to the diversity present within different genotypes of same species. This is due to contrasting alleles of a gene in different individuals producing contrasting phenotypes (Mulusew et al., 2014; Nag et al., 2015; Bhandari et al., 2017). Diversity in plant genetic resources provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics, which include both farmer-preferred traits (high yield potential, large seed, etc.) and breeder-preferred traits (pest and disease resistance and photosensitivity, etc.) (Rahman et al.,2016; Bhandari et al.,2017).

On other hand genetic variability is a measure of the tendency of individual genotypes in a population to vary from one another. Genetic variability in a population is important for biodiversity because without variability, it becomes difficult for a population to adapt to environmental changes and therefore makes it more prone to extinction and genetic variation and mode of inheritance of quantitative and qualitative traits are of prime importance in planning the breeding programme (Shah et al., 2015; Kumar et al., 2016).

Analysis based on multivariate methods using D2 statistic is useful in providing information for more efficient variety development programmes (Leul,M.2014).Assessment of variability for yield and other characters becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement (Kumar et al., 2019).Understanding the genetic diversity of linseed is important for the continued improvement of this crop as well as for its development in the agricultural system. Germplasm characterization is an important link between the conservation and utilization of plant genetic resources. Therefore present study was carried out with the objective to identify genetic divergence among Ethiopian linseed genotypes.

Materials and methods

Experimental materials and management

Genetic variability and characterization of 56 linseed genotypes for yield and other Agronomic traits were studied at Ambo University, Gudar Campus. Among the studied materials 48 genotypes were taken from Ethiopian Institute of Biodiversity (EIB), which was collected from different agro-ecology region of Ethiopia (Table 1), while one local variety and 7 released varieties were collected from Sinan and Kulumsa Agricultural research center.

The experiment was conducted in simple lattice design with two replications. Each replication consisted of two rows of each genotype. Row to row distance was 20 cm with row length of 2 meter and plant to plant distance was 10 cm was maintained by thinning. Appropriately cultural practices were carried out as recommended for linseed. Data was recorded on five randomly selected plants for plant height, number of primary branch, number of secondary branch, number of capsule per branch, number of seed capsule, characters while days to 50 per cent flowering, lodging percentage, days to maturity, harvest index and seed yield data was recorded on plot basis. Harvest index calculated as Harvest index (%) = Seed yield per plot/ Aerial biomass per plot x 100

Table 1. Description of the test genotypes collected from different Ethiopia region

Geographical origin	No of Geno types	Name of genotypes (serial numbers in bracket are codes used in this study)
Oromia	24	13628(2),15475(7),17417(8),17597(9),17598(10),17603(11),17607(12),17608(13),17610(14),17615(15),18792(16),19008(17),19009(18),19010(19),19013(20),13755(3),208360(25),208801(27),212512(28),212854(29),219333(32),219334(34), 216892 (31)
Amhara	6	13522(1),237491(47),235784(46),229802(36), 226032(37), 202501(22),
SNNP	4	13758(4),208358(24),211478(30),2406439(33)
Tigray	10	235170(43),238471(44),235177(45),235158(41),235277(42) 219966(35),19079(21),15248(6), 235784(46), 233996(48)
Benishangul Gumuz	4	23544(39),23545(40),207970(23),
National releases	7	Jitu(49),Belay-96(50), Bekelcha(51), Yadeno(52), Kuma(53), Berene(54), Jeldu(55)
Local variety	1	Local

Statistical analysis

Analysis of variances

All collected data were subjected to analysis of variance using appropriate computer software (SAS, version 9.3,2011) and Tukey's range Test (critical difference) at probability of 0.05 was used to separate the means and ranges for significant parameters with the corresponding statistical model;-

$$Yij = \mu + Gi + Rj + \varepsilon ij ,$$

Where Yij is the plot value of each trait of the i^{th} genotype and the j^{th} replication, μ is the trial mean of the a given trait, Gi, is the effect of genotypes, Rj is the effect of replications, and εij is the plot error

Genetic divergence and Cluster Analysis

Genetic divergence and Cluster analysis was carried out through R software 3.4.4 version using Euclidean distance with average method. The means of traits for clusters were obtained from cluster analysis. Distance between intra and inter clusters was calculated by Minitab software using Euclidean formal as indicated in (Anderberg, 1973)

$$D = \sqrt{\mathcal{E}(xi - xj)} + (yi - yj)$$

The principal component analysis (PCA) was done using the same software employed in estimating the genetic distance (cluster analysis).

Result and discussion

The analysis of variance for Days to flowering, plant height, primary branch per plant, secondary branch per plant, number of capsule per branch, lodging percent, number of seed per capsule, days to maturate, harvest index and yield per hectare revealed that statistically significant differences among the studied genotypes. The genetic divergence and cluster analysis was carried out only for characters which revealed significant difference among the studied genotypes. The result of cluster analysis made on 56 linseed genotypes is presented in Table 2 and Fig 1. The 56 genotypes of linseed from six sources (Table 1) were clustered into seven diversity classes based on D value computed for ten characters

Cluster and Genetic divergence analysis

The cluster analysis revealed that the genotypes were placed into seven clusters (Table 2 and Fig.1) of which the third and fifth cluster encompasses the largest number of genotypes each contain fifteen (15)genotypes , while the first , fourth , second, sixth and seventh cluster each contains twelve (12),six (6), four (4), two (2) and two (2) genotype respectively. Similarly different clustering patterns were also reported by different researchers in linseed genotypes (Paul et al., 2017; Patial et al., 2019).

Genetic improvement through selection and hybridization depends upon the extent of genetic diversity between parents. Genetically divergent parents could lead to the development of desirable recombinants and transgressive segregants, that in turn, may lead to the development of better performing varieties than the released varieties (Legesse, B.2010). In present study linseed genotypes originated from five different regions (Table 1) were randomly distributed to the different clusters with no definite pattern showing their distinct diversity. There was no observed clear cut relationship between the original sources of the tested genotypes and their genetic diversity since genotypes from the different sources fell into the same cluster and genotypes of the same source were distributed into different clusters, indicating that genotypes from the same origin may have different genetic background and genotypes from different origins might have the same clusters.

Table 2. Clustering of fifty six linseed genotypes using mean of ten characters

S.No.	Cluster	Number of genotypes	Genotypes codes
1	I	12	Acc. Nos. 13522, 13628, 13758, 19013, 15248, 17608, 19079, 212512, 212854, 211478, 238471, 235177
2	II	4	13755, 13756, 17598, 17610
3	III	15	17597, 17603, 17607, 15475, 19008, 202501, 208358, 208360, 229802, 226032, 23534, 23544, 235784, Yadeno, Jitu
4	IV	6	Belay- 96, Bale Local, Bekelcha, Berene, 17417,208801
5	V	15	19009, 19010, 17615, 211892, 240643, 219334, 219966, 235158, 235170, 23396, Kuma, Jeldu, 208749, 18792, 207970,
6	VI	2	219333, 23545
7	VII	2	235277, 237491

Table 3. Estimates of average intra and inter- cluster distances for the 7 clusters in 56 Linseed genotypes

	I	II	III	IV	V	VI	VII
I	**11.00**	38.87	24.79	22.34	20.97	39.12	40.0
II		**8.69**	23.21	28.64	37.44	71.64	64.47
III			**9.36**	22.75	28.48	58.89	54.17
IV				**9.32**	19.74	53.19	47.40
V					**11.85**	38.16	28.84
VI						**7.25**	19.84
VII							**7.14**

NB. Bold figure represent intra-cluster distance

Genetic distances (D2) of fifty six genotypes are presented in (Table 3). The estimates of within and between cluster diversity presented by intra and inter cluster (D2) values revealed that the genotypes of same cluster had little divergence from each other with respect to the aggregate effect of 10 characters under study (Table 3). Inter-cluster Euclidean distances (D2) values ranged from 19.74 (between clusters C IV and C V) to 71.64 (between clusters C II and C VI). The largest genetic divergence are revealed between cluster II and VI (D2=71.64), followed by cluster II and VII(D2=58.89), indicating that superior hybrids or recombinants can be realized by mating between the lines of these clusters, while the lowest genetic divergence is revealed between cluster IV and V(19.74), followed by cluster VI and VII(19.84). Intra cluster distance range from 11.85 for cluster V to 7.14 for cluster VII.

The largest intra cluster distance were revealed for cluster V followed by cluster I and cluster III, while smallest intra cluster distance were manifested for cluster VII, followed by cluster VI and cluster II. The clusters characterized by maximum distances reveal superior heterosis effect and variation from their crosses (Gemechu et al., 2018). Similarly (Chaudhary et al., 2016) reported different genetic distances among linseed genotypes in his studies. Similarly (Mulusew et al, 2013) reported as genetic diversity plays an important role in plant breeding since hybrids between lines of diverse origin generally display a greater heterosis than those between closely related strains

Table 4. Mean differences among the seven clusters of 56 linseed genotypes for mean performance for Yield and other Agronomic traits.

Cluster	FD	PH	Pbr	Sbr	Cbr	LG	SC	MD	HI	Yield/ha
I	60.42	69.58	2.55	4.99	3.81	8.54	7.34	114.87	0.10	9.67
II	84.12	87.37	2.37	5.55	3.02	2.87	8.55	137.62	1.17	17.34
III	64.43	75.53	2.60	4.9	3.17	4.47	8.69	137.50	0.21	14.69
IV	62.67	90.08	2.35	5.35	4.31	10.08	7.13	121.50	0.13	11.32
V	63.83	78.8	2.55	5.10	3.52	25.90	6.94	120.23	0.09	8.41
VI	52.5	54.25	2.87	5.75	7.70	38.75	8.40	97.00	0.16	8.64
VII	58.25	65.25	2.5	4.82	3.86	47.50	7.42	108.50	0.05	4.88
Grand mean	63.7	74.4	2.54	5.2	4.2	19.7	7.9	119.6	0.27	10.7

Where;-Cbr= number of capsule per branch, FD=days to flower, MD= days to maturity, HI=harvest index, LG=lodging percent, Pbr=number of primary branch per plant, PH= plant height, Sbr=number of secondary branch per plant Sc=number of seed per capsule, Yldha= Seed yield per hectare

Mean value for each cluster (Table 4) revealed that genotypes in cluster II had highest values for yield per hectare followed by harvest index, days to flowering and days to maturate, cluster III had highest values for number of seed per capsule, cluster IV had highest values for plant height, cluster VI showed highest value for primary branch per plant followed by secondary branch per plant and number of capsule per branch, VII had highest values for lodging percent, while cluster V had lowest value for days to flowering and days to maturate. Cluster analysis revealed wide range of genetic divergence, which is useful for future hybridization breeding programme to getting desirable transgressive segregantes. In present study a cluster II which showed highest days to mature revealed highest yield performance, this mean that it is important for an area which has long rain season, while a cluster VI which manifested short days to maturate are important for an area with short rain season.

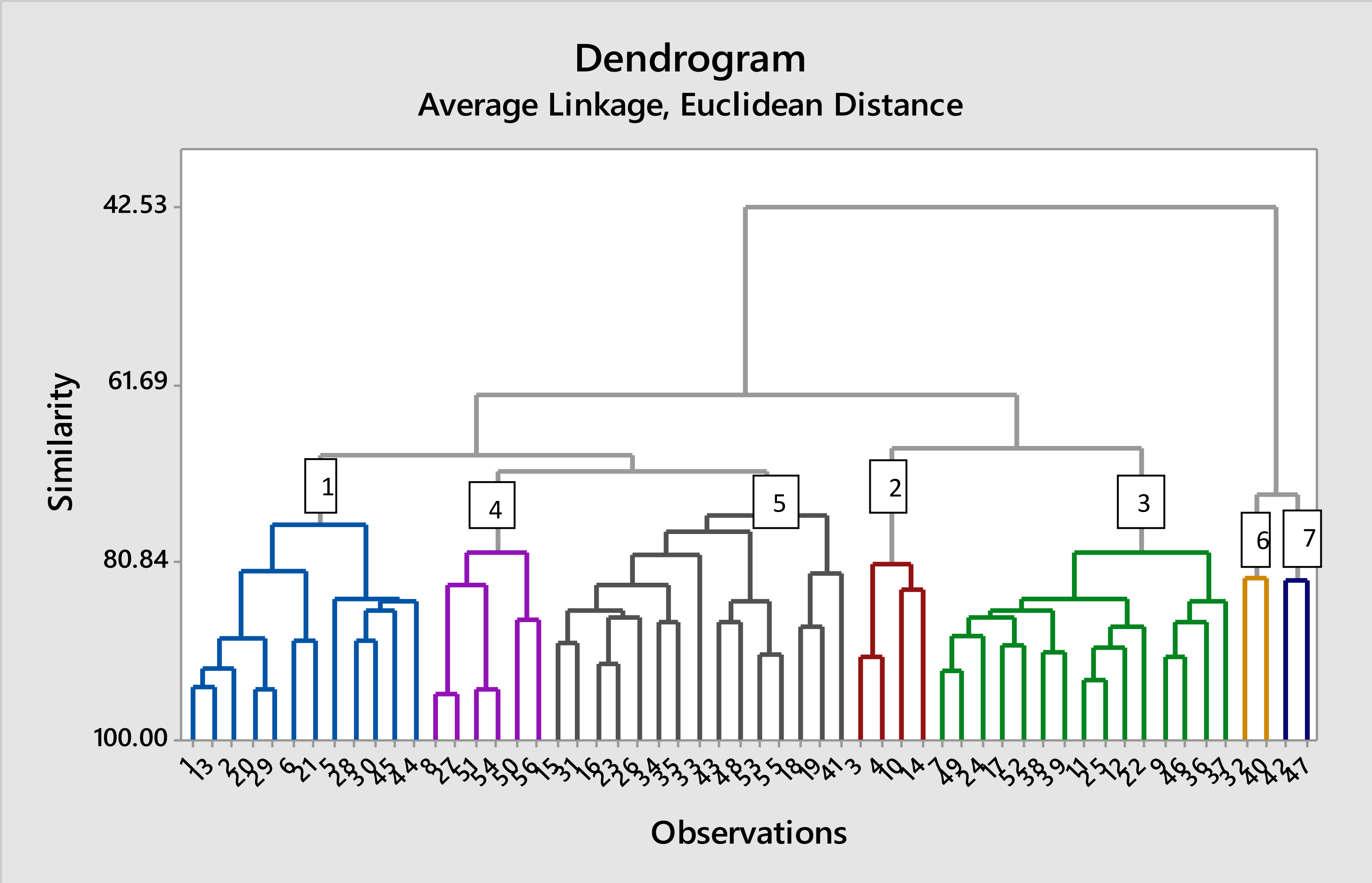

Fig.1 Relationship among 56 linseed genotypes revealed by cluster analysis based on ten traits

Principal Component Analysis

Principal component analysis is a method that reduces data dimensionality without much loss of information. Principal component analysis shows the importance of the largest contributor to the total variation at each axis for differentiation (Sharma, 1998).Four principal components (PCs) extracted about 75.96 % (Table 5) of the entire variation of the genotypesconsidering only PCA Eigen values in PC score greater than 1.In present study about 37.57 % of the total variance explained by the first PCA was due chiefly to variation in harvest index, seed yield per hectare,anddays to maturity. About 15.51% of the whole variance explained by the second PC originated mainly from variation in the primary branch per plant, number capsule per plant, number of seeds per capsule. The third PC accounting for about 12.45% of the entire variance resulted largely from variation in secondary branch per plant, plant height, number of capsules per branch. The fourth PC constituted 10.44% of the variation and demonstrated mainly by primary branch per plant, secondary branch per plant and days to flowering. Characters with relatively larger absolute values of eigenvector weights in PC1 had the largest contribution to the differentiation of the genotypes into clusters as it is normally assumed that characters with larger absolute values closer to unity within the first principal component influence the clustering more than those with lower absolute values closer to zero (Chahal and Gosal, 2002; Legesse 20210).

Table 5. Percent and cumulative variances and Eigenvectors on the first four principal components in 56 genotypes of linseed.

Parameters	**PCA1**	**PCA2**	**PCA3**	**PCA4**
Variance (%)	37.57	15.51	12.45	10.44
Cumulative (%)	37.57	53.07	65.52	75.96
Characters		**Eigenvectors**		
FD	0.31	-0.29	0.22	0.45
PH	0.25	-0.33	0.43	-0.078
Pbr	0.02	0.45	-0.31	0.57
Sbr	0.013	0.31	0.60	0.46
Cbr	-0.22	0.44	0.41	-0.32
LG	-0.38	0.04	0.05	0.15
SC	0.34	0.44	0.04	-0.17
MD	0.45	-0.09	-0.11	0.14
HI	0.39	0.29	-0.28	-0.12
Yieldha	0.41	0.14	0.19	-0.25

Conclusion

The present study manifested good existence of genetic divergence and variability potential among the Ethiopia linseed genotypes. Based on principal component analysis value (PCA1) days to maturity and seed yield characters has played great role for diversity of studied genotypes. Therefore, the breeder should adopt suitable breeding methodology such as hybridization and selection to utilize in future breeding program for the studied genotypes, since varietal and hybrid development will go a long way in the breeding programmers especially in case of linseed. In future to strengthen the obtained result, repeating the study using molecular markers can make more credible since this study was carried out only based on morphological characterization.

Reference

Anderberg, M.R., 1973. Cluster Analysis for Applications, New York: Academic Press, Inc.

Bhandari HR, A NishantBhanu, K Srivastava, MN Singh, Shreya,and A Hemantaranjan(2017). Assessment of genetic diversity in crop plants an overview. Adv Plants Agric Res;7(3):279–286.

Bindroo,B.B and ManthiraMoorthy,Sh.2014. Genetic Divergence, Implication of Diversity, and Conservation of Silkworm, Bombyxmori. International Journal of Biodiversity, Hindawi Publishing Corporation, 1-16pp

BiruA, and Dareje A.2014. Adaptation Study of Improved Linseed (LinumUsitatisimum L) Varieties at KellemWollega Zone, HaroSabu, Ethiopia.Journal of Biology, Agriculture and Healthcare. 4(20);220-224

Chaudhary,M., Rahul, V. P. , Singh,V. and Chauhan, M. P. (2016).Study on genetic divergence in Linseed(Study on genetic divergence in Linseed (LinumUsitatissimumTissimumTissimum L.) Germplasm based on morphological And Quality Traits Ality Traits. The Biosean;11(2):953-957

Chahal GS and Gosal SS (2002). Principles and procedures of plant breeding: biotechnological and conventional approaches. Narosa Publishing House, New Delh, p 391-432

CSA. 2017. Central Statistical Agency Agricultural Sample Survey: Report on area and production of major crops (private peasant holdings, Meher' season of 2016/17). Statistical Bulletin Vol. 1: 584. CSA, Addis Ababa, Ethiopia

FAO/WFP (Food and Agriculture Organization and World Food Program). 2010. Crop and Food Security Assessment Midsession to Ethiopia. http://www.faostat.fao.org

FAOSTAT.2018. Area harvested, total production and productivity of crops.URL:http://www.fao.org/faostat/en/#data/QC. Accessed on date: October 10, 2018

Gemechu, K., Endashaw, B., Fassil, A., Muhammad, I., Tolessa, D., Kifle, D. and Emana, G. (2018).Phenotypic Diversity in Ethiopian Chickpea (Cicerarietinum L.) Germplasm Accessions for Phosphorus Uptake and Use Efficiency.Ethiop. J. Crop Sci. 6 (1);1-22

Kumar, N, Paul, S and SinghDhial, R. (2016). Study on genetic variability, heritability and genetic advance for agro-morphological traits of linseed (Linumusitatissimum L.). Res. Environ. Life Sci. 9(1) 16-18

Kumar.S, Ram ,S., Chakraborty,M., Ahmad E., Verma.N,Lal, HC., Prasad,Y., Kumar,K.,Bhushan, S and Choudhary,AK (2019).Role of genetic variability for seed yield and its attributes in linseed (Linumusitatissimum L.) improvement.Journal of Pharmacognosy and Phytochemistry; 266-268pp.

Legesse, B.(2010).Enetic Diversity Study of Linseed Genotypes on Acidic Soil at Bedi Trial Site, Central Highland Of Ethiopia.A Thesis Presented to the School of Graduate Studies of the Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology.1-81pp

Leul, M.(2014).The Application of D2 Statistic to Measure Genetic Divergence in Different Bread Wheat Genotypes. A Thesis Submitted to The Department of Statistics Presentedin Partial Fulfillment of the Requirements for the Degree of Master of Science in Statistics. Addis Ababa University, Addis Ababa, Ethiopia.1-94pp

Mulusew, F.A ,Firew, M., Adugna, W.(2013). Seed oil diversity of Ethiopian linseed (Linumusitatissimum L.) landraces accessions and some exotic cultivars.Afr. J. Biochem. Res.V. 7(6); 76-85

Mulusew, F.A ,Firew, M., Adugna, W.(2014). Morphological Diversity Of Ethiopian Linseed (LinumUsitatissimum L.)

Landrace Accessions and Non-Native Cultivars.J. Plant Breed. Genet.02 (03). 115-124

Nag S, Mitra,J. and Karmakar, P.G. (2015). An Overview on Flax (Linumusitatissimum L.) and its Genetic Diversity.International Journal of Agriculture, Environment and Biotechnology.8(4): 805-817

Rahman, M.A., Thomson M.J, Shah-E-Alam, M,, de Ocampo, M., Egdane, J., Ismail, AM. (2016) Exploring novel genetic sources of salinity tolerance in rice through molecular and physiological characterization.Ann Bot ;117:1083–1097. https://doi.org/10.1093/aob/mcw030

Patial R, Paul, S., Sharma, D., Sood,V K. and Kumar,N.(2019).Morphological characterization and genetic diversity of linseed (Linumusitatissimum L.).J. Oilseeds Res., 36(1) : 8-16

Paul,S.,Kumar,N. and Kumar,A. (2017). Characterization and Genetic Variation Study among Linseed (LinumUsitatissimum L.) Genotypes for Seed yield and related traits in mid-hills of north-west himalayas. Plant Archives; 17 (1); 407-411

SAS Institute, Inc. 2011.SAS proprietary software. SAS Institute, Inc,Cary,NC,USA

Shah, K. A., Farhatullah, Shah, L., Ali, A., Ahmad, Q.and Zhou, L (2015).Genetic variability and heritability studies for leaf and quality characters in flue cured virginia tobacco. Acad. J. Agric. Res., 3: 044-048

Vavilov, N.I. 1926. Studies on the origin of cultivated plants.Bull. Bet. And Pl. breed. 16: 139-248.

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RESEARCH PAPER

Evaluation of Insecticides on Management of some Sucking Insect Pests in Tomato (Lycopersicon esculentum Mill.) in West Shoa Zone, Toke kutaye District, Ethiopia

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Abstract

Tomato plants (Lycopersicon esculentum L.), which belongs to family Solanaceae, is one of the most popular and cost-effective vegetables for fresh consumption and processing. Certain sucking insects viz., thrips, whiteflies and aphids cause severe damage to crop by transmitting virus disease rather than direct feeding, particularly to the tomato plants. The present study was carried out in RCBD with four replications in open farmer's fields by irrigation water for the period from October to March 2018/2019 for two consecutive years. Two new insecticides Sivanto Energy EC 85 and Delta 2.5 E.C with the doses of the former and later, 800, 1000 & 1200ml-1ha and 350, 400 & 450ml-1ha respectively; and Diazinon 60 E.C at 1000ml-1ha were tested for their efficacy against sucking insect pests on tomatoes. Percent efficacy recorded after 48 hours of each spray in the fields was significantly affected by the dose applied. The percent efficacy obtained by Sivanto Energy EC 85 and Delta 2.5% E.C at the highest doses proved to be the most effective and gave better efficacy against whiteflies, thrips and aphids. Therefore, both insecticides can be used for the management of sucking pests (whitefly, thrips, and aphid) on tomato crops in the field.

Keywords: Aphid, Thrips, Whitefly, Insecticide, Efficacy, Dose, and Tomato

Introduction

Tomato *(Lycopersicon esculentum* Mill.) belongs to the nightshade family Solanaceae. It is one of the most important vegetable crops in the world, and popularly and widely grown crops in Ethiopia (FAOSTAT, 2011). It is an economically important crop among vegetables in the country. For consumption as fresh vegetable, tomato is produced under open fields and green-house conditions. It can be eaten either fresh or processed into different products. It is helpful in healing wounds because of antibiotic properties found in ripe fruits. Tomatoes are the good sources of several vitamins (A, B and C) and minerals such as potassium, and folate and also the carb contents consists mainly of simple sugars and insoluble fibers (Baloch, 1994; Adda, 2019).

The diversity of worldwide biotic communities has greatly changed in recent years due to the collapse of natural barriers to wild species movements mainly in relation to human activities (Liebhold and Tobin, 2008). Among the newly introduced insect species, some can become invasive, with subsequent significant economic impacts. The success or failure of a biological invasion may depend on the species' life history parameters, on its response to climatic conditions, on the competition with native species and on the impact of natural enemies (Grabenweger *et al*., 2010).

In Ethiopia, out of the total vegetable crop production area tomato (L. esculentum Mill.) contributed 2.51% and total production of 5,235.19 hectares during 2017/18 (CSA, 2018). Tomato production faces many problems from several factors which leads to significant yield loss. Among these factors, insect pests are the most important. Sucking insect pests cause a very high level of damage (quantity and quality) to tomato crops (Megido *et al.*, 2012), particularly if no control measures are practiced (Desneux *et al*., 2011).

Tomato growers in Ethiopia regularly experienced the economic damage caused by fruit borer (*Helicoverpa armigera* Hubner), tomato leafminer (*Tuta absoluta*, Meyrick) whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis gossypii* Glover) and thrips (*Frankliniella schultzei* Trybom). The sucking pests are polyphagous in nature throughout the year. Moreover, the cultivation of tomato and availability of alternate hosts encourage the development of pest pressure all year round. The sucking pests *viz.*, thrips, whiteflies and aphids cause severe damage to crop by transmitting virus disease in addition to direct feeding.
In sucking pest complex, whitefly is important as it imparts direct damage to the crop by desaping and also acts as vector for transmission of leaf curl virus disease in tomato (Jones, 2003). Yield losses due to direct and indirect damage caused by whiteflies were reported to the extent of 20 to 100 per cent (Papisarta and Garzia, 2002). Therefore, the study was aimed at evaluation of different doses of insecticides on sucking insects attacking tomato in Toke kutaye district, West Shoa Zone, Oromia Regional State, Ethiopia.

Materials and methods

Description of the study area

The present study was carried out during October to March 2018 to 2019 for two consecutive years at Guder, Toke kutaye district of west Shoa in open farmer's fields. Toke Kutaye districts, is located at 126 km west of Addis Ababa having an altitude of 1990 meter above sea level, latitude of 08° 59' 01.1' North and longitude of 37° 46' 27.6' East (Fig 1).

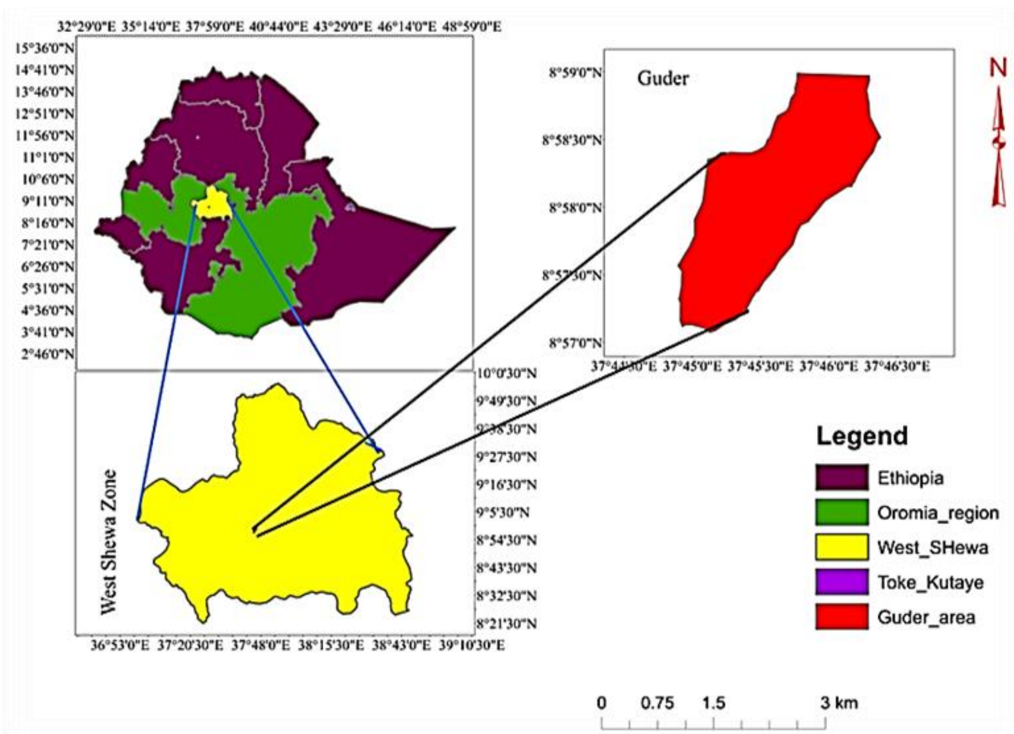

Fig 1: Toke Kutaye District Agricultural Office (2018)

Land preparation and layout

The experiment was laid out in RCBD with eight treatment and four replications including standard check and untreated control. The seedling was transplanted after 40 days in the plots having a size of 4.0m x 3.6m plot at spacing 100 cm x 40 cm between row and plant, respectively. When an appropriated number of sucking pests were reached economic threshold level, the chemicals sprayed with knapsack sprayer as specific doses. In both years insecticides spray was under taken at vegetative, flowering and fruit setting stages.

Table 1: List of experimental treatments at different doses

Common Name	Trade Name	Dose ml ha^{-1}	Dilution in water lt ha^{-1}
Flupyradifurone + Deltametrin	Sivanto Energy EC 85	800	200
		1000	200
		1200	200
Deltamethrin	Delta 2.5 E.C	350	500
		400	500
		450	500
Diazinon	Diazinon 60 E.C	1000	200
Control (untreated)			

For data recording, five plants were selected randomly from each plot and tagged. On each selected plant, three leaves each from upper, middle and bottom portion were inspected from lower side for presence of sucking pests. However, nymphs as well as adults were recorded in respect of aphids, whitefly and thrips by using the hand lenses of 10 times magnifications. Pre-spray count was taken prior to each spray and subsequent counts were recorded after 48 hours of application. Observations were recorded early in the morning before 8.00 a.m. as suggested by Mote (1977). The marketable tomato fruits plucked at each picking were recorded separately for each treatment plot and computed yield data were converted into ton/ha.

Data analysis

Analysis of variance (ANOVA) was conducted using Statistical Analysis Software (SAS, 2009) and treatment effects were compared. The mean comparisons were carried out using Duncan's Multiple Range Test (DMRT). Efficacy analysis was done after data transformation to Arcsine (Gomez and Gomez, 1984):

$$CM(\%) = \frac{[T(\%) - C(\%)]}{[100 - C(\%)]} X100$$

Where: CM (%) - Corrected mortality
T - Mortality in treated insects
C- Mortality untreated insect

Result and discussions

Efficacy of insecticidal treatments against sucking pests of tomato

Efficacy of insecticides against sucking insect pests in the field is shown in Table 2. The data on the effectiveness of insecticides against aphids, thrips and white flies revealed that significant ($P < 0.05$) difference compared to untreated control (Table 2). The results showed that the Sivanto Energy EC 85 insecticide at the rate of 1000ml and 1200ml/ha was significantly ($P < 0.05$) superior over the control but there was no significant ($P > 0.01$) difference with the standard check.

All treatments are significantly ($P < 0.01$) different on plant treated with various treatments and reduced the total numbers of sucking pest per treatment. Effect of Sivanto Energy EC 85 insecticides were evaluated against aphids, thrips and whiteflies at three different doses after 48 hours exposure time. Table 2 shows Sivanto Energy EC 85 at 800 ml ha^{-1}, 1000 ml ha^{-1} and 1200 ml ha^{-1} had maximum toxicity (85.67, 99.33 and 100%) against Aphids, respectively. while Delta 2.5 E.C showed the minimum mortality (63, 79.33 and 84.33%) after 48 h of application.

On the other hand Delta 2.5 E.C at 450 ml ha^{-1} on aphids, white flies and thrips resulted in the percent mortality of 84.33, 81.67 and 86.33%, respectively. Low toxicological effect was observed by low doses of Delta 2.5 E C and Sivanto Energy EC 85 (300 and 800 ml ha^{-1}), respectively (Table 2). In the second year, similar results were observed (Figure 1).

The results showed the combination of flupyradifurone and deltametrin gave better results as compared with deltametrin alone. The result agrees with Worthing (1987) who reported that deltamethrin has very good residual activity for outdoor and indoor insect pests. The result was also in conformity with the work of Haug and Hoffman (1990), who reported that they are reported that deltamethrin is a synthetic insecticide based structurally on natural pyrethrins, which rapidly paralyze the insect nervous system giving a quick knockdown effect. The presented result confirmed the previous work of Shafiq and Maher (2016), also reported that deltametrin caused significant reduction of thrips populations as compared to the untreated control.

Table: 2 Effect of insecticidal treatments (spray) against sucking pests of tomato after 48 hours of applications at Toke kutaye district, west Shoa Zone, Ethiopia during 2018.

Treatment	Dose ml ha^{-1}	Mean number of sucking insect pests /3 leaves		
		Percent Efficacy		
		Aphids	White flies	Thrips
T_1	(800)	85.67^b	77.72^c	70.08^c
T_2 Sivanto Energy EC 85	(1000)	99.33^a	97.67^a	98.58^a
T_3	(1200)	100.0^a	100.0^a	99.33^a
T_4	(350)	63.0^c	65.33^d	62.33^c
T_5 Delta 2.5 E.C)	(400)	79.33^b	83.33^b	81.33^b
T_6	(450)	84.33^b	81.67^b	86.33^b
T_7 (Diazinon 60 E.C)	(1000)	97.33^a	98.67^a	97.67^a
T_8 (Control)		3.75^d	6.05^e	4.92^d
LSD		9.82	8.78	9.01
CV (%)		14.04	12.68	16.91
SE ±		3.09	2.01	2.13

T1= Sivanto Energy EC 85 (800ml), T2=Sivanto Energy EC 85 (1000ml),T3= Sivanto Energy EC 85 (1200ml), T4= Delta 2.5 E.C(), T5= Delta 2.5 E.C, T6= Delta 2.5 E.C, T7= Diazinon 60 E.C and T8= Control

Effect of insecticides on tomato crops

Physical observations were undertaken in the field to assess the impact of the insecticides from the treated plots on health of the crop in the application areas. After application of insecticide there was no phototoxicity effect (abnormal coloring and scorching) on the leaves of tomato crops at recommended rate.

Frequency of application

The spay was made three times at different growth stage. The first and second applications were undertaken at vegetative and flowering stages then the third spray was made at fruit setting stages. The number of application per season presented in the study can serve as an indication for the number of applications on crops and cannot be used as a robust result. The reason for this is that the data was collected within two years and no correction was made for other influences such as extreme climate conditions or infection pressure in the crops. However, this study was in disagreement with the previous work of Ann (2001), who reported the average frequency of applications of the mostly used insecticides and fungicide products on the intensively treated crops was between 10 and 20 times a year. But on most crops single pesticide products were not used more than seven times a year.

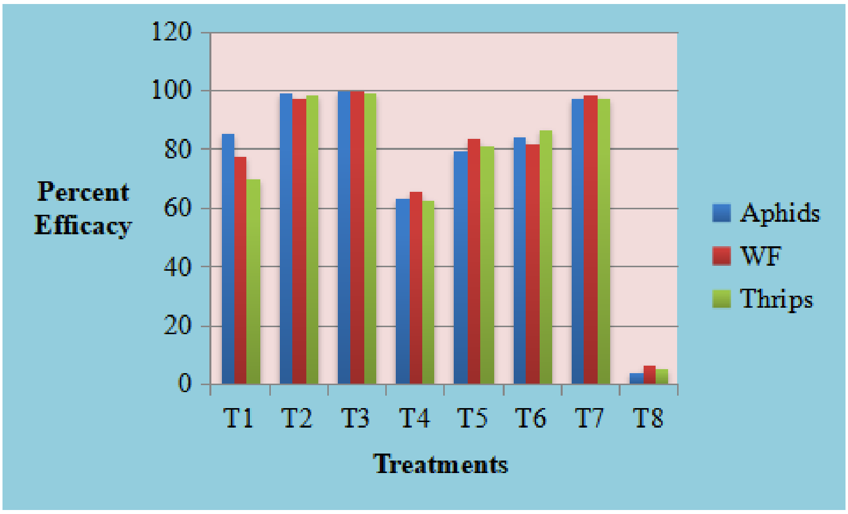

Figure 1: Effect of insecticidal treatments against sucking pests of tomato after 48 hours of spray at Toke kutaye district, West Shoa Zone, Ethiopia during 2019.

Effect of insecticides on yield

Present study attempted to develop alternative control technique, mainly for sucking pests using new chemical insecticides that contribute to reduce the infestations and protect the main crop tomato contributing to increase yield. The obtained result was from studies on the effect of insecticides of the sucking pests. Here the pest is controlled by introducing the new insecticides in to the field and the yield is compared with the untreated plots. There were significant different between doses of insecticides and untreated check but no significant ($P > 0.05$) different between the insecticide (Sivanto Energy EC 85) at highest dose when compared to the standard check (Diazinon 60 E.C).

Table 3: Effect of insecticides against sucking insect pests on yield of tomato

Treatments	Dose ml ha^{-1}	Marketable Yield ton ha^{-1} (2018)	Total Yield ton ha^{-1} (2018)	Marketable Yield ton ha^{-1} (2019)	Total Yield ton ha^{-1} (2019)
T_1	(800)	25.17^{ab}	28.25^{ab}	24.48^{b}	27.38^{b}
T_2 (Sivanto Energy EC 85)	(1000)	27.67^{a}	30.28^{a}	26.65^{ab}	29.85^{a}
T_3	(1200)	30.33^{a}	33.52^{a}	29.50^{a}	31.65^{a}
T_4	(350)	25.5^{ab}	28.87^{ab}	24.33^{a}	29.25^{a}
T_5 (Delta 2.5 E.C)	(400)	25.67^{ab}	28.67^{ab}	25.68^{a}	30.42^{a}
T_6	(450)	26.38^{ab}	29.88^{ab}	26.88^{a}	28.90^{a}
T_7 (Diazinon 60 EC)	(1000)	29.67^{a}	32.58^{a}	28.15^{a}	31.40^{a}
T_8 (Control)		21.4^{c}	25.54^{c}	19.75^{c}	24.62^{c}
LSD		3.52	3.32	2.95	2.25
CV (%)		15.87	18.06	15.26	17.35
SE ±		4.21	4.75	3.54	3.88

The result indicated that yield in the treatment Sivanto Energy EC 85 and Diazinon 60 E.C gave better yield percentage in both years compared to untreated plot (Table 3). The results could be due to low sucking insect pest infestation in tomato crops grown with Sivanto Energy EC 85. High infestation level was recorded in the untreated control treatment that gave low yield due to high damage occurred to tomato by sucking insect pest.

Conclusion and recommendations

Sucking insect pests have been a serious pest of tomatoes in Ethiopia. These studies clearly indicated that the tested insecticide showed good efficacy in controlling whitefly, thrips and aphid. Hence, they can be used in conjunction with chemical products and integrated pest management. Therefore, from this study it is recommended that sivanto energy EC 85 at doses of between 1000-1200ml/ha) and delta 2.5 E.C at dose of 450 ml ha^{-1} can used as a management option of sucking insect pests as components of integrated pest management.

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References

Adda B (2019). Tomatoes 101: Nutrition Facts and Health Benefits. https://www.healthline.com/nutrition/foods/tomatoes

Ann OH (2001). Data on application frequency of pesticide for risk assessment purposes. Occup. Hyg., Vol. 45, No. 1001, Pp. S95–S101.

Baloch FA (1994). Vegetable crops. In: Horticulture National Book Foundation, Islamabad. Pp. 508

CSA (2018). Agricultural sample survey report on area and production of major crops. The federal democratic republic of Ethiopia central statistical agency agricultural sample survey. Volume 1.

Desneux N, Luna MG, Guillemaud T, Urbaneja A (2011). The invasive South American tomato pinworm *Tuta absoluta* continues to spread in Afro-Eurasia and beyond the new threat to tomato world production J Pest Sci. 84: 403-408.

FAOSTAT (2011). Food and agricultural commodities production. htip://faostal.fao.org.

Stepanovic, M.V., V.V. Bjclic. and V.D. Dragicevic. (2000). Effect of crop density on morphological characterstics and yield of cabbage. Acta Hortic. 533:205-207.

Galanihe LD, Madugalle S, Rajapaksha SP, Siriwardena MI (2017). Influence of companion crops on sucking pest complex of tomato. Annals of Sri Lanka Department of Agriculture. 19: 27 – 35.

Gomez KA, Gomez AA (1984). Statistical procedures for Agricultural Research, (2nd edn), John Wiley and Sons, Inc. New York, USA.

Grabenweger G, Kehrli P, Zweımu¨ ller I, Augustın S, Avtzıs N, Bacher S, Freıse J, Girardoz S, Guıchard S, Heitland W, Lethmayer C, Stolz M, Tomov R, Volter L, Kenis M (2010). Temporal and spatial variations in the parasitoid complex of the horse chestnut leaf miner during its invasion of Europe. Biol Invasion 12:2797–2813.

Haug G, Hoffman H (1990). Chemistry of Plant Protection 4: Synthetic Pyrethroid Insecticides: Structures and Properties. Springer-Verlag. Berlin, Heidelberg, New York.

Jones. (2003). Plant virus transmitted by whitefly. European *J. Pl. Prot.,* 109: 195-219.

Liebhold AM Tobin PC (2008). Population ecology of insect invasions and their management. Annu Rev Entomol 35:387–408.

Megido RC, Haubruge E, Verheggen FJ (2012). First evidence of deuterotokous parthenogenesis in the tomato leafminer *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) J Pest Sci 2012; 85(4): 409-412.

Mote UN (1977). Active and feeding period of onion thrips and proper time of application of endosulfan for their control. *Veg. Sci*.**,** 5(2): 143-144.

Papisarta C, Garzia GT (2002). Tomato yellow leaf curl sordinia virus and its vector *Bemisia tabaci* in Sicillia (Italy) : Present status and control possibilities *OEPP/EPPO Bull.*, 32 : 25-29.

SAS Institute (2009). The SAS system for windows, version 10.1.2. SAS, Institute, Cary, NC.

Shafiq AM, Maher AM (2016). Influence of insecticides against onion thrips, *Thrips tabaci (*Lindeman) on onion crop. *Journal of Insect Science* 29 (1): 179-185.

Worthing CR (1987). The Pesticide Manual: A World Compendium. Eighth edition. Published by The British Crop Protection Council.

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RESEARCH PAPER

Effects Blended and Urea Fertilizer rate on Yield and yield Components of Maize in Ultisols of Liben Jawi district

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Abstract

Maize is a major staple crop grown and widely consumed in western Ethiopia but it is low due to declining soil fertility and requires application of high fertilizer for optimum production. A field experiment was carried out on farmers' field to study the effect of blended NPSB and urea fertilizer rate on yield and yield components, and economics of highland maize for two consecutive cropping seasons on Ultisol of Liben Jawi district. Three rates of nitrogen (150 250 and 350 kg urea ha-1) and four rates of blended NPSB (150, 200, 250 and 300 kg NPSB ha-1) were combined in factorial arrangement forming 12 treatments and tested with negative control and recommended (119/69 kg NP ha-1). The experiment was laid out in randomized complete block design with three replications. Combined application of blended NPSB and Urea was significantly affected mean yield and yield components of maize. Significantly higher biomass and grain yield of maize were obtained with application of higher nitrogen and blended NPSB fertilizer rate. Higher mean dry biomass yield of 21333 kg ha-1 and grain yield of 6975 kg ha-1 of maize was obtained with application of 350/300 kg urea/NPSB ha-1 fertilizer rate. Application of 250/250 kg urea/NPSB ha-1 gave net return of EB 44216 and higher marginal rate return of 2036 % for highland maize production. Therefore, application of 250/250 kg urea/NPSB ha-1 fertilizer rate was recommended for highland maize production and economic return in Ultisol of Liben Jawi and similar agroecologies.

Keywords: Blended fertilizer, maize, grain yield, nitrogen

Introduction

Globally maize (Zea mays L) is one of the most versatile and multi utility crops, having wider adaptability in diverse ecologies and queen of cereals because of its highest genetic potential (Kumar et al., 2013) and it is true in Ethiopia. Maize is the most staple food and most cultivated cereal in Africa and Ethiopia in terms of land area, production and is inevitable in achieving food security in Ethiopia (Buchaillot et al. 2019; CSA, 2018, CSA, 2019; Fufa et al., 2019). It is the major source of food, feed, fodder and industrial raw material and provides enormous opportunity for crop diversification, value addition and employment generation (Kumar et al., 2013). Maize is among the most important food source for human consumption in the world and sub Sharan Africa (FAO, 2018). Maize is widely grown by farmers of rural households and some private investors in western Ethiopia and constitutes 16.79 and 18.60 % of the country total 80.71 and 81.39% grain cereal production next to teff (CSA, 2018; CSA, 2019). However, the current national maize grain yield was (3.99 t ha-1) (CSA, 2019) in Ethiopia is very low by international standards, indicating growth potential as compared to the world average (5.75 t ha-1) and southern Africa average (5.79 t ha-1) (FAOstat, 2017). The major reasons for low yield of maize in in western Ethiopia are; low soil fertility (under optimum fertilizer application, soil acidity), and use of non-optimum agronomic practices, diseases, pests and weeds. The use of chemical fertilizers particularly nitrogen for maize production is by far below the recommended rate (Aman and Tewodros, 2019). Maize grain yield can be improved by taking adaptive cultivation practices (fertilizer application, maize varieties, sowing time, sowing density and row and plant spacing) (Sileshi et al., 2010; Pasuquin et al., 2014). Furthermore, increased use of improved maize varieties and mineral fertilizers, coupled with increased extension services are the key factors promoting the accelerated growth in maize productivity in Ethiopia (Tsedeke et al., 2015).

Use of inputs is at a low level, suggesting substantial scope for raising productivity through improved seeds, and fertilizers (Alemayehu et al., 2012). Low soil fertility related mainly to continuous cropping without replenishment of depleted nutrients in SSA is the major constraints to higher crop productivity in smallholder farmers (Rusinamhodzi et al., 2011; Sanchez, 2015). Most countries in SSA applying less than 10 kg of nutrients per ha-1 sum of nitrogen, phosphorus and potassium inputs in organic and chemical fertilizers (Masso et al., 2017; Rurinda et al., 2013). Agricultural sector is expected to produce 60% more food by 2050 (Alexandratos and Bruinsma, 2012) for 9.8 billion world population. The use of fertilizers by farmers in Sub Saharan African countries has less than 10 kg ha-1 and globally the lowest fertilizer uses as compared to countries (Bationo et al., 2012). This is mainly due to high prices associated with acquiring fertilizers (Epule et al., 2015). Mismanagement of plant nutrition is considered to be the major one among different reasons for low productivity of maize production (Paramasivan et al., 2014).

Low crop yields in Sub-Saharan Africa are associated with low fertilizer use (Bonilla et al., 2020). Soil fertility varies throughout the growing season each year due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manure, compost, mulch, and lime or sulfur, in addition to leaching (Ravikumar and Somashekar, 2014). Low soil nitrogen and phosphorus as well as other unpredictable environmental factors have reduced yields at farm level (Gasura et al. 2015). Plants can take only up 30 to 40% of the applied N but over 60% of the N in the soil generally is lost by leaching, surface runoff, denitrification, volatilization, and microbial consumption (Santos et al., 2019).

Soil fertility improvement is one of the most important soil management practices determining better grain yield of maize. But the use of fertilizer could lead to an increase in crop yield in Sab Sharan Africa of about 30-50% in the next 30 years (Ciceri and Allanore, 2019). Identifying site-specific combinations of management practices that are conducive to high yields and low-risk input recommendations was crucial (Grassini et al., 2015).

Use of fertilizer has the greatest influence among all improved production technologies (Ványiné Széles et al., 2012; Crista et al., 2014) on maize yield, as its effect on yield was determined to be 31% (Berzsenyi and Győrffy, 1997) and 48% (Nagy, 2008). Application of nitrogen and phosphorus fertilizer was significantly increased mean grain and biomass yield of maize from 6.21 to 7.11 t ha-1 and 8.39 to 9.54 t ha-1 as compared to control (Muhidin et al., 2019). Application of 175-80-60 kg NPK ha-1 was produced significantly optimum yield and is appropriate and economical rate of for obtaining maximum grain yield of maize (Asghar et al., 2010). Nitrogen application significantly affected and improved mean grain yield of maize by over 57% when compared to the 0-N (Oyebiyi et al., 2019).

Currently, detailed maps of soil nutrients (including micro-nutrients) for SSA, in order to support agricultural development, intensification and monitoring of the soil resource has done for different countries including Ethiopia (Kamau and Shepherd 2012; Shepherd et al. 2015; Wild, 2016). Spatial predictions of soil macro and micro-nutrient content for Ethiopia at 250 m spatial resolution and for 0-30 cm depth was producing (Hengl et al., 2017) showed variation in deficiency different nutrient could help for blending fertilizers for each district in the region.

Currently based on map of Ethiopian Soil Information System (EthioSIS) has confirmed that several nutrients (N, P, K, S, Zn, Fe and B) other than the common (nitrogen and phosphorus) (ATA, 2013). Thus, compound fertilizer (NPS) and three blended fertilizers (NPSB, NPSZnB, and NPSZn) plus or minus potash fertilizer are needed to address the key nutrient deficiencies in the tested soils in Ethiopia (ATA, 2014). Application of 150 kg NPSB ha-1 fertilizer rate was found to be superior and economically viable for maze production in Bako area (Fufa et al., 2019).

Except the Ethio SIS map, so far there is no information or research finding on the differential of newly blended fertilizer responses to high yielding newly released maize varieties in Liben Jawi district. Knowing the contribution blended (NPSB) fertilizer rate in maximizing maize yield in the area are needed to be investigated to explore the yield potential of maize. In addition, asserting the Ethio SIS map of nutrient deficiency is very crucial for sustainable soil fertility management and maize production. Therefore, the objectives were to determine optimum blended (NPSB) and urea fertilizer rate for maize crop in Ultisol of Liben Jawi district and to assess economic benefit of blended (NPSB) and Urea fertilizers rates for maize production in Ultisol of Liben Jawi district.

Materials and Methods

The experiment was conducted on two and one farmers field in 2018/2019 and 2019/20 cropping seasons of humid highland agroecosystems of Chanchudina Masara and Liban Gamo Peasant association, Liben Jawi district, Oromia National Regional State, western Ethiopia. Farm 1, 2 and 3 lies between 8°52'0.57"N, 8°56'40.43"N and 8°52'3.36"N latitude and 37°28'8.76"E, 37°31'47.58"E and 37°28'5.43"E longitude and at an altitude of 1977, 2313 and 1983 meter above sea level in 2018/2019 and 20192020 cropping seasons. The mean annual rainfall of 1040 mm with unimodal distribution (MAARC, 2019). It has a medium cool sub-humid climate with the mean minimum, mean maximum and average air temperatures of 8.9, 27.4 and 18.1oC, respectively (MAARC, 2019). The soil type is brown clay loam Ultisol (Tolera et al., 2016).

The treatment used was three rates of urea (150 250 and 350 kg N ha-1) and four rates of blended NPSB (150, 200, 250 and 300 kg NPSB ha-1) were combined in factorial arrangement forming 12 treatments and tested with negative control and recommended (119/69 kg NP ha-1). The experiment was laid out in randomized complete block design with three replications. Maize variety (Jibat) was used. The plot size was 4.5 x 3m= 13.5m2. The spacing used was 75 x 25 cm between rows and plants. The nitrogen rates from blended fertilizer was applied at the time of planting and the remaining nitrogen rates from urea was applied in split application first at knee height of maize and the remaining half at early tasseling of maize. All other agronomic management practices were applied as per recommendation for the maize production.

Pre soil sampling was collected before planting and treatment application and analyzed for some physicochemical properties of the soil at Kulumsa and Holetta Agricultural Research Center Soil and Plant Laboratory. Determination of soil particle size distribution was carried out using the hydrometer method (Dewis and Freitas, 1984). Soil pH was measured using digital pH meter in 1:2.5 soil to solution ratio with H2O. Exchangeable basis was extracted with 1.0 Molar ammonium acetate at pH 7. Ca and Mg in the extract were measured by atomic absorption spectrophotometer while Na and K were determined using flame photometry (Van Reeuwijk, 1992).

Cation exchange capacity of the soil was determined following the modified Kjeldahl procedure (Chapman, 1965) and reported as CEC of the soil. Percent base saturation was calculated from the sum of exchangeable basis as a percent of the CEC of the soil. Exchangeable acidity was determined by extracting the soil samples with M KCL solution and titrating with sodium hydroxide as described by McLean (1965). Organic carbon was determined following wet digestion methods as described by Walkley and Black

(1934) whereas kjeldahl procedure was used for the determination of total N as described by Jackson (1958). The available P was measured by Bray II method (Bray and Kurtz, 1945).

Grain yield, dry biomass and harvest index of maize were collected at physiological maturity and harvesting. The harvested grain yield was adjusted to 12.5 % moisture level (Birru, 1979 and Nelson et al., 1985). The adjusted seed yield at 12.5 % moisture level per plot was converted to grain yield as kilogram per hectare. The collected data were analyzed using SAS 9.4 software (SAS, 2012). Mean separation was done using least significance difference (LSD) at 5 % probability level (Steel et al., 1997). The economic (partial budget) analysis was used following CIMMYT (1988). The maize grain valued at an average open market price of EB 900 per 100 kg. Labour cost for field operation was EB 60 per man-day. The yield was adjusted down by 10 % to reflect actual production conditions (CIMMYT, 1988). The cost of fertilizer Urea and Blended (NPSB) were EB 14.04 and 14.48 per 100 kg with current market price.

Results and Discussions

Soil physicochemical properties of the experimental site before planting

The soil of the experimental site was sandy clay loam for farm 1 and clay loam for farm 2 and 3 in textural distribution (Table 1). The pH of soil was 5.36, 5.64 and 5.85 found in strongly acidic in farm 1 and medium acidic in farm 2 and 3 (Table 1) (London 1991, Msanya et al., 200). The available phosphorus was ranged between 7.76 to 10.97 mg kg-1 found in medium range (London, 199; Tekalegn, 1991). The total nitrogen content was 0.18 % in farm 1, 0.26 and 0.28 % in farm 2 and farm 3 found in low and medium range (London, 199; Tekalegn, 1991). The organic carbon content of the soil range between 2.9 to 3.34 % found in high range (London, 1991; Tekalegn, 1991). The cation exchange capacity of the soil ranged between 7.98 to 12.76 cmol+ kg-1 soil found in low to medium range (London 1991; Tekalegn, 1991; Msanya et al., 200).

Table 1. Selected soil physicochemical characterization of the experimental field before planting in Liben Jawi District

Farms	pH (1:2.5 H_2O)	Available P (mg kg^{-1})	Total N (%)	OC	OM	Cation exchange capacity	Clay	Silt	Sand	Texture
				(%)		(cmol (+) kg^{-1})		%		
Farm-1	5.36	7.76	0.18	2.9	5	7.98	45	27.55	27.5	Sand clay loam
Farm-2	5.64	9.83	0.26	3.27	5.63	9.18	48	32.5	24.3	Clay loam
Farm-3	5.85	10.97	0.28	3.34	5.74	12.76	54	34.3	21.3	Clay loam

Dry biomass, Grain yield and Harvest index

Combined analysis over years and farms revealed that dry biomass yield of maize was significantly affected by application of urea and NPSB fertilize rates (Table 2). The average dry biomass of farm 2 was greater by 35.31 and 44.71 % as compared to farm 1 and 3. Higher dry biomass yield of maize was obtained with application of higher urea and blended NPSB fertilizer rate as compared to control and recommended fertilizer rate. Similarly, Asghar et al. (2010) reported that the mean biological yield of maize was significantly affected by NPK application and higher mean biological yield (16.83 t ha-1) recorded with application of 250-110-85 kg NPK ha-1 and the minimum (10.80 t ha-1) produced from control. Also, application of 100% of recommended dose of NPK fertilizer was produced higher maize biological yield (17.79 t ha-1) while lowest was observed where no NPK fertilizers was not applied (Sarwar et al. 2017). Azra et al. (2012) reported that application of NPK fertilizers increased the mean grain yield in maize. Likewise, Bakala (2018) reported that. biological yield of maize was significantly influenced by application of Blended NPSB and N fertilizer.

The mean grain yield of maize was significantly affected by application of urea and NPSB fertilize rate in three farms in 2018, 2019 cropping seasons and combined mean of three farms over years (Table 2). The average yield of farm 3 was greater by 14.99 and 3.04 % than farm 1 and 2 respectively. This might be due to variation in field management history of different farmers field for crop production in addition to management practices in the cropping season. Similarly, Fufa et al. (2019) found that maize grain yield was significantly affected by application of blended NPSB fertilizer rate and economically profitable yield was obtained with application of 150 kg NPSB ha-1 at Bako. Asghar et al. (2010) reported that the mean maize grain yield was greatly affected by different levels of NPK application and application of 250-110-85 kg NPK ha-1 produced maximum grain yield 6.03 t ha-1 and minimum from without fertilizer application. Application of 100% of recommended dose of NPK fertilizer was produced higher grain yield (6.99 t ha-1) and grain protein content (8.78%) of maize (Sarwar et al. 2017). Similarly, Sisay (2018) reported that mean grain yield of maize was highly significantly affected due to application of blended NPS fertilizer and N fertilizer rate.

The application of 350/300 kg urea/NPSB ha-1 gave significantly higher mean grain yield of maize and greater by 35.37, 13.41, 42.21 and 29.67 % as compared to recommended NP fertilizer rate in farm 1, 2, 3 and combined mean over years (Table 2). This result confirmed that the old recommended fertilizer rate before a decade should be checked and site-specific recommendation is indeed needed for better production of maize. The higher mean grain yield of maize with application of higher (350/300 kg urea/NPSB ha-1) was greater by 427, 262, 222 and 283 % in farm 1, 2, 3 and combined mean over years as compared to control (Table 2). This result suggested that farmers should apply any sources of fertilizer to produce maize. But if maize planted without any fertilizer sources it is simple loss of his labour and other inputs. Application of N fertilizer significantly increased maize yields between 0.25 and 1.6 t ha-1 (Gotosa et al., 2019). Cai et al. (2012) reported that application of higher N fertilizer is crucial to the better development of maize plant and grain yield.

Higher mean grain yield of maize was related higher rates of nitrogen fertilizer application. Likewise, Onasanya et al. (2009) also reported higher maize grain yield with increase in N rates. Mupangwa et al. (2019) found that application of 90 kg N ha-1 had produced higher mean grain yield of maize as compared with 0 and 30 kg N ha-1 in all three cropping seasons in conservation agriculture-based cropping systems of Southern Africa.

Application of increasing rate of N fertilizer could increase the mean grain yield and higher grain yield of (8.8 t ha-1) obtained with 240 kg N ha-1 as compared to rates between 120-200 kg N ha-1 (Sapkota et al., 2017). Tesfaye et al. (2019) reported that the mean grain yield response for nitrogen fertilizer application of maize was ranged from 2657 to 4266 kg ha-1 in 2015 and from 3648 to 5454 kg ha-1 in 2016 in high rainfall areas, while it ranged from 383 to 1513 kg ha-1 in 2015 and from 1500 to 3310 kg ha-1 in 2016 in moisture stress areas.

The harvest index of maize was significantly ($P<0.05$) affected by application of urea and blended NPSB fertilizer rates (Table 2). Significantly higher harvest index of maize 57.92, 31.24, and 43.10 % were obtained from application recommended 200/150 kg urea/DAP ha-1 in farm 1, 2 and combined over three farms while for farm 3 harvest index of 41.49 % was obtained from application 350/300 Urea/NPSB ha-1. The harvest index of maize was markedly influenced by NPK application and application of 175-80-60 kg NPK ha-1 resulted in higher harvest index of (36.47 %) as compared other treatments and minimum (30.25 %) obtained from control due to subnormal growth and development of the other yield parameters due to shortage of N (Asghar et al., 2010).

Table 2. Effects of nitrogen and blended (NPSB) fertilizer rate on dry biomass and grain yield of maize in Ultisol of Liben Jawi in 2018 and 2019 cropping season

Urea	NPSB	Dry biomass (kg ha^{-1})				Grain yield (kg ha^{-1})				Harvest Index (%)			
(kg ha^{-1})	(kg ha^{-1})	Farm 1	Farm 2	Farm3	Mean	Farm 1	Farm 2	Farm3	Mean	Farm 1	Farm 2	Farm3	Mean
		2018		2019		2018		2019		2018		2019	
150	150	13476de	20067c	13457f	15666d	4371e	5266c	5109f	4915f	32.59b	26.30bc	37.94bcd	32.28bc
150	200	17640abc	21196bc	15286cdef	18041c	5233cde	5505bc	5981cdef	5573e	29.74b	25.91bc	39.10abc	31.58bc
150	250	16716bcd	23502ab	14558def	18259c	4967de	5790abc	5432def	5396ef	29.73b	24.81c	38.28cde	30.61c
150	300	16231cd	23742ab	15563cdef	18512c	5071de	5923abc	5448def	5481ef	31.38b	25.07c	34.96e	30.47c
250	150	17809abc	21844bc	15951bcde	18535c	5687bcd	5697abc	6254bcde	5879cde	31.91b	26.11bc	39.30abc	32.44bc
250	200	18513abc	23520ab	13960ef	18665bc	5578bcd	6114abc	5481def	5724ed	30.08b	25.97bc	39.35abc	31.80bc
250	250	19529abc	25436a	17509abc	20824ab	5709bcd	6360abc	6947abc	6339bc	29.43b	25.08c	39.65abc	31.39bc
250	300	20382ab	25356a	18889a	21542a	6227ab	6201abc	6859abc	6429abc	30.81b	24.40	36.28de	30.50c
350	150	18276abc	24053ab	17143abc	19824abc	5595bcd	6437ab	6637abc	6223bcd	30.58b	26.86abc	38.73abcd	32.06bc
350	200	16533bcd	25680a	16958abcd	19724abc	4963de	6454ab	6468bcd	5962bcde	30.02b	25.16c	38.17bcd	31.12bc
350	250	19531abc	25938a	17551abc	21007a	5992abc	6473ab	7057ab	6507ab	30.52b	25.00c	40.18ab	31.90bc
350	300	20920a	24653ab	18425ab	21333a	6644a	6655a	7624a	6975a	31.76b	27.09abc	41.49a	33.44bc
200	150	10142e	19156c	13338f	14212d	4908de	5868abc	5361ef	5379ef	57.92a	31.24a	40.15ab	43.10a
0	0	3502f	5996d	5733g	5077e	1260f	1839d	2371g	1823g	35.06b	30.71ab	41.39a	35.72b
LSD (5%)		3936	3055.5	2478	2187.8	920.61	972.48	1028	595.27	13.89	4.3942	2.87	5.084
CV (%)		14.33	8.22	9.65	13.05	10.64	10.07	10.33	11.35	25.11	9.91	4.26	16.62

Means followed by different letter(s) in a column and rows are significant at 5% level of Probability

Table 3. Effects of Urea and blended NPSB fertilizer rate on economic profitability of highland of maize production in Ultisol of Liben Jawi

Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Grain yield (kg ha^{-1})	Adjusted Grain yield (kg ha^{-1})	Gross field benefit (EB ha^{-1})	Urea cost (EB ha^{-1})	NPSB cost (EB ha^{-1})	TCV (EB ha-1)	Net benefit (EB ha^{-1})	Value to cost ratio	MRR (%)
0	0	1823	1641	14766	0	0	0	14766		
150	150	4915	4424	39812	2106	2172	4278	35534	8.31	485
200	150	5379	4841	43570	2808	2172	4980	38590	7.75	435
150	200	5573	5016	45141	2106	2896	5002	40139	8.02	7041
250	150	5879	5291	47620	3510	2172	5682	41938	7.38	265
150	250	5396	4856	43708	2106	3620	5726	37982D	6.63	
250	200	5724	5152	46364	3510	2896	6406	39958D	6.24	
150	300	5481	4933	44396	2106	4344	6450	37946D	5.88	
350	150	6223	5601	50406	4914	2172	7086	43320	6.11	98
250	250	6339	5705	51346	3510	3620	7130	44216	6.20	2036
350	200	5962	5366	48292	4914	2896	7810	40482D	5.18	
250	300	6429	5786	52075	3510	4344	7854	44221	5.63	1
350	250	6507	5856	52707	4914	3620	8534	44173D	5.18	
350	300	6975	6278	56498	4914	4344	9258	47240	5.10	215

D = Dominated and Price of urea and NPSB 14.004 and 14.48 EB kg-1 grain price = 9 EB kg-1

Similarly, Sarwar et al. (2017) reported that application of 100% of recommended dose of NPK fertilizer was produced maximum harvest index (39.37%) of maize. Likewise, Anwar et al. (2017) reported that significant increments in harvest index of maize 33.70 to 36.80 and 40.20 with increasing N rate from 0 to 75 and 150 kg N ha-1 respectively.

Higher harvest index from application of maximum N fertilizer rate and minimum from minimum N application rates (Aghdam et al., 2014; Sharifi and Namvar, 2016). Similarly, Jat et al. (2010) reported that higher mean harvest index of 42.40% and 42.60% were obtained with application of 120 kg N ha-1 as compared to 60 kg N ha-1 (41.80 and 41.90%) and control (40.60 and 40.60%) in 2006 and 2007 cropping seasons. Also, Also, Sisay (2018) found that harvest index of maize was significantly affected by application of blended NPS and N fertilizer rates and significantly higher highest harvest index (54.12%) was recorded from application of blended 182 kg NPS ha-1 and 124.8 kg N ha-1 fertilizer rates and lowest from control.

Economic viability of urea and blended fertilizer application on highland maize production

The partial budget analysis due to integrated use of Urea and blended NPSB fertilizer rate is indicated in Table 3. The highest net return of EB 47240 ha-1 with marginal rate return of 215 % and values to cost ratio of EB 5.10 profit per unit investment for maize production in Ultisol of Liben Jawi was recorded from application of 350/300 kg urea/NPSB ha-1, followed by net return of EB 44216 and marginal rate return of 2036 % with values to cost ratio of EB 6.28 from application of 250/250 kg urea/NPSB ha-1 fertilizer rate (Table 3). Similarly, Tamado and Moges (2015) reported that higher net benefit was obtained from higher N rate application. Begizew (2018) also reported that the highest net return EB 46592 ha-1 was obtained from application of 115 kg N ha-1 followed by 92 kg N ha-1. Likewise, Bakala (2018) reported that application of 150 kg NPSB + 110.8N kg ha-1 had the highest net benefit of EB 32321 ha-1. Muhidin et al. (2019) reported that application 138/104 NP kg ha-1 fertilizer rates gave the highest net benefit EB 21,445 ha-1 with marginal rate of return 120% was recommended for maize production in Omonada. The value to cost ratio was ranged from 5.10 to 8.31 profit per unit investment for maize production in Liben Jawi distirct with application urea and blended NPSB fertilizer rate. The highest marginal rate of return of 7041 % was obtained with application of 150/200 kg urea/NPSB ha-1 fertilizer rate. Therefore, application of 250/250 kg urea/NPSB ha-1 fertilizer rate was recommended for better highland maize production and economic return in Ultisol of Liben Jawi, West Showa.

Conclusion

Application of integrated use of urea and blended NPSB fertilizer rate were significantly affected yield and yield components of highland maize. Significantly higher maize grain yield of 6975 kg ha-1 was obtained with application of 350/300 kg urea/NPSB ha-1 followed by 350/250 kg urea/NPSB ha-1 application with grain yield of 6507 kg ha-1. Application of 350/300 kg urea/NPSBha-1 gave the highest net return of EB 47240 ha-1 with marginal rate return of 215 % and values to cost ratio of EB 5.10 profit per unit investment for maize production in Ultisol of Liben Jawi district. Therefore, application of 250/250 kg urea/NPSB ha-1 was produced better grain yield and economical feasible and recommended for highland maize production in Ultisol of Liben Jawi and similar agro-ecologies in western Oromia.

References

Aghdam, S.M., Yeganehpoor, F., Kahrariyan, B. and Shabani, E. (2014). Effect of different urea levels on yield and yield components of corn 704. I. J. Adv. Biol. Biomedical Res., 2(2):.300-305.

Alemayehu Seyoum, Dorosh, P. and Sinafikeh Asrat. (2012). Crop Production in Ethiopia: Regional Patterns and Trends. Ethiopia Strategy Support Program (ESSP II). International Food Policy Research

Institute. Ethiopian Development Research Institute. Research Note 11. Summary of ESSP II Working Paper 16. 2pp.

Alexandratos, N. and Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision. ESA Working paper Rome, FAO.

Aman Tufa and Tewodros Tefera. (2019). Exploring the Drivers of Maize Technologies Adoption Intensity: Empirical Evidence of Smallholders in SNNRP Region, Ethiopia". EC Agri., 5 (2): 113-118.

Anwar, S., Ullah, W., Islam, M., Shafi, M., Iqbal, A. and Alamzeb, M. (2017). Effect of nitrogen rates and application times on growth and yield of maize (Zea mays L.). Pure and Applied Biol., 6(3): 908-916.

Asghar, A., Ali, A., Syed, W.H., Asif, M., Khaliq, T. and Abid, A. A. (2010). Growth and Yield of Maize (Zea mays L.) Cultivars Affected by NPK Application in Different Proportion, Pakistan J. of Sci., 62 (4): 211-216.

ATA. (2013). Survey of NARS researchers conducted in 2012

ATA. (2014). Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia. Ethiopian Agricultural Transformation Agency (ATA), A.A., Ethiopia.

Bakala Anbessa. (2018). Soil Characterization and Response of Maize (Zea mays L.) to Application of Blended Fertilizer Types and Rates in Asossa District, Western Ethiopia. M.Sc Thesis. Hawassa University. 117 pp.

Bationo, A., Hartemink, A., Lungu, O., Naimi, M., Okoth, P., Smaling, E., Thiombiano, L. and Waswa, B. (2012). Knowing the African soils to improve fertilizer recommendations. pp. 19-42. In: Improving Soil Fertility Recommendations in Africa Using the Decision Support System for Agrotechnology Transfer (DSSAT), Springer: Dordrecht, The Netherlands.

Begizew Golla. (2018). Effect of Nitrogen Rate and Intra-Row Spacing on Yield and Yield Components of Maize (Zea mays L.) at Bako, Western Ethiopia. M.Sc Thesis. Jimma University. 88pp.

Berzsenyi, Z. and Győrffy, B. (1997). Effect of crop rotation and fertilization on maize and wheat yields and yield stability in long-term experiments. Agrokémia és Talajtan., 46: 77-98.

Bonilla C. C., Chamberlin, J., Guo, Z. and Hijmans, R.J. (2020). Spatial variation in fertilizer prices in Sub-Saharan Africa. PLoSONE. 15(1): e0227764.

Birru, A. (1979). Agricultural Field Experiment Management Manual Part III. IAR (Institute of Agricultural Research). Addis Ababa, Ethiopia. pp. 35-42.

Bray, H.R. and Kurtz, L.T. (1945). Determination of organic and available forms of phosphorus in soils. Soil Sci., 9: 39-46.

Buchaillot, Ma. L., Gracia-Romero, A., Vergara-Diaz, O. Zaman-Allah, M. A., Tarekegne, A. Cairns, J. E., Prasanna, B. M., Araus, J. L. and Kefauver S. C. (2019). Evaluating Maize Genotype Performance under Low Nitrogen Conditions Using RGB UAV Phenotyping Techniques. Sensors., 19(1815): 2-27.

Cai, H., Chu, Q., Gu, R., Yuan, L., Liu, J., Zhang, X., Chen, F., Mi, G. and Zhang, F. (2012). Identification of QTLs for plant height, ear height and grain yield in maize (Zea mays L.) in response to nitrogen and phosphorus supply. Plant Breeding., 131: 502-510.

Chapman, H.D. (1965). Cation exchange capacity by ammonium saturation. pp. 891- 901. In: Black, CA. (Ed.) Methods of Soil Analysis. Agronomy part II, No. 9, American Society of Agronomy, Madison, Wisconsin, USA.

Ciceri, D. and Allanore, A. (2019). Local fertilizers to achieve food self-sufficiency in Africa. Sci. Total Environ., 648: 669-680.

Crista, F.M., Boldea, M., Radulov, I., Lato, A., Crista, L., Dragomir, C., Berbecea, A., Nita, L. and Okros, A. (2014). The impact of chemical fertilization on maize yield. Res. J. Agri. Sci., 46: 172-177.

CIMMYT. (1988). From agronomic Data to Farmer Recommendations: Economics

Training Manual. Completely Revised Edition. Mexico, D. F.81pp.

CSA. (2018). Agricultural Sample Survey 2017/18 (2010 E.C.). Report on Area and Production of Major Crops Volume I. Statistical Bulletin 586. Addis Ababa, Ethiopia.

CSA. (2019). Area and production of major crops. Agricultural Sample Survey 2018/19 (2011 E.C.). V1. Statistical Bulletin. 589. Addis Ababa, Ethiopia.

Dewis, J. and Freitas, F. (1984). Physical and chemical methods of soil and water analysis. FAO Soil Bulletin No. 10. FAO, Rome. 275 pp.

Epule, E.T. Bryant, C.R., Akkari, C. and Daouda, O. (2015). Can organic fertilizers set the pace for a greener arable agricultural revolution in Africa? Analysis, synthesis and way forward. Land Use Policy., 47: 179-187.

FAOstat. (2017). Food and Agriculture Organization Statistics Data Base, Agricultural production indices. FAO, Rome, Italy.

FAO. (2018). World Food and Agriculture: Statistical Pocketbook 2018. Rome. Licence: CC BY-NC-SA 3.0 IGO. 254 pp.

Fufa Anbessa, Thomas Abraham and Habtamu Ashagre. (2019). Influence of Plant Population and NPSB Blended Fertilizer Rates on Yield Parameters and Yield of Maize (Zea mays L.) in Bako, Ethiopia. I. J. of Agri. Envi. and Biote., 12(4): 345-349.

Gasura, E., Setimela, P.S. and Souta, C. M. (2015). Evaluation of the performance of sorghum genotypes using GGE biplot. Canadian J. Plant Sci., 95(6):1205-1214.

Gotosa, J., Kodzwa, J., Nyamangara, J. and Gwenzi, W. (2019). Effect of Nitrogen Fertiliser Application on Maize Yield Across Agro Ecological Regions and Soil Types in Zimbabwe: A Meta analysis Approach. I. J. of Plant Production, https://doi.org/10.1007/ s42106-019-00045-9.

Grassini, P., van Bussel, L.G.J., Van Wart, J., Wolf, J., Claessens, L., Yang, H., Boogaard, H., de Groote, H., van Ittersum, M.K. and Cassman, K.G. (2015). How good is good enough? Data requirements for reliable crop yield simulations and yield-gap analysis. Field Crops Res., 177: 49-63.

Hengl, T., Leenaars. J. G. B. Shepherd. K. D., Walsh, M. G... Heuvelink, G. B. M., Tekalign Mamo. Helina Tilahun. Ezra Berkhout, Cooper, M., Fegraus, E., Wheeler, I. and Kwabena, N.A. (2017). Soil nutrient maps of Sub-Saharan Africa: assessment of soil nutrient content at 250 m spatial resolution using machine learning. Nut. Cycl. Agroecosy. 109:77-102. DOI 10.1007/s10705-017-9870-x.

Jackson, M.L. (1958). Soil chemical analysis. pp. 183-204. Prentice Hall, Inc., Engle Wood Cliffs. New Jersey.

Jat, N.K., Kumar, A. and Dhar, S. (2010). Influence of Sesbania green manure with or without wheat residues and N fertilization on maize-wheat cropping system. Indian J. of Agron., 55 (4): 253-258.

Kamau, M. and Shepherd, K. (2012). Mineralogy of Africa's soils as a predictor of soil fertility. In: RUFORUM third biennial conference, 24–28 September 2012, Entebbe, Uganda.

Kumar, A., Jat, S. L., Kumar, R. and Yadav, O. P. (2013). Directorate of Maize Research, Pusa Campus, New Delhi- 110 012, 123p.

Landon, J.R. (Ed) (1991) Booker Tropical soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. John Wiley and Sons, Inc., New York. 474pp.

MAARC. (2019). Meteorological data of Ambo area for 1975-2019. Ambo, Oromia, Ethiopia.

Masso, C., Baijukya, F., Ebanyat, P., Bouaziz, S., Wendt, J., Bekunda, M. and Vanlauwe, B. (2017). Dilemma of nitrogen management for future food security in sub-Saharan Africa–a review. Soil Res., 55: 425-434.

McLean, E.O. (1965). Aluminum. pp. 978-998. In Black, CA. (Ed.). Methods of Soil Analysis. Agronomy No. 9. Part II. American Society of Agronomy Madison, Wisconsin. USA.

Msanya B.M., Kimaro, D.N., Mbogoni, J.D.J and Kimbi, G.G. (2000). Soils and Land

Resources Report of Morogoro Urban District, Tanzania. Sokoine University of Agriculture, Faculty of Agriculture, Department of Soil Science, Morogoro, Tanzania. Ministry of Agriculture, ARI-Mlingano, National Soil Service, Tanga, Tanzania.

Muhidin Biya, Sisay Gurmu and Eshetu Yadete. (2019). Determination of NP Fertilizer Requirement for Newly Released Medium Maturing Maize Varieties at Jimma Zone, Southwestern Ethiopia. I. J. of Res. Studies in Sci. Engin. and Tech., 6 (12): 13-19.

Mupangwa, W, Thierfelder, C., Cheesman, S., Nyagumbo, I., Muoni, T., Mhlanga, B., Mwila, M., Sida, T.S. and Ngwira, A. (2019). Effects of maize residue and mineral nitrogen applications on maize yield in conservation agriculture- based cropping systems of Southern Africa. Renewable Agri. and Food Syst., 1–14.

Nagy, J. (2008). Maize production: Food, bioenergy, forage. Akadémiai Kiadó, Budapest.

Nelson, L.A., Voss, R.D. and Pesek, J. (1985). Agronomic and statistical evaluation of fertilizer response. 89 pp.

Onasanya, R.O., Aiyelari, O.P., Onasanya, A.S., Oikeh, F.E. and Oyelakin, O.O. (2009). Growth and Yield Response of Maize (Zea mays L.) to Different Rates of Nitrogen and Phosphorus Fertilizers in Southern Nigeria. World J. of Agri. Sci., 5(4): 400-407.

Oyebiyi F.B., Aula, L., Omara, P., Nambi, E. Dhillon, J.S. and Raun, W.R. (2019). Maize (Zea mays L.) Grain Yield Response to Methods of Nitrogen Fertilization. Commun. Soil Sci. and Plant Analysis., 50(21):2694-2700.

Paramasivan, M., Kumaresan, K. R. Malarvizhi, P. and Velayudham, K. (2014). Effect of different levels of NPK and Zn on yield and nutrient uptake by hybrid maize (COHM%) in Pilamedu and Aplaviduthi series of Tamil Nadu. Madras Agri. J., 98 (10-12): 334-338.

Pasuquin, J.M., Pampolino, M.F., Witt, C., Dobermann, A., Oberthur, T., Fisher, M.J. and Inubushi, K. (2014). Closing yield gaps in maize production in Southeast Asia through site-specific nutrient management. Field Crops Res., 156: 219-230.

Ravikumar, P. and Somashekar, R. K. (2014). Spatial distribution of macronutrients in soils of Markandeya river basin, Belgaum (d), Karnataka(s), India. Proceedings of the I. Academy of Ecology and Environ., 4(2): 81-94.

Rurinda, J., Mapfumo, P., van Wijk, M.T., Mtambanengwe, F., Rufino, M.C., Chikowo, R. and Giller, K.E. (2013). Managing soil fertility to adapt to rainfall variability in smallholder cropping systems in Zimbabwe. Field Crop Res., 154: 211-225.

Rusinamhodzi, L., Corbeels, M., van Wijk, M.T., Rufino, M.C., Nyamangara, J. and Giller, K.E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. Agron. Sust. Devel., 31(4):657-673.

Sanchez, P.A. (2015). En route to plentiful food production in Africa. Native Plants, 1: 14014.

Santos, Ad., Amaral Ju´ nior, A.Td., Fritsche-Neto, R., Kamphorst,I S. H., Ferreira, F.R.A., IFrancisco, J., Amaral3, Td., Vivas, J.M.S., Diniz Santos, P. H.A., Lima, V.J., Khan, S., Schmitt, K.F.M., Leite, J. T., Junior, D. Rd. S., Bispo, R. B., Santos,Td. O., Oliveira, U.Ad., uimarães, ID L. J.M. and Rodriguez, R. (2019). Relative importance of gene effects for nitrogen-use efficiency in popcorn. PLoSONE. 14 (9): e0222726.

Sapkota, A., Shrestha, R. K. and Chalise, D. (2017). Response of Maize to the Soil Application of Nitrogen and Phosphorous Fertilizers. I.J. of Applied sci. and Biot., 5(4): 537-541.

Sarwar, M.A., Tahir, M., Ali, A., Hussain, M., Anwar, M.W., Abuzar, M.K. and Ahmad, I. 2017. Evaluating green manuring of moringa and Jantar along with inorganic fertilizers to enhance the yield and quality attributes of autumn maize (Zea mays L.). Pakistan J. of Agri. Res, 30(4): 356-362.

SAS. (2012). SAS/STAT Software Syntax, Version 9.4. SAS Institute, Cary, NC. USA.

Sharifi, R.S. and Namvar, A. (2016). Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (Zea mays L.). Biologija, 62(1):10-18.

Shepherd, K.D., Shepherd, G. and Walsh, M.G. (2015). Land health surveillance and response: a framework for evidence-informed land management. Agric Syst 132:93-106.

Sileshi, G., Akinnifesi, F.K., Debusho, L.K., Beedy, T., Ajayi, O.C. and Mong, O.S. (2010). Variation in maize yield gaps with plant nutrient inputs, soil type and climate across sub-Saharan Africa. Field Crops Res. 116: 1-13.

Sisay Gurmu. (2018). Effect of Blended NPS Fertilizer and Compost on Growth and Yield of Quality Protein Maize (Zea mays L.) at Jimma, Southwestern Ethiopia. M.Sc Thesis. Jimma University. 115pp.

Steel, R.G.D., Torrie, J.H. and Dicky, D.A. (1997). Principles and Procedures of Statistics, A Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York, 352-358.

Tamado Tana and Moges Assefa. (2015). Effect of Nitrogen Fertilizer Rates and Plant Densities on Yield and Yield Related Traits of Maize (Zea maize L.) Under Irrigation in Southern Tigray, Ethiopia.

Tekalign Tadesse. (1991). Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.

Tsedeke Abate, Bekele Shiferaw, Abebe Menkir, DagneWegary, Yilma Kebede, Kindie T., Menale K., Gezahegn B., Berhanu T. and Tolera K. (2015). Factors that transformed maize productivity in Ethiopia. Food Sci. 7: 965-981.

Tesfaye B., Jairos Rurinda, Mesfin Kebede, James Mutegi, Gebresilasie Hailu, Tolcha Tufa, Tolera Abera and Tesfaye Shiferaw. (2019). Yield Response and Nutrient Use Efficiencies under Different Fertilizer Applications in Maize (Zea mays L.) In Contrasting Agro Ecosystems. I. J. of Plant and Soil Sci, 29(3): 1-19.

Tolera A., Dagne W., Ernest Semu, Msanya, B.M., Tolessa Debele and Haekoo Kim. (2016). Pedological Characterization, Fertility Status and Classification of the Soils under Maize Production of Bako Tibe and Toke Kutaye Districts of Western Showa, Ethiopia. Ethiopian J. of Applied Sci. Techn., 7 (1): 1-17.

Ványiné Széles, A., Megyes, A. and Nagy, J. (2012). Irrigation and nitrogen effects on the leaf chlorophyll content and grain yield of maize in different crop years. Agri. Water Management., 107:133-144.

Van Reeuwijk, L.P. (Ed.) (2002). Procedures for Soil Analysis. 6th Edition. Technical Paper: International Soil Reference and Information Centre, Wageningen, The Netherlands.

Walkley, A. and Black, C.A. (1934). An examination of Degtjareff method for determining soil organic matter and the proposed modification of the chromic acid titration method. Soil Sci. 37: 29-38.

Wild, S. (2016). Mapping Africa's soil microbiome. Nature, 539:152.

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RESEARCH PAPER

Effect Of Nitrogen Fertilizer Rates on Seed Yield And Oil Quality of Linseed (*Linum Usitatissimum* L.) Varieties in Welmera District, Central Highland of Ethiopia

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Abstract

Linseed (Linum usitatissimum L.) is one of the most important oilseed crop in the central highlands of Ethiopia. However, poor soil fertility management and lack of improved varieties affect its seed yield and oil quality. Therefore, an experiment was conducted to evaluate the effects of nitrogen fertilizer rates on yield, and oil quality of linseed varieties in Welmera district. The experiment was laid out in a randomized completed block design with three replications. The treatments were factorial combinations of three linseed varieties (Bekoji-14, Jeldu, and Kulumsa-1) and five rates of Nitrogen (0, 11.5, 23.0, 34.5, and 46.0 kg N ha-1). The analysis of variance showed that the main effect nitrogen and varieties significantly (P<0.05) affected seed and oil yields, oil content, and fatty acid compositions of linseed. The maximum seed yield (1508 kg ha-1) and oil yield (604.4 Lt ha-1) were recorded from 46 kg N ha-1 with Jeldu variety; while the minimum seed yield (782 kg ha-1) and oil yield (445.8 lt ha-1) were obtained from the control treatment with Bokoji-14 variety. The highest polyunsaturated fatty acids content (linolenic 56.24, oleic 19.43, and linoleic 14.37%) and the optimal range of saturated fatty acids (palmitic 5.82 and stearic 4.89%) were recorded from 46 kg N ha-1 treatment. Moreover, the partial budget analysis also indicated that the maximum net benefit 36,865birr ha-1 with MRR 1738% was obtained from 46 kg N ha-1. Therefore, farmers in the study area can be advised to use Juldu variety with 46 kg N ha-1 for better seed and oil yields with optimal fatty acid composition.

Keywords: Fatty acid, oil content, oil yield and seed yield

Introduction

Ethiopia is considered to be the secondary center of diversity, and the 7th major producer of linseed in the world (FAOSTAT, 2014). It is the second most important oil crop in the highlands of Ethiopia (Adefris *et al.*, 1992). In Ethiopia, small-scale farmers have been producing linseed organically without applying any chemicals (fertilizers, herbicides, pesticides) with minimum inputs (Adugna, 2007). This crop is used in a crop rotation of five to seven years with cereals and maize as good precursor crops (Worku *et al.*, 2012), and cultivated in areas where nigerseed and safflower are not cultivated (Geleta and Ortiz, 2013).

Linseed is used for oil production and in the food industries because of its nutritional qualities, essential polyunsaturated fatty acids and rich supply of soluble dietary fiber (Mohammadi *et al.*, 2010). It is a food and cash crop that generate revenue both in local and export markets. The industrial oil is an important ingredient in the manufacture of paints, varnishes and linoleum (Morris, 2005)

The greatest challenges of linseed production in central highland of Ethiopia include poor usage and shortage of improved varieties, poor soil fertility management and unavailability of improved agronomic practices (Abebe and Adane, 2016). For instance the production of linseed in Ethiopia in 2016/17 was about 87,911.655 tons from 80,353.74 hectares with an average productivity of 1.094 tons ha^{-1} (CSA, 2017). On the other hand, using improved varieties along with good agronomic practices gave as high as 2.2 - 3 tons ha^{-1} on research fields and some model farmers managed to produce as high as 2.0- 2.5 tons ha^{-1} with an average of 38.6 percent oil content when supported with improved seed of linseed, intensive training and close supervision (Mulusew *et al.,* 2013; KARC, 2012; Adugna *et al.,* 2004). El-Beltagi *et al*., (2011) also reported as the oil contents of linseed varieties varied with the ranging of 23- 45.7 % which are grown under diverse agro-ecological environments.

Linseed crop productivity and oil quality can be improved through the use of optimal fertilizer and identification of the most suitable variety. However, farmers usually do not apply fertilizers to linseed, rather grown on marginal lands, and priority is given to cereal and pulse crops. Absence of improved management practices, inadequate seedbed preparation and the use of half a century old nitrogen fertilizer recommendation (23 kg N ha^{-1}) are among the factors for low seed and oil yields of linseed crops. Linseed has also diverse and conflicting responses to nitrogen. Several reports indicated that it has a favorable response to nitrogen (Reta, 2015; Tanwar *et al*., 2011; Hocking, 1995) especially when soil nitrogen was low (Marchenkov *et al*., 2003). While other authors reported that linseed has a poor response to nitrogen and nitrogen had no effect on oil content (Leilah, 1993). These variable responses to nitrogen could be due to initial soil nitrogen level, soil moisture and seasons (Genene *et al.,* 2006).

According to Hiruy *et al.* (1992), 23 kg N ha^{-1} is the blanket recommendation for linseed production in the country. However, the amount of fertilizer recommended for crops should be depend on the soil fertility status, and nutrient utilization efficiency of the crops. Moreover, the dynamic nature of the soil environmental, complete removal of crop residues at harvest, and the poor soil management practices affect the efficiency of nitrogen utilization of linseed to enhance its productivity and oil quality.

Improved linseed varieties have better productivity and standard oil content compared to the local genotypes (Worku *et al*., 2012). However, their genetic potential is affected due to variation in agro-ecology, poor soil fertility and poor crop management practices. Hence, this study was undertaken to determine the optimal nitrogen fertilizer level to improve the seed and oil yields, and fatty acid compositions of linseed varieties in the study area.

Materials and methods

Description of Study Areas

The experiment was conducted in Welmera district in the central highland of Ethiopia during the main cropping season of 2017. The experiment was conducted 20 km far away from Holetta agricultural research center at $9^0$07’39’’ N latitude, $38^0$26'09" E longitude and at an altitude of about 2585 m.a.s.l. The area is characterized by a bimodal rainfall pattern and receives 100.2 mm rainfall during the short rainy season (February to April), and 963.2 mm during the long rainy season (mid-June to December) with an average monthly rainfall of 89.3 mm (HARC, 2017). The mean annual maximum and minimum temperatures were 24.1 and 6.6^0C, respectively. The preceding crop grown in the experimental field was barley.

Soil Sampling and Analysis

A composite soil samples were collected from the experimental plots in a diagonal pattern from a depth of 0-20cm before planting, and after harvest on individual plot basis. The selected physico-chemical properties like organic carbon, total nitrogen, soil pH, available phosphorus, cation exchange capacity, and soil textural analysis were undertaken using the standard procedures in Holeta Agricultural Research Center Soil Laboratory. Organic carbon (OC) content was determined by volumetric method (Walkley and Black, 1934). Total nitrogen was analyzed by Kjeldhal digestion method using sulfuric acid (Jackson, 1967). The pH of the soil was determined according to the procedure of FAO (2008), while cation exchange capacity (CEC) was measured as per Chapman, (1965). Available phosphorus was determined by the Bray II method (FAO, 2008). Particle size distribution was done by hydrometer method (FAO, 2008).

Treatments and Experimental Design

Factorial combination of three linseed varieties (Bekoji-14, Jeldu and Kulumsa-1) and five levels of nitrogen fertilizer (0, 11.5, 23, 34.5 and 46 kg ha^{-1}) were evaluated in this study. Urea (46% N kg ha^{-1}) was used as source of nitrogen. The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement with three replications. Each plot consisted of 3m x 2m ($6m^2$) and has 15 rows with inter-row space of 20 cm. Adjacent blocks and plots were separated by 1.5 and 0.4 meter distances, respectively.

Management Practices

The land was prepared with tractor using mounted mould board plough and disc harrowed to break big soil clods into small sizes. The recommended seed rate (25 kg ha^{-1}) at depth of 3 cm was seeded on the well prepared fine seedbed on 6th July 2017. Phosphorus was applied at a rate of 23 P_2O_5 kg ha^{-1} uniformly to all treatments at time of sowing, while nitrogen fertilizer was applied based on the treatment in two equal splits, *i.e.*, half was applied at sowing in furrows and the remaining half was applied at the beginning of tillering stage (36 days after sowing).

All necessary agronomic practices as required for linseed crop were carried out as per the standard procedure. Harvesting was performed at 90% physiological maturity (capsules had turned brown and seed rattled in the capsules and shaken) by hand pulling. The harvested produce was sun dried for about 20 days in open fields. Then the dried crop was threshed manually and separated into seed and straw. The seeds were cleaned and weighed for yield determination and laboratory analysis.

Data Collection Procedures

Seed yield (kgha^{-1}): dry seed yield from the net area of 5.2 m^2 of each plot was recorded at 7% moisture content and yield per plot was converted into hectare.

Percent oil content: It is the proportion of oil in the seed to total oven dried seed weight as determined by a nuclear magnetic resonance spectrometer (NMRS). In this experiment, 22 g of seeds were prepared and dried in an oven for two and half hours at 130^0C, cooled for 30 minutes. Then oil contents of seeds were determined using nuclear magnetic resonance (NMR) in Holeta Agricultural Research Center Food and Nutrition Laboratory.

Oil yield (OYH) (kgha^{-1}): The amount of oil in kilogram per hectare was obtained by multiplying the seed yield per hectare by the corresponding seed oil percentage obtained from the oil content analysis and divide by one hundred (Legesse, 2010).

$$\text{Oil yield} = \frac{\text{Seed Yield (kg/ha) x percent oil content (\%)}}{100}$$

Fatty acid profile analysis: it was analyzed using near infrared reflectance spectroscopy (NIRS) to determine the percent of fatty acids composition. The near infrared spectra was corrected with a minochromator (FOSS NIR system 500) by scanning at 1108-2492 nm spectra range with an 8 nm step and all spectra and reference data were recorded and managed with the Win ISI version II software (infra soft international port Matilda, PA, USA).

Statistical Analysis

The yield and quality parameters data were analyzed using SAS computer software version 9.0 (SAS, 2004). Differences among means were determined using the least significance difference (LSD) test at the 0.05 level of significance. Correlation analysis was carried out between seed yield, percent oil content and fatty acid profile of linseed varieties as affected by nitrogen fertilizer application.

Economic Analysis

The economic analysis was undertaken based on the partial budget analysis technique as described by CIMMYT (1988). The average yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same agronomic practices (CIMMYT, 1988). The analysis was done using the prevailing market prices for inputs at planting and for the output at the time of crop harvest. The net benefit was calculated as the difference between the gross field benefit (EB ha^{-1}) and the total variable costs (EB ha^{-1}) that varied.

Results and discussions

Selected soil physicochemical properties of the experimental site before planting

The results of soil analysis indicated that the soil of the study area had a textural class of clay with clay content (65%), silt (18.75%) and sand (16.25%) (Table 1). High clay content in the experimental site may indicate better water and nutrient holding capacity of the soil. The pH (H_2O) of the soil is 4.8, which is within the suitable range for the growth of the crop (Adugna, 2007). The pH showed a strongly acidic reaction according to the rating of Motsara and Roy (2008). The cation exchange capacity of the soil was found to be 21.56 $cmol_{(+)}$ kg^{-1}, which was in medium category (Roy *et al.*, 2006).The soil organic carbon content (1.95%) and organic matter (3.36 %),were very low, which indicates a high potential to add nitrogen through mineralization (Landon, 1991). The soil has a medium level of total nitrogen (0.25%) in the study area. The available phosphorus content was also at low level (7.48 mg/ kg) as described by Marx (1996). Hence, this indicates that there is a need to apply fertilizer in the study area for improving production and productivity of linseed.

Table 1. Selected soil physico-chemical properties of soils before planting

Soil Parameter	Value
pH	4.8
Cation exchange capacity	21.56
Total nitrogen	0.25
Available phosphorous	7.45
Organic carbon	1.95
Organic matter	3.36
Texture	
Sand	16.25
Silt	18.75
Clay	65
Textural class	**Clay**

Selected Soil Physico-chemical Properties of Experimental Soil after Harvesting

The post-harvest soil analysis indicated that total nitrogen values did not showed wide variation due to different treatment combinations (Table 2). The total nitrogen content of the soil before planting was 0.25 % and after harvesting it varied from 0.18 to 0.22 %. The highest and the lowest concentrations of total nitrogen content were observed from treatment received 46 kg N ha^{-1} and 11.5 kg N ha^{-1}, respectively. The reason for the reduction of total soil nitrogen may be due to the removal of soil N through grains and other plant parts of the crops (Reta, 2015). However, CEC of the experimental soil 21.56 cmol kg^{-1} before planting was increased to 27.43 cmol kg^{-1} after harvesting. Available phosphorous of the soil before planting was 7.45 (mg kg^{-1}), while after harvest it varied from 8.2 to 11.7 (mg kg^{-1}). The increase in phosphorous content after harvest might be due to its less accumulation in seed and straw, and to some extent this increased its unavailability in the soil. The organic carbon of the soil before planting and after harvest were 1.95 (%) and varied from 1.92 to 2.39 (%), respectively. Similarly, the soil organic matter before planting and after harvest was 3.36 (%) and varied from 3.31 to 4.12 (%), respectively (Table 2).

Table 2. Selected physico-chemical properties of the experimental soil after harvest

Soil parameter							Particle size distribution			
N (kg/ha)	pH (1:2:5 H_2O)	Av.P (mg/ kg)	Tot.N (kg ha-1)	OC (%)	OM (%)	CEC $cmol_{(+)}$/kg	Sand	Silt	Clay	Textural class
0	4.7	8.2	0.2	2.06	3.46	27.43	17.25	18.22	64.53	Clay
11.5	4.7	11.7	0.18	1.92	3.31	19.35	16.23	19.92	63.85	Clay
23	4.9	10.8	0.19	2.39	4.12	23.31	11.92	26.85	61.23	Clay
34.5	4.8	10	0.2	2.04	3.52	25.25	14.58	20.19	65.23	Clay
46	4.8	9.8	0.22	2.09	3.60	22.32	15.21	25.59	59.2	Clay

Effect of Nitrogen Fertilizer on Seed Yield and Oil quality of Linseed Varieties

The analysis of variance showed that there was a significant ($P<0.01$) effect of nitrogen level on seed yield, percent of oil content, oil yield, and linoleic fatty acid ($P<0.05$). Similarly, oil yield, palmitiec ($P<0.01$) and Oleic ($P<0.05$) fatty acids were significantly affected by the main effect of varieties. The main effects of nitrogen level and varieties significantly ($P<0.01$) affected oil yield of linseed. Similarly, the interaction effect of main factors significantly ($P<0.01$) affected seed yield of linseed (Table 3).

Table 3. Levels of significance for seed yield, oil yield and fatty acid composition of linseed as affected by nitrogen level, varieties and their interaction

Source of Variation	Mean squares								
	DF	SY	POC (%)	OLY (Lt ha^{-1})	C16:2 (%)	C18:.0 (%)	C18:1 (%)	C18:2 (%)	C18:3 (%)
Rep	2	NS	NS	NS	NS	NS	NS	NS	NS
V	2	NS	NS	**	**	NS	*	NS	NS
N	4	**	**	**	NS	NS	NS	*	NS
V*N	8	**	NS	NS	NS	NS	NS	NS	NS

Where, DF= Degree of freedom; Rep= Replication; N= Nitrogen level; V= Linseed varieties; N x V= Nitrogen and varieties interaction; SY= Seed yield; POC= percent of oil content; OLY= Oil yield; C16:2= Palmitiec fatty acid; C18:0 = Stearic fatty acid; C18:1 Oleic fatty acid; C18:2 = Linoleic fatty acid; C18:3= Linoliniec fatty acid.

Seed yield

The interaction effect of nitrogen and varieties significantly (P<0.05) influenced seed yield of linseed (Table 4). The highest seed yields (1508 and 1423 kg ha^{-1}) were recorded from the 46 kg N ha^{-1} and 34.5 kg N ha^{-1} with Jeldu variety, respectively. However, the minimum seed yield was recorded from no nitrogen application with Kulumsa-1 (781.9 kg ha^{-1}), Bokoji-14 (833 kg ha^{-1}) and Jeldu (1040 kg ha^{-1}). Thus, application of 46 kg N ha^{-1} had about 92.8% more than the yield advantage than the control treatment. This increase in yield could be the synergetic effect of N fertilizer and the suitability of the improved linseed variety to the growing agro-ecology. Similarly, Reta (2015) reported that nitrogen fertilizer level and improved varieties had a synergetic effect on yield and oil quality of linseed.

Table 4. Interaction effect of nitrogen fertilizer levels and linseed varieties on seed yield (kg ha^{-1}) in Wolmera district

	Varieties			
N (kg ha^{-1})	Bokoji-14	Jeldu	Kulumsa-1	Mean
0	833^{gh}	1040^{cd}	782^{h}	889
11.5	916^{efg}	1327^{b}	893^{fgh}	1045
23	1017^{cde}	1347^{b}	987^{def}	1117
34.5	1312^{b}	1423^{ab}	1109^{c}	1312
46	1365^{b}	1508^{a}	1247^{b}	1427
Mean	10886	1329	1004	
LSD (5%)= 121		CV (%)= 5.3		

Means in rows and columns followed by the same letter are not significantly different at P > 0.05 levels of significance

Seed oil content

The percent seed oil content of linseed was significantly (P<0.01) influenced by the main effect of nitrogen fertilizer levels, however it was not affected by the main effect of varieties and their interactions (Table 5). Increase the levels of nitrogen from zero to 46 kg ha^{-1} significantly reduced percent seed oil content except 11.5kg N ha^{-1}. The lowest percent seed oil content (35%) was recorded from 46 kg ha^{-1}, while the highest seed oil content (36.5%) was recorded from the control treatments. The decrease in oil content with high nitrogen availability could be due to the dilution effect of oil in heavier seeds produced under higher nitrogen. An increase in nitrogen levels promotes protein and starch contents in the seed, which dilute the percent oil content (Sharma *et al.* 2007). Similar, result was reported by Tanwar *et al*. (2011) who obtained the highest oil content from lowest dose of nitrogen levels. Nykter and Kymäläinen, (2006) also reported that the linseed oil content ranged from 26-45%. With regard to varieties, the lowest (35.8 %) and the highest (36.7%) oil content were recorded from Kulumsa-1 and Bokoji-14 varieties, respectively. Linseed has high oil content (20-40%) depending on the varieties (Pali and Mehta, 2014).

Table 5. Main effect of nitrogen fertilizer levels and linseed varieties on percent oil content and seed oil yield of linseed at Wolmera district in 2017 cropping season

Treatment	Seed oil content (%)	Seed oil yield (Lt ha^{-1})
Varieties		
Bokoji-14	36.7	517.9^{b}
Jeldu	36.4	579.7^{a}
Kulumsa-1	35.8	481.3^{c}
LSD (5%)	NS	34.9
N (kg/ha)		
0	36.5^{a}	445.8^{d}
11.5	36.0^{ab}	469.6^{cd}
23	35.9^{b}	509.7^{c}
34.5	35.6^{bc}	561.1^{b}
46	35.2^{c}	604.4^{a}
LSD (5%)	0.6	37.6
CV (%)	1.7	9.1

Means in the columns followed by the same letter are not significantly different at $p < 0.05$ levels

Seed oil yield

The oil yield of linseed was significantly (P<0.01) influenced by the main effect of nitrogen and varieties, however it was not significantly affected by their interaction (Table 5). An increase in the levels of nitrogen fertilizer significantly increased the seed oil yield. The maximum (604 Lt ha^{-1}) and minimum (446 Lt ha^{-1}) seed oil yields of linseed were obtained from 46 kg N ha^{-1} and control treatments, respectively. The oil yield obtained from 46 kg N ha^{-1} treatment exceeds by 35.6% over the control. This result agreed with Ozer *et al.* (2004) and Aglave *et al.* (2009) who found increased seed oil yield in response to increasing rate of nitrogen. Cheema *et al.* (2001) and Poonia (2003) also reported the role of nitrogen fertilizer to enhance the seed and oil yields of linseed. In the case of varieties the maximum oil yield (580 Lt ha^{-1}) and the minimum oil yield (481 Lt ha^{-1}) of linseed were obtained from Jeldu and Kulumsa-1 varieties, respectively (Table 5). This showed the existence of genetic variability among varieties in their seed oil yield.

Effect of Nitrogen Fertilizer Levels on Fatty Acid Composition of Linseed Varieties

Palmitic and Stearic fatty acids composition

The analysis of variance showed that the palmitic fatty acid composition of linseed was significantly (P<0.01) influenced only by the main effect of varieties, however it was not affected by nitrogen fertilizer level and main factors interaction (Table 6). The maximum (6.1 %) and minimum (5.6 %) percent of palmitic fatty acid composition of linseed were obtained from Jeldu and Kulumsa-1 varieties, respectively. This difference in palmitic fatty acid could be due to the genetic variability of varieties. This is in agreement with Pali and Mehta (2014) who reported the range of palmitic fatty acid in linseed (5.0 - 9.9 %).

The stearic fatty acid composition of linseed was not influenced by the main effect of nitrogen and varieties, as well as by their interaction (Table 6). Increasing the amount of nitrogen from zero to 46 kg ha^{-1} increased the percent stearic fatty acid composition of linseed numerically but it was not statistically significant. Similarly, Gambus *et al.* (2003) reported that linseed oil contains from 4 to 5.4% stearic acid. Pali and Mehta (2014) also stated that stearic acid of linseed ranged from 1.3-7.6 % depending of varieties and soil fertility. Hence, the result of this study is in line with the range of stearic fatty acids of other studies.

Oleic (C18:1) fatty acid composition

The oleic fatty acid composition of linseed was significantly (P<0.05) affected by the main factor of varieties and nitrogen fertilizer level, however not affected by their interaction (Table 6). The highest (19.6 %) and the lowest (18.6 %) percent of oleic fatty acid composition of linseed were obtained from Jeldu and Bokoji-14 varieties, respectively. The varietal difference in oleic fatty acid composition could be due to their inherent characteristics. Pali and Mehta, (2014) also reported that the oleic fatty acid content in linseed genotypes differ and ranged from 13.3 - 35%. As nitrogen level increased from zero to the highest level, it increased percent of oleic fatty acid significantly (Table 6). Accordingly, oleic fatty acid obtained from 46 kg Nha^{-1} was statistically comparable with 23 and 34.5 kg N ha^{-1}, and significantly superior from the control treatment. This result is in agreement with Klimek *et al.,* (2013) who reported that increasing the levels of mineral fertilizer increased the content of oleic fatty acids. Linseed oil contains approximately 15-21% oleic acid (Hume, 1982).

Table 6. Main effect of nitrogen fertilizer levels and varieties on fatty acid composition of linseed at Wolmera district in 2017 cropping season

Treatment	Fatty acids (%)				
	Unsaturated fatty acid		Saturated fatty acid		
	Palmitic	Stearic	Oleic	Linoleic	Linoliniec
Varieties					
Bokoji-14	5.8[b]	4.8	18.6[b]	14.2	56.2
Jeldu	6.1[a]	4.9	19.6[a]	14.2	55.6
Kulumsa-1	5.6[b]	4.9	18.7[b]	14.3	55.8
LSD (5%)	0.2	NS	0.6	NS	NS
N (kg/ha)					
0	5.93	4.83	18.48[b]	14.12[b]	55.49
11.5	5.92	4.84	18.57[b]	14.17[ab]	55.64
23	5.92	4.87	19.02[ab]	14.26[ab]	55.79
34.5	5.86	4.88	19.22[ab]	14.32[ab]	56.12
46	5.82	4.89	19.43[a]	14.37[a]	56.24
LSD (5%)	NS	NS	0.8	0.23	NS
CV (%)	3.5	3.0	4.4	1.7	1.8

Means in columns followed by the same letter are not significantly different at p < 0.05 levels

Linoleic (C18:2) and Linolineic (C18:3) fatty acids composition

The analysis of variance indicated that percent of linoleic fatty acid composition of linseed was significantly (P<0.05) influenced by the main effect of nitrogen, while varieties and the interaction of main factors didn't affected linoleic fatty acid composition (Table 6). As the level of nitrogen fertilizer increased from 11.5 to 46 kg ha^{-1} the percent of linoleic fatty acid did not showed significant differences (Table 6). However, the highest (14.37%) and the lowest (14.12%) linoleic fatty acid compositions were recorded from 46 kg ha^{-1} and control treatments, respectively. An increase in nitrogen fertilizer per plant and unit area leads to increases in the amounts of linoleic acids (Abramovic and Abram, 2005). The result of this study was in agreement with Hosseinian (2004) who reported that the content of linoleic fatty acid of linseed ranged from 11.18 - 16.13%. Similarly,Pali and Mehta (2014) reported that the values of linoleic acids ranged 10.4 - 20.9 % for linseed.

The linolineic fatty acid composition of linseed was not significantly influenced by the main factors of varieties and nitrogen fertilizer levels and their interaction (Table 6). In this study the content of linolineic fatty acid composition ranged from 55.49 to 56.24 %, and it was at optimal range. Similarly, Pali and Mehta (2014) reported that the values of alpha-linolenic acids in linseed range (33.1 to 63.1%).

The Relationship between Oil Yield with Seed Yield and Fatty Acid Composition

Seed oil yield had highly significant positive correlation with seed yield (0.99**), palmitic fatty acid (0.56**), stearic fatty acid (0.44**), and oleic fatty acid (0.62**) (Table 7). Hence, oil yield of linseed can be enhanced through improvement of seed yield, and this also contributes to improve the fatty acids components. However, positive correlation was not established between seed yield and oil content of the seed. The negative correlation between seed yield and seed oil content observed in this study could be the decrease in seed oil content as seed yield increased with application of nitrogen fertilizer.

Table 7. Linear correlation coefficients (r) among yield and percent oil content and fatty acid related traits of linseed.

	SY	OC	OY	PA	SA	OA	LA
SY	1						
OC	-0.26*	1					
OY	0.99**	-0.18ns	1				
PA	0.52**	0.32*	0.56*	1			
SA	0.4**	0.48**	0.44**	0.82**	1		
OA	0.6**	0.12ns	0.62**	0.76**	0.76**	1	
LA	0.29**	-0.07ns	0.29**	0.24*	0.17ns	0.33**	1
LNA	-0.4**	-0.47**	-0.45**	-0.75**	-0.87**	1-081	-0.32**

Where, SY= Seed yield ha^{-1}; OC= percent oil content; OY= seed oil yield ha^{-1}; PA= Palmitic fatty acid; SA= Stearic fatty acid; OA = Oleic fatty acid; LA= Linoleic fatty acid; LNA=Linoliniec fatty acid.

Effects of Nitrogen Fertilizer levels on Economic Feasibility for Linseed Production

The partial budget analysis indicated that the highest net benefit ETB 36865 ha^{-1} with marginal rate return 1738% was recorded from treatment that received 46 kg N ha^{-1} (Table 8). While the lowest net economic return ETB 23890 ha^{-1} was recorded from no nitrogen fertilizer application (Table 8). Therefore, application of 46 kg N ha^{-1} was more profitable than the rest of treatment combinations on farmer field for linseed crop production.

Table 8. Partial budget analysis of different nitrogen levels and linseed varieties under on farm condition

Nitrogen (kg ha^{-1})	Average Seed Yield (kg ha^{-1})	Adjusted Seed yield (kg ha^{-1})	Gross Benefit (ETB ha^{-1})	Total Variable cost (ETB ha^{-1})	Net Benefit (ETB ha^{-1})	MRR (%)
0	885	796	23890	0	23890	0
11.5	1045	940	28210	799	27463	447
23	1130	1017	30520	1436	29187	271
34.5	1109	998	29940	1582	28365^{D}	-
46	1427	1284	38530	2071	36865	1738

Cost of linseed grain = 30ETB kg^{-1}, Urea = 10.9 ETB kg^{-1}, TSP = 13.9 ETB kg^{-1}, Man-day= 32 ETB

Conclusion and recommendation

This experiment has clearly demonstrated that nitrogen had significant effects on seed yield, oil content and fatty acid composition of linseed varieties. The optimum oil yield and percent of fatty acid compositions were obtained in response to application of 46 kg ha^{-1} nitrogen in the study area. The maximum seed (1508 kg ha^{-1}) and oil (604.4 Lt ha^{-1}) yields were recorded from 46 kg N ha^{-1} with Jeldu variety. The fatty acid composition of linseed oil had high level of unsaturated fatty acid such as linolenic (56.24%), oleic (19.43%) and linoleic (14.37%) fatty acids from 46 kg N ha^{-1}, while the saturated fatty acids like palmitiec (5.82 %) and stearic (4.89%) were also to the optimal range. Therefore, based on this study Jeldu variety with 46 kg N ha^{-1} gave high seed and oil yields, and oil quality, thus it can be recommended to the study area and other similar agro-ecology.

References

Abebe Delesa and Adane Choferie (2016). Response of linseed (*Linum usitatissimum* L.) to fertilizer application and weeds control in South-Eastern Highlands of Ethiopia. J. Cereals and Oilseeds. 7(5):44-54.

Abramovic, H and Abram V (2005). Physico-chemical properties improvement of *Camelina sativa* L., an under exploited oilseed. In: Janick, J. (eds.). Progress in New Crops. ASHS Press, Alexandria, pp. 357–362.

Adefris Tekilewolde, Getinet Alemaw and Tesfaye G (1992). Linseed breeding in Ethiopia. In oilseeds research and development in Ethiopia. Proc. of the first national oilseeds workshop 3-5 Dec. 1991. IAR, Addis Ababa, Ethiopia, pp.41 50.

Adugna Wakjira (2007). Linseed (*Linum usitatissimum* L.) in: van der Vossen H.A.M. and Mikilamo G.S. (Eds.) Plant Resources of Tropical Africa 14.Vegetable oils PROTA Foundation, Wageningen, Netherlands/Backhuys Publishers, Leiden, Nether lands pp. 108-115.

Adugna Wakjira, Labuschagne, M. T. and Hugo, A (2004) Variability in oil content and fatty acid composition of Ethiopian and introduced cultivars of linseed. J. Sci. Food and Agri., 84:601-607.

Aglave, B. N., Kalegore, N. K., Chavan, M. H. and Jagtap, P. K (2009). Performance of rained rabi sunflower under varied cropping sequence and nitrogen levels. J. Soils and Crops. 19 (2): 265-68.

Central Statistical Agency (CSA) (2017). The Federal Democratic Republic of Ethiopia, Key Findings of the 2015/2016.Agricultural Sample Surveys. Addis Ababa.

Chapman, H.D (1965). Cation exchange capacity by ammonium saturation, In: C.A Blank, L, E. Ensminger and F.E. Clark (Eds.), Method of soil analysis, American Society of Agronomy, Madison's Wisconsis, USA. Pp. 891-909.

Cheema, M. A., Malik, M. A., Hussain, A., Shah, S. H. and Basra, S. M. A (2001). Effect of time and rate of nitrogen and phosphorus application on the growth and the seed and oil yields of canola (*Brassica napus* L.). J. Agron. and Crop Sci.186: 103-110.

CIMMYT (International center for wheat and maize improvement) (1988). From agronomic data to farmer recommendations: An economics training manual. Completely revised edition. Mexico, D.F.

El-Beltagi, H. S., Salama, Z. A., El-Hariri, D. M (2011) Variations in oil and some phytochemical contents in flaxseed cultivars (*Linum usitatissimum* L.). J. Envi., Agri. and Food Chem., 10: 2711-2721.

FAOSTAT (2014). Food and agricultural commodities production: countries by commodity. Rome, Italy: FAO. http://faostat.fao.org/site/339/default.aspx.

Food and Agriculture Organization of the United Nations (2008). FAO fertilizer and plant nutrition bulletin: Guide to laboratory establishment for plant nutrient analysis, FAO, Rome, Italy. 203p.

Gambus, H.F and Zajac.T (2003). Chemical composition of linseed with different colour of bran layer. polish J. food nutr.sci.12: 67-70.

Geleta, M and Ortiz R (2013). The importance of Niger (*Guizotia abyssinica*) for sustainable food security in Ethiopia. Geneti. Res. Crop. E. 60:1763–1770.

Genene Gezu, Habtamu Seboka, Kedir Nefo, Tilahun Geleto, Ashinie Bogale (2006). Response of linseed to nitrogen and phosphurus fertilizers in the highlands of Bale, South-estern Ethiopia. Sebil. Proceedings of the 12th Annual Conference of the Crop Science Society of Ethiopia 22-24 May 2006, Addis Ababa, Ethiopia. 12:117-125.

Hiruy Belayneh and Nigusie Alemayeh (1992). Verification of improved linseed production practices on farmers' fields. In: Proceedings of the 4th oil crops network workshop. Njoro, Kenya. Pp. 92-95.

Hocking, P.J (1995). Critical nitrate-nitrogen and total nitrogen concentrations for vegetative growth and seed yield of Linola (edible-oil linseed) as affected by plant age. Aust. J Exp. Agric. 35:239-246.

HARC (Holeta Agricultural Research Center). 2017. Agrometeorological data of Annual progress report. Holeta, Ethiopia.

Hosseinian, F.S.; Rowland, G.G.; Bhirud, P.R.; Dyck, J.H. and Tyler, R.T (2004). Chemical Composition Physico-chemical and Hydrogenation Characteristics of High-Palmitic Acid Solin (low-linolenic acid flaxseed) Oil. J. Ameri. Oil Chemi.' Soci., 81(2): 185-188.

Hume, D.J (1982). Protein seed crop: Notes on Agriculture .No. 18:17-18.

Jackson, M.L (1967). Soil chemical analysis. New Delhi, Prentice Hall of India Private Limited, New Delhi, p. 326-338.

Klimek, Kopyra, A., Zając, T. and Rębilas, K (2013). A mathematical model for the evaluation of cooperation and competition effects in intercrops. Eur. J. Agron. 51: 9-17.

Kulumsa Agricultural Research Center (KARC) (2012). Highland Oil Crops Research Project Report. pp 25

Landon, J.R (1991). Booker tropical soil manual: A Hand Book for soil survey and agricultural land evaluation in the tropics and subtropics. Long man Scientific and Technical, Essex, New York. pp 474.

Legesse Burako (2010). Genetic diversity study of linseed genotypes on acidic soil at Bedi trial site, Central Highland of Ethiopia, MSc. Thesis. Addis Ababa University, Addis Ababa.

Leilah, A.A (1993). Evaluation of yield and its components of flax cultivars under different nitrogen fertilizer levels. J. Agri. Sci. 18(2): 313-321.

Marchenkov, A., Rozhmina, T. Uschapovsky, L. and Muir, A. D (2003). Cultivation of flax. In A. D. Muir and N. D. Westcott (eds). Flax - The genus Linum. Taylor and Francis, London.

Marx, E.S., Har, J. and Stevens, R.G (1996). Soil test interpretation guide. Oregon State University Extension Service. Corvallis or, USA. pp 8.

Mulusew Fikere, Firew Mekbib and Adugna Wakjira (2013). Seed oil diversity of Ethiopian linseed (*Linum usitatissimum* L.) landraces accessions and some exotic cultivars. Afri. J. Biochemi. Res., 7(6):76-85.

Mohammadi.A.A, Saeidi G and Arzani. A (2010). Genetic analysis of some agronomic traits in flax (*Linum usitatissimum* L.). Aust. J. Crop Sci. 4: 343-352.

Morris, D.H (2005). Flax-A Health and Nutrition Primer. Flax Council of Canada. Available athttp://www.flaxcouncil.ca/english/ index. pmp? p=primer and mp=nutrition. Accessed on Sep 27, 2017.

Motsara, M.R., and Roy, R.N (2008). Guide to laboratory establishment for plant nutrient analysis. FAO Fertilizer and Plant Nutrition Bulletin 19. Rome. PP 204.

Nykter, M.; Kymäläinen, H.R (2006). Quality characteristics of edible linseed oil. Agri. and Food Sci.15: 402- 413.

Ozer, H., Polat, T. and Ozturk, E (2004). Response of irrigated sunflower (*Helianthus annuus* L.) hybrids to fertilization, growth, yield and yield components. AUE, Turkey. Plant Soil Envi. 50(5): 205-211.

Pali, V., Mehta, N (2014). Evaluation of oil content and fatty acid compositions of flax (*Linum usitatissimum* L.) varieties of India. J. Agri. Sci. 6:198-207.

Poonia, K.L (2003). Effect of planting geometry, nitrogen and sulphur on quality of sunflower (*Helianthus annuus* L.*)* Annals of Agric. Res. 24(4): 828- 832.

Reta Dargie, (2015). Effect of nitrogen and sulfur fertilizer levels on growth, yield, and oil content of linseed (*Linum usitatissimum* L.) in Sinana, South-eastern Ethiopia, Haramaya University, Ethiopia.

Roy. R. N., Finck, A.,Blair, G.J. and Tandon, H.L.S (2006). Plant nutrition for food security. A guide for integrated nutrient management. FAO. Fertilizer and Plant Nutrition.

SAS Institute (2004). SAS/STAT guide for personnel computers, version 9.0, edition. September. 20. Cary, NC: SAS Institute Inc.

Sharma, R. Thakur, K.S. and opra, P (2007). Response of N and spacing on production of Ethopian mustard under mid-hill conditions of Himachal Pradesh. Research on Crops. 8(1): 65–68.

Tanwar, S., Zhang, L. and Teixeira, M (2011). Adenomatous polyposis coli (APC) is essential for maintaining the integrity of the seminiferous epithelium. Molecular Endoc., 25: 1725–1739.

Walkley, A. and C.A. Black (1934). Determination of organic matter in the soil by chromic acid digestion. Soil Sci. 63: 251-264.

Worku Nugussie, Zemede A, Haileselassie Y (2012). Linseed (*Linum usitatissimum*) ethnobotany and its cultivation status in Ethiopia. Int. J. Agric. Appl. Sci. 4:48-57.

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Short Communication

Evaluations of Garlic Varieties and Fungicides for the Management of White Rot (Sclerotium cepivorum Berk.) in West Showa, Ethiopia

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Abstract

Garlic (Allium sativum L.) is the second most widely cultivated vegetables next to onion in Ethiopia and mainly produced for its medicinal and nutritional purpose white rot caused by a soil borne fungus (Sclerotium cepivorum Berk.) is a major production threat of garlic where ever the crop is grown. Therefore, this study was carried out to evaluate the effectiveness of fungicides, and garlic varieties against garlic white rot in West Shewa, Ethiopia. The field experiment was conducted at Ambo University, Gudar campus experimental field in 2018/2019 cropping season, arranged in 5 x 3 factorial treatment combination of five varieties namely Holeta, Chefe, Tseday (G-493), kuriftu and local cultiver (as check) and two fungicides namely Pro-seed plus 63 WS and Tebuconazole (Natura 250 EW) along with the untreated control plots in randomized complete block design with three replications. Garlic cloves were treated using fungicides before planting. A total of fifteen treatments were evaluated per replication. Two fungicides were effective in reducing the disease epidemics and improving garlic yield over untreated plots. However, among fungicides used, plots treated with Pro-seed plus was the most effective in reducing the disease epidemics and gave better yield advantage. Pro-seed plus 63 Ws treated plots 57.12 %, 35 % and 64.25 % reduced initial, final incidence and final severity was recorded respectively as compared to untreated plots. The results showed significantly highest marketable yield was recorded from Tseday varieties treated with Pro-seed plus 63 WS (3.047t ha-1) followed by Kuriftu varieties treated with the same fungicides (2.973t ha-1) compared to the untreated control plots. Significantly, higher net profit was obtained from Pro-seed plus 63WS treated varieties compared to Tebuconazole and untreated control plots. Among the garlic varieties, Tseday (G-493) was promising in reducing the disease epidemics and gave better total and marketable bulb yield. Further research should be conducted with the same varieties combinations with fungicides against white rot under multi locations and in different seasons.

Keywords: Garlic, White rot, Sclerotium cepivorum, Disease epidemics, Fungicides, Pro-seed plus, Tebuconazole

Introduction

Garlic *(Allium sativum* L.*)* is a member of *Alliaceae* family with an erect biennial herb normally grown as annual crop and it's originated in the north-western side of the Tien-Shan Mountains of Kirgizia in the arid and semi-arid areas of central Asia (Etoh and Simon, 2002). It is an excellent source of several minerals and vitamins that are essential for health and has medicinal role for centuries such as antibacterial, antifungal, antiviral, antitumor and antiseptic properties (Deresse, 2010; Sovova and Sova, 2004). In Ethiopia, garlic has been used as medicine for a range of skin and stomach problems and to treat many conditions such as common cold (Kero, 2010). Its Economic significance in Ethiopia is quite considerable. It is grown as spice and used for flavoring local dishes, and contributes to the national economy as export commodity (Fekadu and Dandena, 2006). Production of cash crops like garlic and other spices is proved to be income generating activity for farmers, especially for those who have limited cultivated land or small holder farmers (FAO, 2016).

The world garlic cultivation is increasing from 771,000 ha of lands in 1989/90 to 26,573,001 ha of lands in 2016 with total production from 6.5 million to 26.6 million tons, and productivity from 8.43 quintals/ha to 180.915 quintals/ha, respectively (FAO, 2016). In Ethiopia, the total area under garlic production in 2016/17 reached 15,381.01 ha and the production is estimated to be over 1,386,643.07 quintals, percent distribution (6.71%) and yield 90.15 quintals/ha (CSA, 2016-2017). In West Shewa zone, the garlic is widely cultivated using rain.

In spite of its importance and increased production, garlic productivity in many parts of the world is low due to genetic, abiotic and biotic factors (Nonnecke, 1989). Numerous production problems accounted for the low yield of garlic in Ethiopia: lack of proper diseases and insect pest management practices, lack of improved planting materials, inappropriate agronomic practices and marketing facilities are the main constraints (Zeray and Mohammed 2013). However, the most important constraint for garlic production and productivity are fungal diseases. Of the fungal diseases, white rot caused by *Scerotium cepivorum* is the most destructive disease of garlic throughout the world including Ethiopia (Dennis, 1986). According to Amin *et a.l*, 2014, white rot is the most pressing problem to the subsistence onion and garlic farming community more than any other category of vegetable diseases in Ethiopia., Around Northern Shewa of Ethiopia, white rot incidence was reported at a level ranging from 37.28 to 42% in farmers' fields and the yield loss has been found to range between 20.7 and 53.4 % (Tamire *et al*., 2007).

Management of diseases caused by soil-borne pathogens like *S. cepivorum* needs a multi-pronged management strategy. In Ethiopia research efforts on host resistant against white rot is very limited. Fungicides are among the most effective options for garlic white rot management. According to Tamire *et al*. (2007), systemic as well as non-systemic fungicides significantly reduce incidence of white rot, its progress rate, severity, and there by improved garlic yield. Tebuconazole was the effective in reducing the incidence and progress of the disease and in increasing the yield when applied as clove treatment (Melero-Vara *et al*., 2000; Duff *et al*., 2001). In Ethiopia, no detailed information available on the integrated management of garlic white rot involving varieties and fungicides. This study, therefore, was carried out to evaluate the best combination (s) of garlic varieties and fungicides to manage white rot, and assess garlic yield losses incurred due to the diseases in Gudar, West Shewa, Ethiopia.

Materials and methods

Description of the study area

The field experiment was conducted at Ambo University, Gudar campus experimental farms, during 2018/19 main cropping season under rain fed. Gudar is located 130 km West of Addis Ababa at 8°98' North latitude, 37°83' East longitude and altitude ranging from 2000-2010. The area receives annual rainfall between 900-1100 mm, and temperature ranging from 10-27 ºC, with an average of 18 ºC.

The soil type of the study site is vertisol with a pH value of 6.7 (EARO, 2004). The trial was conducted in experimental field naturally infested with white rot sclerotia based on the previous year's history that it was planted to garlic and onion infested by *S. cepivorum*.

Experimental materials used

Varieties used: Five garlic varieties viz. Holeta (G-HL), Chefe (G-104-1/94), Tsedey (G-493), Kuriftu (G-59-2/94) and local were used for the field trial. Holeta, Chefe, Kuriftu and Tsedey are improved varieties released by Debre Zeit Agricultural Research Center, while the local variety was obtained from Gudar areas locally cultivated by farmers.

Table1.Characteristics of garlic varieties used in this experiment.

Garlic varieties	Genotype	Year released	Breeder/Maintainer
Holeta	(G - HL)	2015	DebreZeit ARC/ EIAR /
Chefe	(G -104-1/94)	2015	DebreZeit ARC/ EIAR /
Kuriftu	(G-59-2/94)	2010	DZARC/EIAR
Tsedey	(G-493)	1999	DZARC/EIAR
Local	*	*	Gudar Farmers

Fungicides used, their Preparation and applications:

The registered fungicides, Tebuconazole (Natura 250 EW 0.5lts/ha), which is recommended for garlic white rot is used as a standard check and Pro-seed plus 63 WS (200g/100kg) which is registered for soil and seed borne diseases were used as test fungicide. Fungicides were obtained from Lion International Trading PLC, Addis Ababa, Ethiopia. Clove coating with wettable powders of Pro-seed plus 63 WS was done by making slurry of the required fungicide in 5 ml of water and then coating on 480 g cloves in a polythene bag by rotating repeatedly. Cloves dip treatment of Tebuconazole was done by dipping 480 g cloves in solution of 1ml Tebuconazole in one liter of water for 5 hr and also each variety are compared with control separately (Getachew *et al.*, 2011).

Experimental Design and Management

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications in 3 m^2 plots with 1 m spacing between blocks and 0.5 m between plots. The experiment was arranged in two factors of each at three levels (5 x 3) factorial experiment of five varieties and two fungicides along with the untreated control. The trial was conducted in a field naturally infested by white rot sclerotia.

Uniform size and healthy cloves of garlic varieties treated with fungicides were planted in experimental fields on August 7, 2018 at Gudar Campus. The planting was done in a plot of five rows with 0.30 m between rows and 0.15m between plants in the row.

Data collection:

Data for initial and final plant stand count at emergence and harvest, and the disease incidence (percent diseased plants) was recorded from each plot. Garlic initial stand establishment was determined as percentage of germinated cloves at 30 DAP (days after planting) and final stand count as the bulb harvested. Plant height was also recorded from 15 randomly selected plants at the maximum growth stage. White rot incidence was recorded six times every 15 days interval from the first appearance of the disease in the plots.

The number of infected plants were counted from three central rows of 12 pre tagged plants per each plot at 45, 60, 75, 90, 105 and 120 DAP (days after planting). Disease incidence was calculated according to the following equation:

$$\textbf{Disease incidence } \% = \frac{\text{Number of diseased plants}}{\text{Total number of plants inspected}} \text{x} 100$$

Bulbs were harvested from the middle three rows and the bulbs collected from each plot were allowed to dry for 15 days and weighed to determine yield and other yield components like bulb diameter, number of cloves per bulb, total and marketable yields and infected bulbs were selected from harvested bulbs and severity was rated on 0-5 scale where 0 = healthy; 1 = bulb covered with mycelium but not rotted; 2 = 1-25% of the bulb rotted; 3 = 25-50% of the bulb rotted 4 = 50-75% of the bulb rotted and 5 = 75-100% of the bulb rotted (Tian and Bertolini, 1995). Disease severity scores were converted into percentage as per procedures stated below:

$$\text{Disease severity } (\%) = \frac{\text{Total Point score}}{\text{Total number of } \textbf{bulbs} \text{ scored} * \text{highest score on the scale}} \text{X } 100$$

Area under disease progress curve (AUDPC) was calculated for each treatment from the assessment of disease incidence using the formula:

$$AUDPC = \sum_{t-1}^{n-1} \left[\frac{1}{2} (X_i + X_{i+1})(t_{i+1} - t_i) \right)$$

Where xi is the disease incidence in percentage at ith assessment, ti is the time of the ith assessment in days from the first assessment date, and n is the total number of days the disease was assessed (Campbell and Madden, 1990). Because incidence was expressed in percent and time in days, AUDPC was expressed in %-days.

Disease incidence was transformed using linear model ln(y/l-y) (Campbell and Madden, 1990) transformation before analysis. Transformed data were subjected to linear regression to determine disease progress rate. The disease progress rate for each plot was estimated as the slope of the regression line of the disease progress data. In all cases, DAP (Days after planting) was used as predictor and incidence as response variables.

The relative losses in yield of each treatment were determined as percentage of the treated plots of the experiment. Losses were calculated separately for each of the treatments. Percentage of the protected plots and yield loss was calculated based on the formula (Lotz *et al*., 1990).

$$RYL(\%) = \frac{(Yp - Yt)}{Yp} * 100$$

Where, RYL =Relative Yield Loss in percent, YP =Yield from the maximum treated plots and Yt= yield from other plots.

Data Analysis

All data were analyzed and ANOVA was performed for a randomized completely blocks designs with factorial arrangement of treatments to evaluate the effect of fungicides and varieties using SAS software (SAS Institute, 2008). Treatments means were compared using fisher's least significant difference (LSD).

Cost - benefit Analysis

Prices of garlic bulbs (Birr ton-^{1}) were obtained from local market and total sale from one hectare was computed. The price of all improved and local garlic cultivar was birr 24000/800 kg. The price of fungicides, Tebuconazole and Pro-seed Plus 63 WS were 625 birr per liter and 960 birr per kilogram, respectively.

Cost benefit analysis was performed using partial budget analysis. Partial budget analysis is a method of organizing data and information about the cost and benefit of various agricultural alternatives (CIMMYT. 1988). It provides the value of benefit obtained per the amount of additional cost incurred in percentage. The formula is as follows.

$$MRR = \frac{DNI}{DIC} * 100$$

Where, MRR is marginal rate of returns, DNI, difference in net income compared with control, DIC, difference in input cost compared with control,

The following points were considered during cost benefit analysis using partial budget.

- Costs for all agronomic practices were uniform for all treatments.
- Price of garlic bulb per tons for each variety was taken based on local price
- Costs of labor was taken based on local price
- Costs and benefit were calculated per hectare basis.

Results and discussions

White rot incidence, severity and AUDPC

In this study, the white rot symptoms were noticed 40 days after planting. Infected plants had yellowish lower leaves, and wilting symptoms. Significantly lowest initial and final disease incidence was observed on fungicide treated plots as compared to untreated plots. The results showed that in plots treated with Pro-seed plus 63 WS and Tebuconazole, the average final disease incidences were, respectively, reduced by 35% and 11% as compared to the untreated plots. The lowest initial and final white rot incidence was recorded from the interaction of fungicide with a variety as compared with untreated ones.

The results showed that the lowest initial (2.78%) and final (33.33%) diseases incidences were recorded from Tseday variety treated with a Pro-seed plus **63WS** as compared with other interactions. The highest initial and final incidences were recorded from untreated varieties viz. local, Holeta and Chefe, in order, as compared to other treatments. The results showed that the variety Tseday and Pro-seed plus 63 WS fungicides were promising in reducing diseases incidence followed by Kuriftu variety and Tebuconazole treated plots (Table 2).

Table 2. Interaction effect of fungicide and varieties on white rot incidence, severity and AUDPC at Gudar, West Shewa, Ethiopia during 2018/2019*

Treatments	IWRI (%)	FWRI (%)	WRS (%)	AUDPC
Holeta + Tebuconazole	16.67^{e}	55.55^{c}	13.33^{bcd}	2667^{f}
Holeta + Proseed plus 63 WS	8.33^{bc}	41.67^{b}	12.00^{bcd}	2000^{bc}
Holeta control	16.67^{e}	58.33^{c}	18.67^{d}	3062^{g}
Chefe + Tebuconazole	8.33^{bc}	47.22^{b}	13.33^{bcd}	2292de
Chefe + Proseed Plus63WS	8.33^{bc}	41.67^{b}	6.67^{ab}	1833^{b}
Chefe control	13.89^{de}	66.67^{d}	29.33^{e}	3188^{g}
Tseday + Tebuconazole	8.33^{bc}	44.45^{b}	9.33^{abc}	2104^{cd}
Tseday + Proseed plus 63WS	2.78^{a}	33.33^{a}	4.00^{a}	1354^{a}
Tseday control	16.67^{e}	55.55^{c}	12^{bcd}	2458^{ef}
Kuriftu + Tebuconazole	8.33^{bc}	55.55^{c}	13.33^{bcd}	2396^{e}
Kuriftu + Proseed plus 63WS	5.55^{ab}	41.67^{b}	10.67^{abc}	1937^{bc}
Kuriftu control	13.89^{de}	55.55^{c}	18.67^{d}	2521^{ef}
Local + Tebuconazole	11.11^{cd}	47.22^{b}	16.00^{cd}	2146^{cd}
Local +Proseed plus 63WS	8.33^{bc}	44.45^{b}	9.33^{abc}	1771^{b}
Local control	16.67^{e}	66.67^{d}	42.67^{f}	2958^{g}
CV (%)	**25.4**	**7**	**30.7**	**6.1**
LSD (5%)	**4.68**	**6.05**	**7.9**	**241.8**

*Means in every columns with same letters are not significant difference at (P<0.05)
CV= Coefficient of Variation; LSD= Least Significant Difference, (IWRI) =Initial white rot incidence at 45 days after planting (DAP), (FWRI) =Final white rot incidence at 120 days after planting (DAP), (WRS) =white rot severity on harvested bulbs; AUDPC = Area under Disease Progress Curve

Disease severity data recorded on harvestable bulbs also indicated the significant differences among treatments ($p<0.05$). Significantly highest severity was recorded on untreated control plots when compared to fungicide treated plots. In Pro-seed plus 63 WS treated plots, disease severity was reduced by 64.25%, while it was reduced by 46.15% in Tebuconazole treated plots as compared to untreated control plots. Significant difference of disease severity was recorded among treatment combinations involving varieties and fungicides (Table 2). The highest percentage of diseases severity was recorded from untreated local variety (42.67%) and the lowest percentage of disease severity was recorded from Tseday variety treated with Pro-seed plus 63 (4.0%).

Statistically significant differences were observed among treatments on Area under Disease Progress Curve (AUDPC) value at ($P<0.05$). As compared to other treatments, the lowest AUDPC (1354 % -days) was recorded from Tseday variety treated with Pro-seed plus, while the highest AUDPC was recorded from untreated Chefe variety (3188%-days). Even if the two fungicide treatments were effective in reducing white rot incidence, severity and AUDPC as compared to untreated plots, complete control was not attained. This result is in line with the previous research findings of different authors. For instance, Tamire *et al*. (2007) reported that the systemic as well as non-systemic fungicides significantly reduced incidence of white rot, its progress rate, severity, and there by improved garlic yield. Similarly, Duff *et al.* (2001) reported that Tebuconazole was effective in reducing the incidence, severity and progress of the disease and increased yield when applied as clove treatments. Fullerton and Stewart (1991) also found that the disease incidence was reduced by up to 85% in Tebuconazole treated plots compared with untreated plots in onion.

Getachew *et al.* (2011) reported that fungicide treatments protected plants not only from white rot at different stages, but also reduced the formation of sclerotia in the soil as recorded at the time of harvesting. In this study the degree of disease control achieved by treating with Pro-seed plus 63 WS was higher than that treated by Tebuconazole and untreated control plots. Melero-Vara *et al*. (2000) achieved similar result that treatment of garlic cloves with Tebuconazole and basal spray resulted in significant reduction of disease progress rate and the final incidence of plant death by white rot.

Similarly, Prados-Ligero *et al.* (2002) reported significant reduction of disease incidence, severity and AUDPC values in solarized and Tebuconazole treated cloves, and thereby resulted in quantitative and qualitative yield improvement. Other researchers were also reported that the combinations of Tebuconazole and bio-agents enhanced the control of onion white rot (Clarkson *et al.,* 2006; Ararsa and Selvaraj, 2013).

Table 3. Garlic white rot incidence progress rate under treatment combination involving fungicides and varieties.

Treatments	Intercept	SE* of Intercept	Disease progress rate **	SE*of rate	R^2 (%)	Significant
Holeta + Tebuconazole	-2.646	0.153239	0.02422	0.02348	94%	0.0001
Holeta + Proseed Plus63WS	-3.458	0.274383	0.02783	0.07529	88%	0.0001
Holeta control	-2.538	0.214271	0.02533	0.04591	91%	0.0001
Chefe + Tebuconazole	-3.426	0.268787	0.02971	0.0722	89%	0.0001
Chefe + Proseed Plus63WS	-3.625	0.236035	0.02854	0.05571	91%	0.0001
Chefe control	-3.163	0.322257	0.03339	0.1038	88%	0.0001
Tseday + Tebuconazole	-3.6	0.258694	0.03025	0.0669	90%	0.0001
Tseday + Proosed plus63WS	-2.104	0.758219	0.009534	0.5749	5%	0.191
Tseday control	-2.839	0.192369	0.02514	0.03701	92%	0.0001
Kuriftu + Tebuconazole	-3.811	0.167512	0.03517	0.0281	97%	0.0001
Kuriftu + Proosedplus63WS	-2.956	0.609545	0.02272	0.37155	48%	0.001
Kuriftu control	-3.109	0.262097	0.02833	0.0687	89%	0.0001
Local + Tebuconazole	-3.215	0.214645	0.02663	0.04607	91%	0.0001
Local +Proseed plus63WS	-3.976	0.248679	0.03203	0.0618	92%	0.0001
Local control	-2.838	0.141665	0.02875	0.02007	97%	0.0001

*Standard error of the parameter estimates; R^2= coefficient of determination. **Disease progress rate is measure in unit per days.

Disease progress rate:

The effect of different fungicides on disease incidence was assessed six times during the cropping season. The rate of disease progress was significantly different among treatments at ($P<0.05$). The rate of disease progress and coefficient of determination on five varieties are given in (Table 3). Significant difference in disease development among fungicides treated plots was observed. Least disease progress rate was observed in Tseday variety treated with Pro-seed plus (0.009534unit day^{-1}) followed by Kuriftu variety treated with Pro-seed plus (0.02272 unit day $^{-1}$). The fastest diseases progress rate was recorded in untreated Chefe variety (0.03339 unit days $^{-1}$).

Almost similar rate of disease development was observed among untreated garlic varieties (Table 3). A similar result was reported by Melero-Vara *et al*. (2000) who stated that the treatment of garlic cloves with Tebuconazole and basal spray was achieved significant reduction in disease progressive rate and the final incidence of plant death by white rot. Moreover, Tamire *et al*. (2007) also reported that the systemic fungicides significantly reduced progress rate of white rot and there by improved garlic yield.

Yield and yield components:

The interaction results showed that significantly varied plant height was observed among treatments at ($P <0.05$) and the highest plant height was recorded from Tseday variety treated with Pro-seed plus followed by local variety treated with the same fungicide which is statistically different and the lowest plant height was recorded from untreated Holeta and Chefe varieties.

The number of harvested bulbs (expressed as percent of final stand) was evaluated and there were a significant differences at ($P<0.05$) among treatments (Table 4). Significantly highest marketable yield was recorded from Tseday variety treated with Pro-seed plus 63 WS (3.047t ha^{-1}) followed by Kuriftu variety treated with the same fungicide (2.973t ha^{-1}) compared to the untreated control plots, which gave the lowest yield. The significant difference in total and marketable yield among garlic varieties were also observed with Tseday variety recorded higher marketable yield compared to the other four varieties (Table 4). The results are in agreement with what Duff *et al*. (2001) achieved that highest marketable yields were obtained from Tebuconazole treated garlic cloves compared with Procymidone treated garlic cloves on the trial conducted in heavily infested field with sclerotia of *S. cepivorum*. Similarly, Prados-Ligero *et al*. (2002) also reported significant reduction of disease incidence and severity in Tebuconazole treated cloves, resulting in quantitative and qualitative yield improvement. In this study, plots planted to Pro-seed plus 63 WS treated Tseday garlic variety gave significantly increased total and marketable yield as compared to the other four garlic varieties.

The relative yield losses due to white rot on the marketable bulb yield of garlic**.** The variation in yield losses was observed between treatments. Losses on bulb yield for different fungicide treated plots were calculated relative to the higher yield recorded plots. In untreated (control) plots, the yield losses were distinctly higher than in plots treated with fungicide. Similarly, Zeray and Mohammed (2013) also reported that during favorable weather conditions and when susceptible varieties are in the production system the white rot disease can cause 100% yield loss. In Ethiopia yield loss due white rot has been found to range between 20.7% and 53.4% (Tamire *et al.*, 2007).

Cost benefit Analysis of variances showed that significant difference was observed among treatments in total income, input cost, marginal cost, net benefit ($P<0.05$) . Significantly, higher net profit was obtained from Pro-seed plus63 WS treated varieties compared to Tebuconazole treated and untreated control plots. Therefore, application of Pro-seed plus 63 WS, provided net benefit birr 55275 (ETB/ha) in Holeta, 33225 (ETB/ha) in Chefe, 112155 (ETB/ha) in Tseday (G-493), 108825 (ETB/ha) in Kuriftu and 93390 (ETB/ha) in Local varieties. The corresponding value of marginal rate of return was 5759.38, 3584.38, 7325, 7193.75 and 8665%, respectively (Table 5). The significant differences among garlic variety on net benefit was observed (P<0.01). Tseday (G-493) variety treated with Pro-seed plus shows highest net benefit (112155) birr t^{-1} over the other four garlic variety with zero and minimum input difference (Table 5). The additional input cost in fungicide treated plots was 625.00 and 960.00 birr in Tebuconazole and Pro-seed Plus, respectively. It was found that Pro-seed plus 63 WS treated plots provided significantly higher net benefit over Tebuconazole and untreated control plots. The best recommendation for treatments not subjected to the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation (CIMMYT, 1988).

Table 4. Effect of treatment combinations on yield and yield components of garlic varieties treated with fungicides at Gudar, west Shewa, Ethiopia.

Treatments	**IPS**	**PH**	**HB**	**NC**	**BD**	**TY**	**MY**
Holeta + Tebuconazole	41.88^{g}	50.8^{h}	76.97^{de}	5.53^{e}	20.41^{def}	1.87^{gh}	0.88^{h}
Holeta + Proseed Plus63WS	52.14^{f}	55.27^{fgh}	84.24^{cd}	6.2^{de}	23.79^{bcd}	2.11^{f}	1.78^{ef}
Holeta Control	29.92h	44.39i	72.12^{ef}	4.73^{e}	16.16^{f}	1.74^{hi}	0.53^{h}
Chefe + Tebuconazole	40.17^{g}	52.15^{gh}	76.36^{e}	6.27^{de}	19.44^{def}	1.74^{hi}	0.88^{h}
Chefe + Proseed Plus63WS	51.28^{f}	59.83^{def}	84.24^{cd}	7.2^{cd}	22.46^{cde}	2.00^{fg}	1.29^{fg}
Chefe Control	40.17^{g}	51.13^{h}	64.85^{f}	5.67^{de}	17.49^{ef}	1.61^{i}	0.50^{h}
Tseday + Tebuconazole	73.5^{cde}	64.68^{cd}	92.73^{ab}	9.27^{ab}	28.74^{ab}	3.62^{b}	2.24^{cd}
Tseday + Proseedplus63WS	82.05^{abc}	71.77^{a}	95.15^{a}	9.93^{a}	32.54^{a}	4.04^{a}	3.047^{a}
Tseday control	72.65^{de}	58.94^{ef}	84.24^{cd}	8.4^{abc}	26.59^{bc}	2.88^{d}	1.46^{fg}
Kuriftu + Tebuconazole	66.67^{e}	60.75^{de}	93.94^{ab}	8.67^{abc}	22.06^{cde}	3.14^{c}	2.19^{d}
Kuriftu + Proseedplus63WS	77.78^{bcd}	69.02^{abc}	90.91^{abc}	9.33^{ab}	24.1^{bcd}	3.53^{b}	2.97^{ab}
Kuriftu control	51.28^{f}	56.25^{efg}	86.67^{bc}	8.13^{bc}	21.54^{cde}	2.36^{e}	1.42^{fg}
Local + Tebuconazole	84.62^{ab}	66.03^{bc}	95.15^{a}	8.73^{abc}	28.28^{ab}	3.13^{c}	1.96^{de}
Local + Proseed plus 63WS	90.6^{a}	70.39^{ab}	96.97^{a}	9.07^{ab}	28.59^{ab}	3.96^{a}	2.63^{bc}
Local Control	77.78^{bcd}	61.07^{de}	93.33^{ab}	8.13^{bc}	21.12^{def}	2.94^{d}	0.76^{h}
CV (%)	**10.1**	**5.5**	**4.9**	**11.8**	**13.6**	**3.3**	**14.97**
LSD (5%)	**9.17**	**4.87**	**7.34**	**1.54**	**5.32**	**0.15**	**0.41**

IPS=Initial plant stand (%), PH=Plant Height (cm), HB=Harvested Bulb (%), TY=Total yield (t/ha), MY-Marketable yield (t/ha), NC=Number of clove/ bulb, BD=Bulb diameter (cm).

Table 5.Partial budget analysis for management of garlic white rots using fungicides and host resistance in Gudar, West Shewa, Ethiopia.

Treatments	Cost benefit data							
	MY	SP	SR	TIC	MC	NB	MB	MRR
Holeta + Tebuconazole	0.88	45000.00	39465.00	24625.00	625.00	14840.00	14855.00	2376.80
Holeta + Proseed Plus	1.78	45000.00	80235.00	24960.00	960.00	55275.00	55290.00	5759.38
Holeta control	0.53	45000.00	23985.00	24000.00	0.00	-15.00	0.00	0.00
Chefe + Tebuconazole	0.88	45000.00	39600.00	24625.00	625.00	14975.00	16160.00	2585.60
Chefe + Proseed Plus	1.29	45000.00	58185.00	24960.00	960.00	33225.00	34410.00	3584.38
Chefe control	0.51	45000.00	22815.00	24000.00	0.00	-1185.00	0.00	0.00
Tseday + Tebuconazole	2.24	45000.00	100665.00	24625.00	625.00	76040.00	34205.00	5472.80
Tseday + Proosed plus	3.05	45000.00	137115.00	24960.00	960.00	112155.00	70320.00	7325.00
Tseday control	1.46	45000.00	65835.00	24000.00	0.00	41835.00	0.00	0.00
Kuriftu + Tebuconazole	2.20	45000.00	98865.00	24625.00	625.00	74240.00	34475.00	5516.00
Kuriftu + Proosed plus	2.97	45000.00	133785.00	24960.00	960.00	108825.00	69060.00	7193.75
Kuriftu control	1.42	45000.00	63765.00	24000.00	0.00	39765.00	0.00	0.00
Local + Tebuconazole	1.96	45000.00	88200.00	24625.00	625.00	63575.00	53375.00	8540.00
Local +Proseed plus	2.63	45000.00	118350.00	24960.00	960.00	93390.00	83190.00	8665.63
Local control	0.76	45000.00	34200.00	24000.00	0.00	10200.00	0.00	0.00

MY=Marketable Yield (t/ha), SP=selling price ((Birr t^{-1}), SR=Selling Revenue, TIC= Total input cost (ETB/ha), MC=Marginal Cost (ETB/ha), NB=Net Benefit (ETB/ha), MB=Marginal Benefit (ETB/ha), MRR= Marginal Ret of Return (%)

Conclusions

The present study identified that white rot incidence, severity, AUDPC, disease progress rate and other yield and yield components was varied among fungicides and varieties. Even if the two fungicides were effective in reducing the disease incidence, diseases severity, diseases progress rate and AUDPC over untreated control plots, Pro-seed plus 63 WS was the most effective in reducing the disease incidence, diseases severity, diseases progress rate and area under progress than Tebuconazole treated plots. Significantly higher increment on total and marketable yield as well as other yield and yield components was observed in Proseed plus 63 WS treated plots as compared to Tebuconazole and untreated control plots. Although it is not as much as effective as Pro-seed plus, Tebuconazole was also reduced the incidence, severity, diseases progress rate and area under progress curve as compared to untreated varieties. Among garlic varieties, Tseday (G-493) was promising in reducing the disease epidemics and gave better total and marketable bulb yield and yield components followed by Kuriftu (G-59. Hence, compared with other treatments, combination of Tseday variety with Proseed plus 63 WS was the most effective in reducing white rot epidemics and improving garlic yield and yield components. It is, however, suggested that for wider application of this treatment combination should be further verified under multi location and different season before recommending.

References

Amin, M., Tadele, S. and Selvaraj, T. 2014. White rot (*Sclerotium cepivorum*-Berk) an aggressive pest of onion and garlic in Ethiopia: An overview. *Journal of Agricultural Biotechnology and Sustainable Development*, 6: 6-15. 11.

Ararsa, L. and Selvaraj, T. 2013. Evaluation of *Arbuscular mycorrhizal* fungi and *Trichoderma Species* for the control of onion white rot (*Sclerotium cepivorum* Berk) *J. Plant Pathol. Microbiol.* 4:159.

Campbell, C.L. and Madden, V.L. 1990. Introduction to Plant Disease Epidemiology, Wiley, New York, USA.

CIMMYT. 1988. Farm Agronomic data to farmers' recommendations: Economic training manual. International Maize and Wheat Research Center, Mexico, 124p.

Clarkson, J.P., Mead, A., Payne, T. and Whipps, J.M. 2006. Effects of environmental factors and *Sclerotium cepivorum* isolate on sclerotial degradation and biological control of white rot by *Trichoderma*. *Plant Pathol.* 53:353- 362.

CSA (Central Statistical Agency). 2016/ 2017. The preliminary results of area, production and yield of temporary crops. Statistical Bulletin, Volume 1, Addis Ababa, Ethiopia.

Dennis, A.J., 1986. *Botrytis* neck rots of onion. Plant disease. http://cru.cahe.wsu.edu/CEPublications/eb1359/eb1359.html.

Deresse, D. 2010. Antibacterial effect of garlic (*Allium sativum*) on *Staphyloccus aureus*; An in vitro study. *Asian Journal of Medical Sciences* 10: 62-65.

Duff, A.A., Jackson, K.J. and O'Donnell, W.E. 2001. Tebuconazole (Folicur®) shows potential in the control of white rot (*Sclerotium cepivorum*) in garlic in subtropical Queensland, Australia. *Proceedings of the 2nd International Symposium on Edible Alliaceae*. p. 247-250.

EARO (Ethiopian Agricultural Research Organization) 2004. Directory of released crop varieties and their recommended cultural practices. Addis Ababa, Ethiopia.

Etoh, T. and Simon, P. 2002. Diversity, fertility and seed production in garlic. In: Rabino witch, H. and Currah L. (Eds) *Allium* Crop Science: Recent Advances. CABIPp. 101-118.

FAO 2016. Garlic, production quantity (tons) for Ethiopia.

Fekadu, M .and Dandena, G. 2006. Review of the status of vegetable crops production and marketing in Ethiopia. *Uganda Journal of Agricultural Sciences,* 12: 26 - 30.

Fullerton, R.and Stewart, A. 1991. Chemical control of onion white rots (*Sclerotium cepivorum* Berk) in the Pukekaohe district of New Zealand. *New Zealand J. Crop. Hort. Sci.* 19:121127.

Getachew, T., Eshetu, D. and Tebkew, D. 2011. Management system of onion and garlic production and productivity technique by using fungicides (in Amharic) Debrezeit Agricultural Research Centre (2nd edn.) Pp. 29-34.

Kero, J. 2010. Survey and serological identification of viruses infecting Garlic (*Allium sativum)* in Ethiopia. M.Sc.,Thesis, Addis Ababa University, Addis Ababa, Ethiopia Pp.67

Lotz, L.A.P., Kropff, M.J. and Groeneveld, R.M.W. 1990 Modelling weed competition and yield losses to study the effect of omission of herbicides in winter wheat. Netherlands *Journal of Agricultural Sciences* 38: 711 -718.

Melero-Vara, J.M., Prados-Ligero, A.M. and Basallote-Ureba, M.J. 2000. Comparison of physical, chemical and biological methods of controlling garlic white rot (*Sclerotium cepivorum* Berk.). *European Journal of Plant Pathology* 106: 581-588.

Nonnecke., I.L. 1989. Vegetable Production. Springer. New York, pp. 657 - 659.

SAS Institute. 2008. SAS Institute Inc,Guide for Personal Computers. Cary, NC 2008

Sovova, M. and Sova, P. 2004. Pharmaceutical importance of Allium sativum L., pp. 117-123 Hypolipemic effects in -vitro and in- vivo (in Czech). Vol. 53 (3) CeskaSlovFarm.

Prados-Ligero, A.M., Bascon-Fernandez, J., Calvet-pinos, C., Corpas-Hervias, C., Ruiz, A.L and Melero-Vara, J.M. 2002. Effect of different soil and clove treatments in the control of white rot of garlic. *Journal of Applied Biology* 140:247:253.

Tamire, Z., Chemeda, F., Sakhuja. K. P. and Seid, A. 2007. Yield loss assessment of garlic due to white rot (*Sclerotium cepivorum*), M.Sc., Thesis Addis Ababa, Ethiopia.

Tian, S.P. and Bertolini, P.1995. Effects of temperature on mycelial growth and spore germination of *Botrytis allii* in culture and on its pathogenicity to stored garlic bulbs. *Journal of plant pathology* 44:1008-1015.

Zeray, S. and Mohammed, Y. (2013). Searching and evaluating of cost effective management options of garlic white rot (*Sclerotium cepivorum* Berk) in Tigray, Northern Ethiopia. *J. Plant Pathol. Microb.* 4: 189.

JSSD Editorial Policy

1. Overview: Replication and/or Extension of Results

Ambo university is committed to fostering the meaningful exchange of information to help create an environment for constructive criticism and free exchange of ideas. As publisher of the Journal of Science and Sustainable Development, the Ambo University expects authors to adhere to the highest standards of integrity in research and the communication of research results and findings. Papers submitted to Journal of Science and Sustainable Development (JSSD) should include enough information (including in-text, Web appendix, or other online supplements) so as to allow a reasonably trained researcher to replicate the results. This should include a precise description of the research and analysis procedures. Ambo University requires the authors of manuscripts submitted to JSSD to share additional details of their research findings and insights when requested by a journal editor. If there are any proprietary restriction on information, authors must notify the editor at time of manuscript submission.

2. Additional Supplementary Materials during the Review Process

In addition to the above, during the course of the review process the editor may request additional materials—including data—if they are seen as essential for judging the merits of the research. Data and other requested materials would be viewed confidentially by the review team. The editor must be notified in advance if such requests could not be met due to proprietary or other restrictions.

3. Protecting Intellectual Property

JSSD is committed to the protection of intellectual property. When supplementary materials are requested during the review period, they will be subject to the JSSD's double-blind peer-review process in order to maintain author anonymity. Reviewer team members will not use ideas from or show another person the manuscript or supplementary materials they have been asked to review without the explicit permission of the manuscript's author, obtained through the journal editor and/or editorial manager. Advice regarding specific, limited aspects of the manuscript may be sought from colleagues with specific expertise, provided the author's identity and intellectual property remain secure.

4. Falsification of Data/Misreporting of Data

JSSD expects all submissions to include data that are honestly and accurately reported according to the accepted best practices of scholarly publishing. In instances in which falsified or misreported data are suspected, the procedures outlined below will be followed.

In any instance of suspected misconduct, the JSSD pledges to carry out the process of detection, investigation, and penalty with fairness and confidentiality during the internal inquiry. The process for detection, investigation, and, if necessary, penalty and retraction for suspected falsification/misreporting of data is as follows:

a. Detection

JSSD Editor, along with the Editorial Board, will serve to detect instances of data falsification. When an Editor suspects malfeasance (or is informed by a reviewer who suspects malfeasance), he/she shall make a judgment whether the claim has any merit. If the Editor determines that there has been potential misconduct, he/she shall inform the Managing Editor/ Director for Publication and Dissemination and provide a detailed account of the possible violation or misconduct. In the case where work has been published, readers suspecting falsification/misreporting should contact the editor. The sitting editor will then review the case, operating under the policies provided herein.

b. Investigation

When informed by the journal Editor, the Managing Editor/Director for Publication and Dissemination shall determine whether further investigation is required. The Director for Publication and Dissemination may choose to assemble a review committee of scholars to determine the exact nature and extent of the suspected misconduct. Each individual investigation may warrant the assembly of a new ad hoc committee. Any committee member who is perceived to have a conflict of interest must recuse him-/herself from the process. The Editor of the journal in question shall not serve on the committee. If it is determined that an act of misconduct has been committed, the Director for Publication and Dissemination in consultation with the Vice President for Research and Community Service shall inform the author(s), in writing, with a detailed description of the alleged offense. The Director for Publication and Dissemination shall offer the author(s) an opportunity to respond to the allegation. In events in which more than one author is involved, the authors may collaborate on their response or respond individually. If the committee concludes that no offense has been committed, no further action shall be taken, and the Director for Publication and Dissemination shall inform the authors the same. If the committee determines that there has been misconduct, the process will move into a penalty phase.

In order to conduct a full and fair investigation, authors may be required to provide materials that go above and beyond the aforementioned (***2. Requesting Supplementary Materials***). If a paper uses proprietary data covered by a non-disclosure agreement signed by the author(s), and the author(s) are not able to meet the data requirements, the committee chair may ask for specific (appropriately redacted) details of the agreement that prevent the authors from providing the required materials. The committee may choose to provide an exemption. If the committee chooses not to waive the requirements, the author(s) will have the option of withdrawing the paper from the journal review process. However, in such cases, the committee chair may determine to continue the investigation and levy a penalty if misconduct is suspected. All information provided will be used solely for the purpose of conducting the investigation. All information will remain private and will not be distributed beyond the investigating committee. All materials will be destroyed upon the conclusion of the investigation.

c. Penalty

In the event that an author (or authors) is found to have engaged in some form of misconduct, he/she shall be subject to a penalty, the nature and extent of which will be determined by the Vice President for Research and Community Service in consultation with Director for Publication and Dissemination and with the counsel of the committee members. The penalty shall be commensurate with the nature of the offense and will likely include a ban on submitting to JSSD for a period of time. All sitting Editors of JSSD will be informed of the penalty. The committee is empowered to customize penalties for each individual author in instances in which multiple authors are involved. In extreme circumstances, the committee reserves the right to inform an author's institution, depending on the seriousness of the offense.

d. Article Retraction

In the event that ethical misconduct (e.g. misrepresentation/falsification of data, pervasive errors, plagiarism, multiple submission, etc.) is determined to have occurred in a manuscript published in JSSD, the Managing Editor reserves the right to issue a public retraction of the manuscript in question. The retraction will come in the form of a note published in a subsequent issue of the journal. The article's citation will be labeled as "Retracted" in all databases and the electronic version of the manuscript file will be clearly marked as "Retracted."

5. Concurrent Reviews

Ambo University publication policy prohibits an article under review at JSSD from being concurrently reviewed at another journal without prior discussion with and written permission from the involved JSSD editor.

6. Author Misconduct Policy and Procedures

a. Overview

As a publisher of peer-reviewed journal, Ambo University requires all journal submissions to adhere to the highest of ethical standards and best practices in publishing. All writing and research submitted to JSSD is expected to present accurate information and to properly cite all content referenced from other materials.

b. Overlap

The value of a publication depends on its incremental contribution. Therefore, it is inappropriate to submit articles with substantial overlap. This overlap can result from the use of the same data or analyses or when providing parallel substantive or theoretical results. When there is a question about defining overlap, particularly that which arises from their own work, it is the authors' responsibility to notify and alert the editor. The Editor will make a binding decision whether a manuscript submitted to JSSD is too similar to an article already published there or elsewhere.

When writing a paper, it is important for authors to define its incremental contribution by referencing relevant work on which the paper builds. Authors are expected to search for and reference the related work of others. Authors are especially responsible for informing the Editor about their own work, whether it is published, in working paper form, or under review. When questions arise about related work, the Editor will provide guidance to the authors. Submitting a paper that is substantially the same as a previously published paper is considered a serious breach of professional ethics and may warrant the Editorial Manager contacting officials at the authors' institutions of this breach. In the event that the author(s) is not affiliated with an institution, alternative steps may be taken, including a ban from submitting to JSSD.

c. Plagiarism

As defined by the Merriam-Webster dictionary, to plagiarize is "to steal and pass off (the ideas or words of another) as one's own," "use (another's production) without crediting the source," or to "present as new and original an idea or product derived from an existing source" (http://www.merriam-webster.com/dictionary/plagiarize). Ambo University considers other forms of plagiarism to include "self-plagiarism"—instances in which an author borrows from his or her own previously published work without the proper citation. It is also unacceptable to submit manuscripts to JSSD that have previously been published anywhere in any language. It is the authors' responsibility to inform or notify the Editor upon submission if there is any doubt whether a manuscript may violate any of these terms.

d. Detection, Investigation, and Penalty

In any instance of suspected misconduct, Ambo University pledges to carry out the process of detection, investigation, and penalty with fairness and confidentiality during the internal investigation. The process for detection, investigation, and penalty for suspected plagiarism is as follows:

i. Detection

The JSSD Editor, along with the Editorial Board and non–Editorial Board reviewers, will serve to detect instances of plagiarism. When an Editor suspects plagiarism (or is informed by a reviewer who suspects plagiarism), he/she shall make a judgment whether the claim has any merit. If the Editor determines that there has been potential misconduct, he/she shall inform the Director for Publication and Dissemination/Managing Editor and provide a detailed account of the possible violation or misconduct.

ii. Investigation

When informed by the journal Editor, the Director for Publication and Dissemination/Managing Editor shall determine whether further investigation is required. the Director for Publication and

Dissemination/Managing Editor may choose to assemble a review committee of scholars to determine the exact nature and extent of the suspected misconduct. Each individual investigation may warrant the assembly of a new ad hoc committee. Any committee member who is perceived to have a conflict of interest must recuse him-/herself from the process. The Editor of the journal in question will not serve on the committee. If it is determined that an act of plagiarism has been committed, the Director for Publication and Dissemination/Managing Editor in consultation with the Vice President for Research and Community Service (VPRCS) will inform the author(s), in writing, with a detailed description of the alleged offense. The Director for Publication and Dissemination/Managing Editor shall offer the author(s) an opportunity to respond to the allegation. In events in which more than one author is involved, the authors may collaborate on their response or respond individually. If the committee concludes that no offense has been committed, no further action will be taken, and the Director for Publication and Dissemination/Managing Editor will inform the authors the same. If the committee determines that there has been misconduct, the process will move into a penalty phase.

iii. Penalty

In the event that an author (or authors) has been found to have engaged in some form of misconduct, he/she is to be subjected to a penalty. The nature and extent of the penalty will be determined by the VPRCS in consultation with the Director for Publication and Dissemination/Managing Editor and with the advice of the committee members. The penalty will be dictated by the nature of the offense and will likely include a ban on submitting to any journal published by Ambo University for a period of time. All sitting Editors of Ambo University journals will be informed. The committee is empowered to customize penalties for each individual in instances in which multiple authors are involved. In extreme circumstances, the Director for Publication and Dissemination/Managing Editor reserves the right to inform an author's institution, depending on the seriousness of the offense.

7. Falsification of Data/Misreporting of Data

The JSSD expects all submissions to include data that are honestly and accurately reported according to the accepted best practices of scholarly publishing. In instances in which falsified or grossly misreported data are suspected, the process outlined above (see Plagiarism) will be activated.

8. Resubmissions

Manuscripts that have been rejected are not eligible for further consideration by the same journal and thus should not be resubmitted. If a revision is allowed, it will be explicitly stated in the Editor's decision. Other revisions of previously rejected manuscripts will be promptly returned to the authors without review.

9. Conflicts of Interest

Conflicts of interest may arise in a variety of situations, and therefore the author is required to inform the editor of such conflict. A conflict of interest may exist when a manuscript under review puts forth a position contrary to the reviewer's published work or when a manuscript author or reviewer has a substantial direct or indirect financial interest in the subject matter of the manuscript. Because it is Ambo University policy to engage in a double-blind review process, a conflict of interest may also exist when a reviewer knows the author of a manuscript. The reviewer should consult the journal editor in such situations to decide whether to review the manuscript. A conflict of interest does not exist when an author disagrees with a reviewer's assessment that a problem is unimportant or disagrees with an editorial outcome.

10. Protecting Intellectual Property

Protecting intellectual property is a primary responsibility of the reviewer and the editor. Reviewers, therefore, will not use ideas from or show another person the manuscript they have been asked to review without the explicit permission of the manuscript's author, obtained through the journal editor. Advice regarding specific, limited aspects of the manuscript may be sought from colleagues with specific expertise, provided the author’s identity and intellectual property remain secure.

11. Sharing of Reviewing Responsibilities

Sharing of reviewing responsibilities is inappropriate. The review is the sole responsibility of the person to whom it was assigned by the journal editor. Students and colleagues should not be asked to prepare reviews unless the journal editor has given explicit prior approval. Each person contributing to a review should receive formal recognition.

12. Review Process

All reviews will use a double-blind review process. Reviewers and journal editors are expected to provide comments and critiques in a confidential, constructive, prompt, and unbiased manner appropriate for their position of responsibility. Collegiality, respect for the author’s dignity, and the search for ways to improve the quality of the manuscript should characterize the review process. The editor has the final authority for the acceptance or rejection of any article.

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