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A Qualitative Risk Assessment of Factors Contributing to Spread of Foot and Mouth Disease through Cattle Markets in Western Kenya

By Richard Onduso, Joshua Orungo Onono, Jackson Nyarongi Ombui
& Aondo Ezra Ochami

University of Nairobi

Abstract- There has been a surge in the number of Foot and Mouth Disease (FMD) outbreaks in western Kenya between the years 2016 and 2018. A qualitative risk assessment was done to investigate the role played by cattle markets in maintenance of these outbreaks. The specific objective of the study was assessment of factors contributing to spread of FMD through cattle markets in Western Kenya. Both qualitative and quantitative data were collected using a semi-structured questionnaire. Additional data collection was done through focus group discussions guided by checklist questions and secondary data obtained through review of published and grey sources of literature. The World Organization for Animal Health (OIE) framework was adapted for this study. The conduct of selected cattle markets was assessed to determining the risk for release and exposure of FMD virus during cattle trade. The study shows there was high risk of spreading FMD virus through cattle marketing activities.

Keywords: *risk assessment, foot and mouth disease, market conduct, western Kenya.*

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A Qualitative Risk Assessment of Factors Contributing to Spread of Foot and Mouth Disease through Cattle Markets in Western Kenya

Richard Onduso ^α, Joshua Orungo Onono ^σ, Jackson Nyarongi Ombui ^ρ & Aondo Ezra Ochami ^ω

Abstract- There has been a surge in the number of Foot and Mouth Disease (FMD) outbreaks in western Kenya between the years 2016 and 2018. A qualitative risk assessment was done to investigate the role played by cattle markets in maintenance of these outbreaks. The specific objective of the study was assessment of factors contributing to spread of FMD through cattle markets in Western Kenya. Both qualitative and quantitative data were collected using a semi-structured questionnaire. Additional data collection was done through focus group discussions guided by checklist questions and secondary data obtained through review of published and grey sources of literature. The World Organization for Animal Health (OIE) framework was adapted for this study. The conduct of selected cattle markets was assessed to determining the risk for release and exposure of FMD virus during cattle trade. The study shows there was high risk of spreading FMD virus through cattle marketing activities. Inadequate facilitation of veterinary department, trade on non-vaccinated cattle, cattle evaluation practices, cattle movement without permits, trekking cattle for long distances, lack of isolation of traded cattle at farms and visiting of many livestock markets within short period, were identified as risk practices which could increase the risk of FMD spread. This study recommend that some risk management measures' needs to be put in place, these include adequate resource allocation to the veterinary department, subsidizing of the strategic cattle vaccinations, provision of market place facilities and creation of awareness among traders on the roles they play in cattle disease control and management.

Keywords: risk assessment, foot and mouth disease, market conduct, western Kenya.

1. INTRODUCTION

Foot and mouth disease is a highly contagious, viral disease of domesticated and wild ruminants, characterized by high morbidity and low mortality (Coetzer et al., 1994). It has huge global economic impact due to large number of animals affected. These impacts include direct losses as result of reduced production and change of herd structure as it causes

abortions and infertilities, while indirect losses are due to control costs and limited access to markets (Knight Jones *et al.*, 2013). The disease has a global distribution and is endemic in many parts of the world, particularly Africa, Asia and regions of South America (Knowles *et al.*, 2003). The disease is caused by a single-stranded RNA virus of the family picornaviridae, a member of the genus Aphthovirus (Belsham *et al.*, 1993). The virus is genetically highly variable (Mertinez.salas *et al.*, 2011) and has seven immunologically distinct serotypes; Southern African Territories, SAT 1, SAT 2, and SAT 3, serotypes, A (Allemagne), C (Island Riems), O (Oise) and Asia 1 (OIE 2004). Within each serotype there are numerous strains (Van regenmortel *et al.*, 2000). The incubation period for FMD virus is between 1 - 14 days depending on virus strain and dose, as well as site of infection (Artz *et al.*, 2011). The virus is highly infectious, and it is produced in high titer in respiratory secretions and in large volumes, it is stable in natural environment and replicates rapidly. Foot and mouth disease virus spread rapidly in susceptible population. Infection of any one of the serotypes does not cause cross immunity against the other strains thus complicating the control of the disease during outbreaks (Sellers *et al.*, 1971). In Kenya FMD is endemic with type A, O, C, SAT 1, SAT 2 and SAT 3 serotypes being the most common strains (Vosloo *et al.*, 2002), and has a prevalence of 52% in Kenya and almost 100% in Western Kenya (Kibore *et al.*, 2013). Foot and mouth disease outbreaks are associated with many risk factors, these include; farm management, animal husbandry, animal trade, herd immunity, and human activity (Bronsvort *et al.*, 2005). While the virus can be transmitted from infected animal to susceptible animal in a number of ways; aerosol transmission which occurs mostly during physical or close animal to animal contact often following animal movement is the most common. This is closely followed by ingestion of contaminated materials; that can occur when there is consumption of contaminated water, concentrates or pastures (Donaldson *et al.*, 2001). Long distance spread can also occur through aerosol and fomite, or contaminated inanimate objects especially, motor

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vehicles, clothes and skin of animal handlers such as farmers and traders. Foot and mouth disease infected animals have high fever of between 39.4-40.6°C (103-105°F), that declines rapidly after two or three days, they develop vesicle lesions on dental pad, gums, soft palate, nostrils, inter-digital space, coronary bands, muzzle, teat, and on the tongue (Woodbury *et al.*, 1995) which later ruptures leading to copious discharge of contaminated saliva (foamy saliva and which is drooling), nasal discharge, smacking of lips, grinding of teeth, kicking of feet and lameness. Infected adult animals often lose weight, are anorexic, mature males develop swelling in the testicles, and in milking cows, there is significant decline in milk production. Most affected animals recover, a few, especially newborn ones, may develop myocarditis and eventually die (Stenfeldt *et al.*, 2014). Cattle farmers when faced with household financial need would sell their animals to meet these needs (African Union 2010). In livestock trade, animals are moved from different production system and long distances to the market where they interact with animals from various sources and to different destinations. Sometime animals are moved through many markets before they get a buyer or before they are to their final slaughter destination. Production systems which bring in animals from other farms have been found to be 2.2 times more likely to experience FMD outbreaks compared to farms which do not bring in animals from other farms (Bronsvort *et al.*, 2005). A study in Ecuador by Lindholm *et al.* (2007) reported that farms purchasing cattle from cattle market are 10.9 times more likely to have FMD outbreaks compared to herds which have not purchased cattle from markets. Allepuz *et al.* (2013) in their study in Tanzania had a similar finding in which they reported that FMD occurrence has a higher correlation with animal movement and human activities and related this to proximity to public roads and railway lines. Kenya has an estimated cattle population of 17.5 million and with an estimated annual off take of 2.9 million heads of cattle. The contribution of cattle to Kenyan GDP is estimated to be Ksh. 356.217 billion, of which Ksh.53.960 billion is derived from domestic farming (Behnke and Muthami 2011). In 2009, Kenya National Bureau of Statistics (KNBS) estimated that livestock provide about 45% of the total agricultural GDP in Kenya (GOK, 2012). Furthermore, it is estimated that the agricultural sector contributes about 26% of Kenya's GDP, and employs about 75% of the population (GOK 2005). In Kenya, beef production is mainly practiced by the pastoralist community who own about 12.2 million head of cattle and produce about two thirds of the Country's red meat (Behnke and Muthami 2011, Farmer *et al.*, 2012). In Western Kenya, cattle farming is practiced under small scale mixed farming system (Paul *et al.*, 2016). Semi-intensive management is the preferred management system with animals

communally grazed on open grazing fields. In case of disease outbreaks under such management systems, the effect would be huge since many cattle would be exposed within a short time, and huge costs would be incurred by the government and farmers to effectively control such outbreaks, hence the need for enhanced disease surveillance systems within the connected markets. Therefore, the objective of this study was to identify the risk cattle trading practices in the region which is crucial for designing an efficient disease control program and surveillance system.

II. MATERIAL AND METHODS

a) Description of study area

The study was conducted in Bungoma and Busia Counties of Western Kenya. The counties were purposively selected for the study because of their geographical location; they lie at transit line of beef cattle from producing counties; Turkana, West Pokot and Keiyo Marakwet to urban and peri-urban beef markets at Kakamega, Kisumu, Bungoma and Busia towns (Fig. 1). Busia County is at the Kenya Uganda border with two border crossing points at Busia and Malaba towns, and the communities staying in this county have their relatives in Uganda. Bungoma County borders Uganda and is home to Mt. Elgon national park, which is associated with FMD outbreaks in the region. Busia county is estimated to have a surface area of 1,695 square kilometers (Km²) and a population of 816 452 people while Bungoma County has a population of 1,375,063 people and surface area of 2,069 km². The economy of the two counties depends on agriculture, centering on livestock keeping and cultivation of sugarcane, maize and cassava. The Zebu and their crosses are the predominant breeds of cattle kept in the region (Wanjara and Njehia 2014). There are three major livestock marketing channels recognized in the region, which include butchers, speculators and dealers. Other actors in these markets are farmers, brokers (middlemen), transporters, revenue collection officers, and officers from veterinary office who issue movement permits.

b) Study units

A total of six markets were considered in the study, these markets were Bumala, Funyula and Amukura in Busia county and Kamukuywa, Chwele and Kimillili in Bungoma county. These markets were purposively selected. Funyula and Amukura were considered as major markets along Kenya Uganda border, Kamukuywa, Bumala, Kimillili and Chwele markets were considered as major markets located on cattle transit routes from Northern Kenya: Kenya Ethiopia border, Kenya Uganda Border through Turkana and West pokot Counties to major urban centers in western Kenya; Kakamega, Bungoma, Busia and Kisumu, in search of better market prices for their cattle.

c) *Data collection*

This was a cross-sectional study in which data was collected within a single period of time from the study area. This design was chosen because it was considered less expensive and required less time to collect data using participatory epidemiological tools. The data collected from this study allowed easy computation of the statistics from which interpretations were easily made. Data was obtained on the following key areas; animal movement, disease control activities, livestock trading activities, cattle pricing practices and characteristic of respondents using a structured questionnaire and focus group discussions (FGD) which were guided by checklist questions. The questionnaires were administered to traders who bought cattle from study markets, on one-on-one interviews with the respondents. Members of the focus group discussions comprised of; two traders, two farmers, county revenue collection officer and a staff from the sub-county animal production office. Data obtained from these key variables were on the sources and destination of traded animals, knowledge on FMD outbreaks in the region, if traders had been able to buy or sell cattle during quarantine periods, how movement permits were issued and their uptake by livestock traders, mode of transporting of trade cattle and average time taken to resale animals they buy, on isolation of traded animals at traders own farms and how cattle evaluation was done (table 1). More information was obtained from published and grey literature on the prevalence and strains of FMD in the region, structure and disease surveillance of veterinary department and on livestock management system in Western Kenya.

d) *Data analysis*

Questionnaire data were entered in Microsoft Excel spreadsheet then exported to statistical package on Social Package for Social Sciences (SPSS 20 Version) for analysis, while data obtained from oral discussions was transcribed into Microsoft word for further analysis. Qualitative risk assessment for the spread of FMD in connected cattle markets and farms was performed. The OIE risk assessment framework (OIE 2004) and the guidelines of Zepeda (1998) were used to do the qualitative risk assessment. The OIE risk assessment framework entails: hazard identification, release assessment, exposure assessment, consequence assessment and risk estimation. The following variables were evaluated and their risk ranked; organization of the veterinary structure, conduct of cattle traders, status of FMD in the region, cattle movement and epidemiological surveillance systems in place. The overall risk of release, exposure or consequences was determined using a combination matrix (Table 2). The descriptive scale developed by Zepeda, (1998) was used to rank the risk of occurrence of each event (Table 3).

e) *The study questions*

This study was attempting to answer the question of what is the risk of spreading FMD virus through cattle markets if infected animal is selected for sale in western Kenya markets (Fig. 2). The overall risk for the spread of FMD through cattle markets in the study area was assessed as a function of the risk of occurrence of the hazard and the consequences of that hazard occurring. The risk of occurrence of hazard was considered a product of the risk of release of FMD virus from infected animal in the market, the exposure of susceptible animal to FMD virus and the extent of spread of the FMD pathogen (Figure 3). Consequence assessment was done by considering the economic and public health impact of the disease to the local economy. The economic assessment was done by considering the predominant cattle breeds in the region, cattle uses, FMD status in the region and resources used in disease control in case of outbreak. Public health impacts were done by considering the zoonosis of the disease and challenges of disposing animals dying from the disease. The risk assessment in this study focused on the spread of the FMD virus through trade of live cattle activities. Spread through cattle products and other animal species (sheep and goats) were not considered in this study though it is a possibility.

III. RESULTS

a) *Demographic characteristic of respondents and Hazard identification*

A total of 250 out of 271 questionnaires were administered and completed by the respondents. Twenty-one (21) questionnaires were not fully completed and were therefore not used in the final analysis. Of the 250 traders who were interviewed, their distribution in the study markets, age and level of education is as given in table 4 and 5.

Prevalence of FMD virus in the region, practices of cattle traders and disease surveillance systems in place were considered in hazard identification. Data from the study area of 2-4 confirmed FMD outbreaks, positive response (98.4%) of traders on quarantine imposed in the area for the last two years and other risk practices of traders such as trading and moving animals during the quarantine period (26%) and previous study findings on FMD prevalence, serotypes, virus characteristic and market biosafety confirms the presence of FMD virus in the study area, (table 6A, presence of quarantine, movement during quarantine, confirmed FMD cases and FMD prevalence).

b) *Release assessment*

Risk of release of FMD virus into the cattle market environment after introduction of an infected animal was examined by considering four parameters namely; risk of infected cattle moving through the

livestock markets, survival capacity of the virus in the environment, practices related to cattle marketing in the region and volume of cattle traded in the study markets.

The risk of infected cattle moving through the market unnoticed is a function of the risk of occurrence of FMD in the region. This is dependent on; prevalence of FMD virus in the region, efficiency of the surveillance systems and FMD vaccination coverage. Prevalence of FMD virus in the region as discussed on hazard identification above was rated as high. The veterinary network in Kenya is well structured at both the national and county level. At the national level, there is the Director of Veterinary Services (DVS), who at the county level, is represented by the County Director of Veterinary services (CDVS). Sub-counties are under the Sub-County veterinary officer (SCVO), assisted by animal health assistants at the ward level. The CDVS are in charge of all disease control activities in their territories. Acute shortage of staff and funding were observed in the study, these present challenges in disease control and surveillance. Low coverage of animal vaccination was also observed, which was attributed to the fact that farmers paid for these vaccinations and most times, vaccinations were carried out long after the outbreaks had been contained, therefore farmers did not see value for this intervention. Due to poor funding whenever there was an outbreak it took time to collect and present samples for FMD confirmation and serotype identification at FMD laboratories located in Embakasi, Nairobi. The only laboratory with capacity to confirm FMD outbreaks in the whole Country, located over 400 km from the study area. The procurement of vaccines would delay the response time and at times even after the vaccine had been procured there would be further delay due to logistics of assembling the vaccination teams and transportation logistics. The low vaccination coverage implied continued presence of FMD virus in the study area. Data from focus group discussion revealed that sometimes it took up to six months to lift the imposed quarantine, with this lifted often without any vaccination campaign organized due to lack of funds. It was concluded that there was limited capacity with respect to disease surveillance, reporting and control of notifiable diseases in the area. Based on this information i.e almost 100% sero-prevalence of bovine FMD virus in Western Kenya, low vaccination coverage, poorly funded and understaffed veterinary departments, the risk of an FMD infected cattle moving through a cattle market unnoticed was categorized as high, (table 6D, veterinary network, staffing, funding and response time to an outbreak).

In the study area cattle are mainly kept in small scale mixed farms under semi-intensive management system, in which neighbors share grazing fields and watering points (table 6C, management system). Majority of the livestock traders (87%) do not

observe any bio-security measures (at their farms and market) while 61.3% trekked their traded cattle to and from the markets, animal movement permits were issued without consideration of animal disease situation in the area and some traders (26.8%) were moving animals without movement permit, (table 6B, transport mode and obtain movement permit). The survival of FMD virus in the environment was rated high.

Cattle marketing practices which were considered include mode of transporting trade animals (61.2% trekked), time taken to resale animal bought from the market (86.6% sold their stock within four days), animal evaluation (47.6% used visual evaluation while 31.2% used both visual and weight evaluation), source, origin and destination of animals and trader's level of respect and actions with regard to quarantine measures. Based on trader's response on above factors, the risk of disseminating FMD virus by movement of trade animals was thus rated high.

On average, at each market day the 250 traders transacted a total of 2,052 animals which translates to 8 animals per trader per day. The risk of FMD spread was rated high given that hundreds of animals are traded each market day, their source and origin vary, and are destined to markets within and outside the region (table 6B, animal source, origin and destination)

c) Overall release assessment

The matrix proposed by Zepeda (1998) was used in the overall release assessment. The risk of FMD virus release from infected animal to the environment was a function of combination of risks relating to the risk of an infected animal moving through the livestock market chain which was rated high, the risk of FMD virus survival in the environment which was rated high, risks due to trader's marketing activities categorized as high, and risk due to volumes of traded cattle rated as high. The risk of traded cattle contaminating the environment with FMD virus was rated as high (Fig.3, A).

d) Exposure assessment

The parameters considered in determining the risk of exposure were; risk of market animals making infectious contacts, risk of cattle from markets not being quarantined and risk of FMD transmission within and between the farms.

Herd immunity is a function of vaccination coverage and vaccine efficacy. Vaccination coverage depends on vaccination campaign efficiency and commitment of farmers to present their cattle for vaccination. Data obtained in the study revealed that farmers were not willing to present their animals for vaccination, likely because of limited resources, but also because they did not see the value of this intervention since their animals were not always sick at the time of the vaccination, (table 6D, Vaccination coverage (poor) and herd immunity (low)). The study observed that veterinary departments do not have enough

resources to carry out regular vaccinations, sometimes vaccinations were carried out long after the outbreaks had been contained. Generally, vaccination coverage was low. Based on the fact that there are seven immunologically distinct serotypes each with numerous strains and given that infection with any one of the serotypes does not confer immunity of the other serotypes, a large proportion of cattle population were susceptible to the disease (table 6A, FMD serotypes and virus characteristic). In the market, each trader or a group of traders grouped their animals together. Market grounds were often used as grazing fields by the surrounding community during non-market days (table 6A, market bio-security). Based on the above that there were no regular FMD vaccinations, low commitment from livestock farmers to take animals for vaccinations, and low bio-security measures observed in the market the risk of FMD infected animals making infectious contact in the study markets was considered to be high.

It is common for traders to take purchased animals to their farms, for fattening or perhaps awaiting the next market day. Animals purchased from the markets were grazed, watered and penned together with other animals in the farm without proper examination and observation for disease (table 6C, Isolation at farms). If any of the animal brought into the farm was a carrier or had sub-clinical FMD it would contaminate the whole farm and infect all susceptible animals in that farm. Effective quarantine requires complete restriction of animal movement, while being examined for development of diseases; proper restraining facilities such as fence and trained personnel were needed. Considering the setting of farms in western Kenya (Wanjara and Njehia 2014), this was not possible at farm level which implies a high risk of spreading FMD from animals bought from markets to animals found in the farms.

The risk of FMD transmission to susceptible animals was assessed by considering the mode of spread of FMD virus and the virus characteristic in terms of virus production, virus survival in the environment and infectiousness. FMD spreads rapidly through movement of infected animals or mechanically through fomites such as contaminated vehicles, visitors and animal handlers, clothing, feeds, and veterinary inputs. The virus is produced in high titer and in large volumes by infected animals, it is stable and replicates rapidly and has a short incubation period of 2 to 12 days. Additionally, it has many serotypes, and immunity against one strain does not confer immunity against other serotypes, causing challenges in the disease control, (table 6A, FMD serotypes and virus characteristic). Traders were not taking any bio-security at their farms, trade animals were not quarantined and their farms were not isolated from neighboring farms, they were moving from one market to another and were able to resale their animals within a short period of time.

(table 6B, time to resale), Based on the above facts the risk of FMD virus transmissions was rated high.

e) *Overall exposure assessment*

The risk of exposure resulting from the combination of the four parameters examined: risk of an infected animal making susceptible contacts (high), risk of marketed animals making infectious contacts (high), risk of cattle from the market not being quarantined (high) and risk of FMD transmission within and between the farms (high), was thus considered to be high (Fig. 3, B).

f) *Magnitude of the consequences*

Outbreaks of FMD in Western Kenya have high economic impacts to the local economy. Though farmers do not loose animals to the disease, but when livestock markets are closed, traders cannot sell or buy, thus they lose sources of their daily income (they cannot meet their family obligations such as paying school fees for their children). Furthermore, the government would spend a lot of resources for ring vaccinations to control the outbreak. There is negligible impact on public health since the disease does not affect humans and the disease has low mortality. The magnitude of the consequences was thus rated as moderate.

g) *Overall risk assessment*

The overall risk assessment for occurrence of the hazard (FMD virus spread) in western Kenya was considered to results from the combination of all perceived risk factors assessed under risks of release and exposure and both cases considered as high. Thus, the risk of occurrence was considered to be high (Fig. 3, C). The overall risk was assessed as the combination of the risk of occurrence (high) and of the consequences of occurrence (moderate), thus rated as high (Fig.3, D).

IV. DISCUSSION

This study used a simple and acceptable methodology as described by world organization of animal health (OIE). It is a preliminary step in the process of building more sophisticated qualitative or quantitative risk assessment models. The data collection methods used in the study has been used by other epidemiological survey study of, risk assessment in Danish swine population (Bronsvort *et al.*, 2005). The study is the first of its kind in the region, therefore forms the basis of more funded and structured studies to be used in disease surveillance policy formulation. All the markets selected for the study lacked the basic facilities and adequate staff for screening cattle diseases making it possible for infected animals to go through the market un-detected. This is especially so when dealing with cattle traders whose main objective is moving from one market to another while buying and selling to make profit. This implies that FMD infected animal could be moved in more than one market before

showing clinical signs of the disease, in the process infecting many animals. Most of the traded animals were trekked to and from the market, this causes more environmental contamination as the animals' graze, drink, defecate and sometimes they get into contact with other animals while on transit. Traders were not taking much consideration of the immunity status of the cattle they handled, they were estimating animal value by palpation of the animal with bare hands and generally there was lack of bio- security measures in their farms and the markets they visit which is a concern for the success of FMD control. The movement of FMD infected cattle to the market has been reported as a risk factor in the FMD virus spread during the outbreaks in Britain and Netherland (Donnelly *et al.*, 2001). Lack of enforcement of restrictions for animal movement and trade on non-vaccinated animals were some of the factors which enable FMD infected cattle to reach the market thus making them a hub of disease transmission. Movement permits were being issued as a formality in the markets visited as opposed to being a disease surveillance tool, cattle were not being examined prior to issuance of movement permit and not all traders obtained the permit yet they were able to move their animals. The capacity of veterinary department with respect to veterinary disease surveillance, reporting and control of notifiable diseases in the area were affected by shortage of both staff and funds. This has the potential to cripple its ability to carry out effective disease surveillance. For instance, due to poor funding and staffing of veterinary department whenever there was an outbreak it took time to collect samples send them to the FMD laboratory for confirmation and serotype identification, procure vaccines, assemble a temporally vaccination team and organize transport logistics. For this reason, disease quarantine could take up to six months to be lifted in the study area, this discourages traders whose only source of income is buying and selling of cattle and in the process, they find ways to violate the quarantine law thus putting the cattle population at risk of spread of communicable diseases. Traders confirmed as being able to trade and move animals when there was quarantine in place. This was possible as buying and selling can take place at farms and along the roads outside the market, an indication of lack of adequate reinforcement. Despite the fact that FMD was endemic in western Kenya, vaccinations were irregular and characterized by poor turnout. This was attributed to the fact that farmers paid for these vaccinations and most times, vaccinations were carried out long after the outbreaks had been contained. With poor turnout there is low vaccination coverage which results to low herd immunity and therefore a large susceptible population. The overall results for this study support the hypothesis that cattle marketing activities in Western Kenya have a potential effect on the transmission of FMD within connected farms and systems.

V. CONCLUSION

The study calls for adequately funding of the veterinary department to enable it improve on its capacity to conduct adequate and efficient epidemiological surveillance. Veterinary officers needs to follow due procedure in issuing of movement permit and putting in place of quarantines and law enforcement agents needs to implement them fully while farmers and traders needs to respect the quarantines. There is need to review animal movement policy in the country in order to have structures in place to trace cattle movement and to improve on the perception on movement permit and quarantines in the region, they should be regarded as tools of disease control as opposed to revenue generating tools. There should be collaboration of the National government of Kenya and respective county governments to conduct subsidized FMD strategic vaccination programs to improve on herd immunity thus reducing the virus survival in the environment. Market place facilities need to be improved by provision of weighing scale and other bio-safety measures. Traders should be organized to form groups / cooperative and trained on roles they play on spread of cattle diseases and tracking animal movement.

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Conflict of interest

The authors declare that they have no conflict of interest on this work and its publication.

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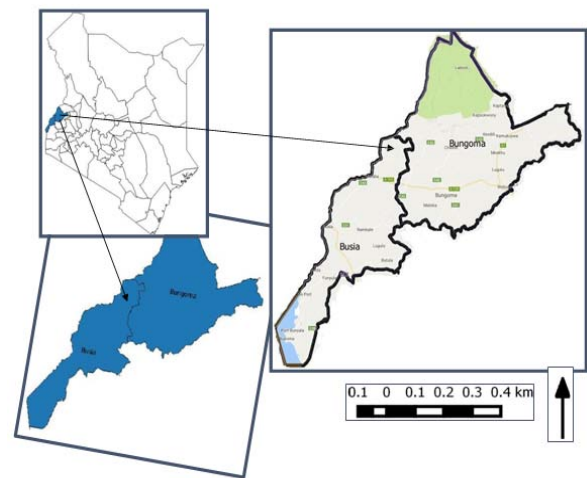


Figure 1: Map of Kenya showing study area (Busia and Bungoma Counties)

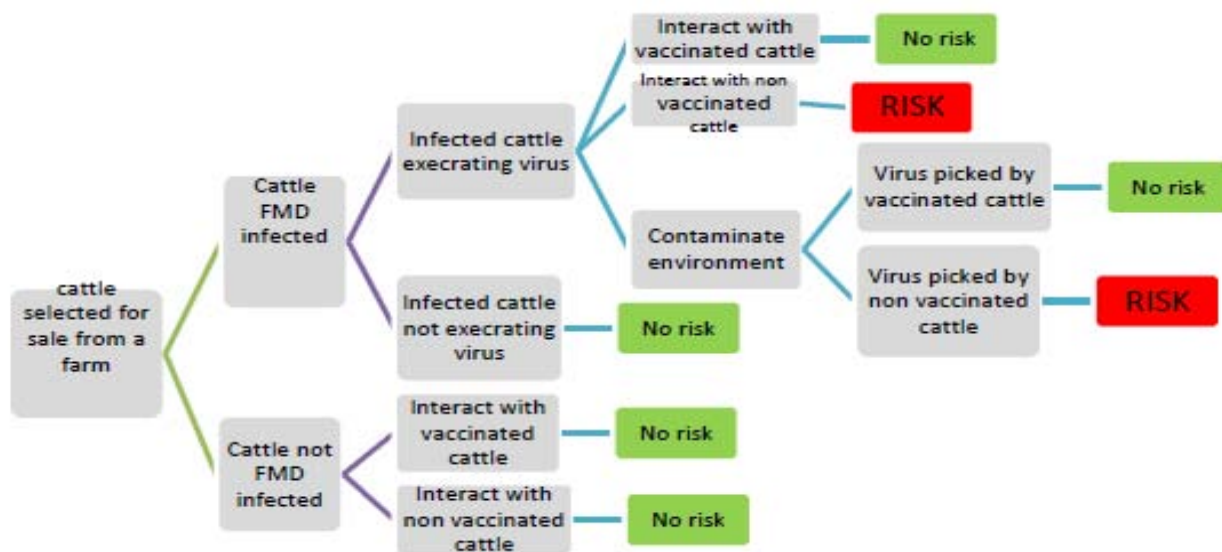
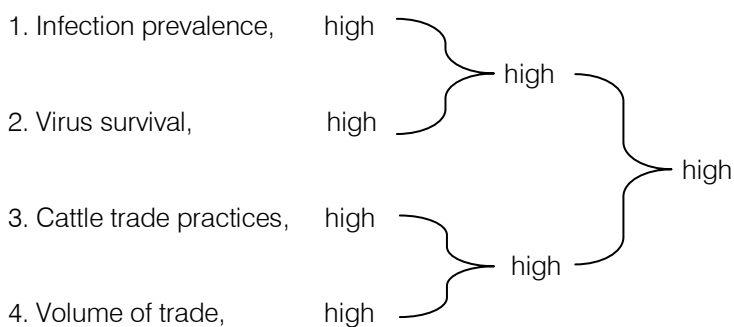
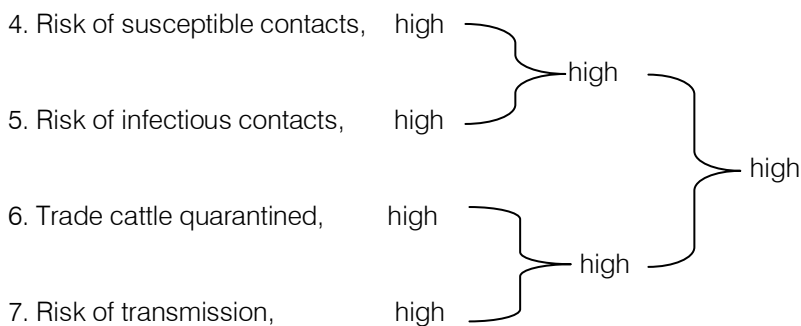


Figure 2: Risk assessment framework for the spread of foot and mouth disease through cattle markets in western Ken

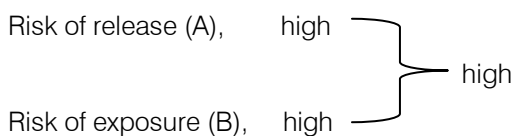
A. Risk of release



B. Risk of exposure



C. Risk of occurrence of hazard



D. Overall risk assessment

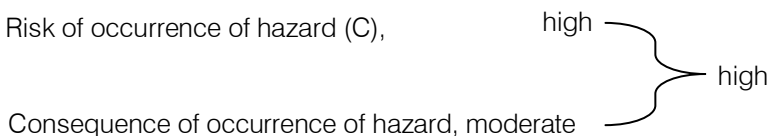


Figure 3: Risk of occurrence of various risk factors using descriptive scale and classification matrix defined by Zepeda (considering two factors at a time)

Table 1: Variables together with their measurements

Variable	How variable was measured
FMD prevalence	Expressed in percentage (%) from previous study findings
FMD serotypes	Expresses in No. of FMD strains reported to have been confirmed in the country by previous studies
Virus characteristics	As described by other studies
Market bio-security	Described by observing various market place parameters and traders' activities
Confirmed FMD cases	No. of FMD confirmed cases as obtained from FGD
Movement during Quarantine	Categorized into two levels, 1) Yes, traders were able to move animals through quarantine area and, 2) No, traders were not able to move animals through quarantine area
Presence of quarantine	Traders were asked if there has been any quarantine in their area of operation and Categorized into two levels, 1) Yes, 2) No.
Mode of transport	Trade animals were transported to and from the market by, 1) Trucking 2) Trekking
Movement permit	Traders were grouped into 1) Yes, those who obtained animal movement permit and, 2) No, those who did not obtain movement permit
Origin of animal	Categorized into 4 levels depending on where animals traded were coming from. 1) Same county, 2) Neighbouring county, 3) Distant county and 4) Uganda
Animal destination	Categorized into 3 levels based on where animals bought from study markets were to go. 1) Same county, 2) Neighbouring county and, 3) Distant county.
Time to resale	Traders were categorized into 3 levels depending on the time they take to resale the animals they bought from study markets, 1) 1-2 days, 2)3- 4 days, 3) 5and above days
Source of animal	Animals brought for sale were obtained either from 1) Farm or 2) other Markets
Purpose of buying	Animals bought from study markets were either for 1) Resale, 2) Slaughter, 3) Breeding or
	4) Others
Animal evaluation	Animals were evaluated to estimate their value by 1) Weight, 2) Visual or 3) both

Isolation at farm	Traders are supposed to isolate their trade animals from other animals at their farms. There were two groups, 1) Yes, isolates trade animals at their farms. 2) No, do not isolate trade animals from other animals at their farms
Management system	This was based on the findings of other studies in the region
Veterinary stuffing, network and funding	These were based on how they were described by the FGD
Vaccination coverage	This was based on information from the veterinary records and information from FGD
Heard immunity	Assessed by considering the vaccination program in place and turn out to those vaccinations
Response time to outbreak	This is days taken from when an outbreak is confirmed to when an appropriate action is taken.

Table 2: Combination matrix table used when two parameters are considered (Zepeda Sein1998)

Risk of parameter I	Risk of parameter II			
	Negligible	Low	Moderate	High
Negligible	Negligible	Low	Low	Moderate
Low	Low	Low	Moderate	Moderate
Moderate	Low	Moderate	Moderate	High
High	Low	Moderate	High	High

Table 3: Interpretation of Qualitative risk ratings (Zepada sein 1998)

Term	Meaning on event occurrence	Meaning for consequence
Negligible	Occurrence of the event is possible Only on exceptional circumstances	Low or no impact
Low	Occurrence of an event is a possibility in some cases	Minor impact
Moderate	Occurrence of the event Is a possibility	Average impact
High	Occurrence of the event is Clearly a possibility	Serious impact

Table 4: Distribution of respondents and the number of animals they traded.

No.	Cattle market	No. of sampled Traders	No. of cattle Traded
1	Funyula	18	93
2	Bumala	20	141
3	Amukura	15	73
4	Chwele	40	347
5	Kimilili	76	677
6	Kamukuywa	80	721
	Total	250	2052

Table 5: Demography of the respondents.

Demographic factor	Demographic category	frequency (n=250)	Percentage (%)
Age	0 – 30 years	56	22.4
	30 – 50 years	141	56.4
	50 and above years	53	21.2
Education	No formal education	40	16
	Primary education	96	38.4
	Secondary education	84	33.6
	Post-secondary education	30	12

Table 6: Summary table of responses of themes and variables as obtained from the study

Theme number	Theme	Variables	Response frequency and percentage (n=250)	Variable rating	Source
A	FMD prevalence and virus characteristic	Presence of quarantine	Yes – 246 (98.4)	High	Traders
		Movement during quarantine	No – 4 (1.6)	High	Traders
		Confirmed FMD prevalence	Yes – 65 (26)	High	FGD
		FMD serotypes	No – 185 (74)	High	Kibore et al. (2013)
		Virus characteristics	2 – 4 outbreaks (50 -100%)	High	Vosloo et al. 2013
B	Animal movement	Market bio-security	Six strains	High	Sellers et al.1971
			No cross immunity	High	Traders
			Two out of six markets fenced, cattle randomly mixed in the market	High	Traders
		Mode of transport	Truck – 97 (38.8) Trek – 153 (61.2)	High	Traders
		Movement permit	Yes – 183 (73.2) No – 67 (26.8) Same county -763 (37.1)	High	Traders
		Origin of animal	Neighbouring county – 697(33.9) Distant county- 507(24.7)	High	Traders
		Animal destination	Uganda – 85 (4.1) Same county – 780 (38) Neighbouring county – 676 (32)	High	Traders
Time to resale	Distant county – 596-(29) 1 2 days – 139 (55.6)	High	Traders		
Source of animal	3 – 4 days – 75 (30) 5 days and above-36 (14.4)	High	Traders		
Purpose of buying	Farm – 54 (21.6) Market – 196 (78.4)	High	Traders		





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Maize Vegetative Growth Response to Poultry Manure and Sowing Date during Delayed onset of Rainfall in a Humid Agroecology of Nigeria

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Abstract- Soil moisture deficit due to delayed onset of rainfall creates stress conditions at the early season when maize is at the early vegetative stage of growth. In 2009 and 2010 the impact of poultry manure and sowing date on maize vegetative growth during delayed onset of rainfall was assessed in a rainforest agroecology of Nigeria. The treatments comprised four sowing dates (February 28, March 15, March 30 and April 14), three maize varieties (TZE COMP3C3, TZL COMP4C3 and OKA AWAKA) and two poultry manure rates (0 and 10 tons ha⁻¹). These treatments were arranged as a split-split plot and laid out in randomized complete block design with three replications. Maize vegetative parameters, including height, number of leaves, leaf area and stem dry weight were significantly affected by year of cropping, thereby indicating inter-annual variability in climatic variables.

Keywords: *delayed onset, maize, moisture deficit, poultry manure, rainfall, sowing date.*

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N. C Adikuru ^α & I. J Ogoke ^ο

Abstract- Soil moisture deficit due to delayed onset of rainfall creates stress conditions at the early season when maize is at the early vegetative stage of growth. In 2009 and 2010 the impact of poultry manure and sowing date on maize vegetative growth during delayed onset of rainfall was assessed in a rainforest agroecology of Nigeria. The treatments comprised four sowing dates (February 28, March 15, March 30 and April 14), three maize varieties (TZE COMP3C3, TZL COMP4C3 and OKA AWAKA) and two poultry manure rates (0 and 10 tons ha⁻¹). These treatments were arranged as a split-split plot and laid out in randomized complete block design with three replications. Maize vegetative parameters, including height, number of leaves, leaf area and stem dry weight were significantly affected by year of cropping, thereby indicating inter-annual variability in climatic variables. At 42 days (6 weeks) after planting, soil moisture deficit reduced height, number of leaves and leaf area by 55.7, 22.2 and 65.5 % respectively and consequently led to 80.3 and 73.0 % reduction in dry weight of stem and leaf respectively when maize was planted on February 28 compared to March 30. However, application of poultry manure reduced the impact of moisture deficit and led to improvement in height, number of leaves, leaf area, stem and leaf dry weight by 131.6, 44.2, 184.3, 211.4 and 215.8 % respectively. This study shows that during delayed onset of rainfall in the rainforest agroecology of Nigeria, maize vegetative growth and dry weight can be enhanced through delayed planting and application of moisture conservation strategies including poultry manure application.

Keywords: *delayed onset, maize, moisture deficit, poultry manure, rainfall, sowing date.*

I. INTRODUCTION

Change in rainfall pattern is a manifestation of climate change (Jones and Thornton, 2003). It is characterized by delayed onset and early cessation and leads to the shortening of the growing season across southern (humid) Nigeria in particular (NIMET, 2008). Delayed onset of rainfall causes soil moisture deficit, high solar radiation, reduced humidity and high evapotranspiration there by creating moisture stress condition at the early season (Campos *et al.*, 2004). Solar radiation receipts in this region are highest around October/November (rainfall cessation) and February / March (rainfall onset) while lowest values are

recorded around June/July (rainfall peak) (Augustine and Nnabuchi, 2010). With a mean maximum temperature between 30°C and 32°C almost through the year (Adejuwon, 2004), evapotranspiration exhibits similar trend as solar radiation with high rates between February and March and lowest rates between July and September (Chinekeet *al.*, 2011). The tendency therefore is for spells of soil moisture deficit to occur in these humid areas (Adejuwon, 2004) particularly between February and April. According to Adikuru *et. al.*(2020), delayed onset of rainfall in Owerri, southeastern Nigeria is the consequence of a shift in rainfall pattern within the months of February and March and it results in moisture deficit. Prior to the incidence of climate change, maize was traditionally planted at the beginning of the rains in March. Therefore the period of delayed onset of rainfall when moisture deficit often occurs in this location, coincides with the early vegetative stage of maize growth. The vegetative stage of maize development is physiologically designed for interception of radiant energy and conversion of same to dry matter (Maddoni and Otegui, 1996; Moore *et. al.*, 1998) which is later remobilized to the kernels during the period of rapid kernel growth (Setter and Meller, 1984). Hence, moisture stress at the vegetative growth stage causes reduction in total biomass accumulation (Otegui *et. al.*, 1995; Khan *et. al.*, 2001) through its effect on cell enlargement and cell division and consequently leaf expansion (Jones, 1992; Nonami, 1998).The high sensitivity of leaf growth to water deficits is considered to be a 'stress avoidance' mechanism, because it enables plants to tolerate severe drought conditions by saving soil water (Lopes *et. al.*, 2011).The objective of this study was to assess the performance of maize planted at different dates with a view to determine the impact of moisture deficit on the vegetative growth of maize in Owerri.

II. MATERIALS AND METHODS

a) Location of Experimental Site

This experiment was carried out in 2009 and 2010 at the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The experimental site which is in the rainforest ecological zone of Nigeria lies

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between latitudes 5° 20'N and 5° 27'N and longitudes 7° 00'E and 7° 07'E. The location which is found in Southeast Nigeria, experiences annual rainfall of 2500 mm and minimum and maximum annual ambient temperature of 20°C and 32°C respectively, while the soils are classified as Arenic Hapludult (USDA, 1999). The rainfall pattern is seasonal and double maxima with a short dry season period (commonly referred to as August break) from July to August (Odjugo, 2005).

b) *Treatments and Design of the experiment*

The experiment which was laid out as a split-split plot in randomized complete block design comprised four sowing dates (February 28, March 15, March 30 and April 14), two poultry manure rates (0 and 10 tons per hectare) and three maize varieties. The treatment combinations obtained (24) were replicated three times. While maize varieties constituted the sub-subplot, poultry manure was the sub-plot treatment and sowing date the main plot. Each sub-subplot measured 3.75 x 3.0 m², subplots measured 3.75 x 11.0 m² and main plots measured 8.5 x 11.0 m². The International Institute for Tropical Agriculture in Ibadan Nigeria supplied the seeds of the maize varieties- TZE COMP3C3 (early maturing) and TZL COMP4C3 (late maturing)- while the third variety (OKA AWAKA) was a landrace from Awaka in Owerri North local government area of Imo state, Nigeria.

III. DATA COLLECTION & STATISTICAL ANALYSIS

A population of 53,333 plants ha⁻¹ was established by planting two maize seeds per hill at a spacing of 0.75 x 0.25 m and thinning the seedlings to one per hill at three weeks after planting (WAP). After growing for 6 weeks (42 days), the plant height, number of leaves, leaf area, stem and leaf dry weight of the maize varieties were measured. Subsequently, analysis of variance procedures for a split-split plot design using Genstat 7.2 (Discovery Edition 3) were employed in analyzing the data. Means were separated using the least significant difference.

IV. RESULTS AND DISCUSSION

a) *Description of climatic variables at the study location*

The total rainfall received at the study site for the period of the experiment (February – August) in 2009 and 2010 was 1,816.4 and 1191.9 mm respectively. In 2009, the location experienced average maximum and minimum temperature of 34.5 and 17.4°C, while in 2010 it was 37.3 and 18.3°C respectively (Table 1). Average relative humidity for the location was 79.5 and 76.6 % for 2009 and 2010 respectively. Obviously, the location received more rainfall in 2009 than 2010. This resulted in higher relative humidity and lower temperature (79.5 % and 34.5°C) in 2009. Therefore drier conditions were

experienced in 2010 when compared to 2009 thereby indicating inter-annual variability in climatic condition in the study location. These temporal variations which are prevalent within the country (Afangideh *et. al.*, 2010) indicate uncertainty in climatic variables from year to year. Therefore performance of maize in the location will depend on the prevailing climatic conditions in a season (Adikuru *et. al.*, 2020). However, within both seasons the pattern of rainfall was largely the same.

b) *Maize vegetative growth response to season*

Inter-annual variability in climatic conditions at the study location is confirmed by the significant differences in height ($p=0.019$), stem dry matter ($p=0.015$) and highly significant differences in leaf area ($p=0.004$) between 2009 and 2010 (Table 2). This is an indication of uncertainty in climatic variables from year to year (Adikuru *et. al.*, 2020) and significant impact of climatic factors on maize development (Oluwaranti *et. al.*, 2015). The difference in climatic factors between the years led to significant differences in maize vegetative growth. Hence, the effect of year x variety interaction was highly significant on height ($p=0.003$), number of leaves ($p=0.001$) and leaf area ($p=0.003$). Adikuru *et. al.*, (2020) had reported that inter-annual variability in climatic factors only caused a minor year x variety interaction effect at the reproductive stage of maize development. This suggests that the effects of change in climatic factors are more significant on maize at the vegetative than the reproductive stage of development. This is due to the fact that moisture stress associated with climate change in the area occurs at the early vegetative stage of maize development. Furthermore, increase in soil moisture availability at the later stages, due to increase in rainfall, enables maize to recover from the adverse effect of moisture deficit at the early stages.

c) *Effect of time of planting on maize vegetative growth*

The effect of time of planting was highly significant ($p=0.001$) on all the parameters (Table 3). This must have resulted from the variation in available moisture determined by the prevailing rainfall and temperature conditions at the different time of planting. Across the planting months and in both years, total rainfall at the study site was lowest in February (65.8 and 36 mm) and highest in April (237.8 and 125.5 mm), while maximum temperature was generally the same. Consequently, moisture availability was lowest in February and highest in April most likely due to higher evapotranspiration in February when compared to April (Odjugo, 2010; Chineke *et. al.*, 2011). Maize planted on March 30 did not differ significantly from maize planted on April 14 in all parameters except in leaf area where it grew significantly greater by 14.3%. Therefore during delayed onset of rain in this location, optimum vegetative development of maize can be achieved by delaying planting till about March 30. When compared with maize planted on February 28, maize planted on

March 30 had 125.9, 28.5, 190.2, 408.8 and 270.5 % increase in plant height, number of leaves, leaf area, stem and leaf dry matter respectively. This implies that moisture deficit caused a 55.7, 22.2 and 65.5 % reduction in height, number of leaves and leaf area respectively when maize was planted on February 28 compared to March 30. Accumulation of dry matter in stem and leaf was therefore reduced by 80.4 and 73.0 % respectively due to moisture deficit. Maize is affected directly and indirectly by moisture stress at all stages of development with the overall effect being the reduction in growth (Schussler and Westgate, 1991; Danquah *et al.*, 2001; Khan *et al.*, 2001; Anjum *et al.*, 2011). At the vegetative growth stage, reduction in plant height, stem diameter and leaf area with increasing water stress causes reduction in total biomass accumulation (Khan *et al.*, 2001). Reduction in dry matter production when maize encounters water deficit is a result of decline in photosynthesis per plant. Decline in photosynthesis can be due to a reduction in light interception as leaf expansion is reduced or as leaves senesce, and to reduction in carbon fixation per unit leaf area as stomata closes or as photo-oxidation damages the photosynthetic mechanism (Bruce *et al.*, 2002).

d) *Response of maize vegetative growth to poultry manure application*

The effect of poultry manure application was highly significant ($p=0.001$) on all the parameters (Table 3). Maize height, number of leaves, leaf area, stem and leaf dry matter significantly increased by 106.2, 24.0, 159.0, 117.5 and 115.9 % respectively in response to 10 tons ha^{-1} of poultry manure. Similar result had been reported by Uduma and Eka (2006). Poultry manure improves soil organic matter, increases availability of exchangeable cations and thus enhances crop growth (Onwuka and Asawalam, 2006; Boateng *et al.*, 2006). Significant sowing date x poultry manure effect indicate that response of maize vegetative parameters to poultry manure application was highly dependent on time of planting (Iken and Amusa, 2004). It also showed that application of poultry manure reduced the impact of moisture deficit and led to improvement in height, number of leaves, leaf area, stem and leaf dry weight by 131.6, 44.2, 184.3, 211.4 and 215.8 % respectively after 42 days from planting. The greatest responses occurred when maize was planted on February 28 and April 14. This suggests that when maize is planted before the onset of rains, poultry manure could absorb the moderate moisture available in the soil and release same along with nutrients at dry moments. When the rains are established, the role of poultry manure basically becomes the supply of nutrient elements. Therefore poultry manure could play a dual role of supplying nutrient and moisture conservation (Ewulo *et al.*, 2008; Adeyemo and Agele, 2010). However, this study could not determine the extent to which each role

contributed to the total effect on vegetative growth. The response of maize varieties to poultry manure application did not differ significantly in all the parameters except number of leaves ($p=0.002$), just as the effect of poultry manure on all the parameters except stem dry matter did not differ significantly between the years. The year x sowing date x poultry manure interaction was highly significant ($p=0.001$) on all the parameters except leaf dry matter. This shows that the effect of poultry manure neither depends on the variety of maize nor the year but in response to time of planting the effect of poultry manure depends on the year. The implication is that response of maize vegetative development to application of poultry manure (and perhaps other amendments) in the location depends on time of planting (Iken and Amusa, 2004). This may be attributed to differences in moisture availability at the different planting times since moisture is required for absorption and translocation of dissolved nutrients.

e) *Varietal differences in vegetative growth of maize*

Among the maize varieties, significant differences occurred in plant height ($p=0.016$) while highly significant differences ($p=0.001$) occurred in number of leaves and leaf area (Table 4). When compared with TZL COMP4 C3, the landrace OKA AWAKA grew taller by 14.7 % had 6.6 % more leaves and 21.7 % larger leaf area. Similarly, OKA AWAKA had 6.8 % more leaves and 20.1 % larger leaf area when compared with TZE COMP3 C3. There were no significant differences between TZE COMP3 C3 and TZL COMP4 C3 in all the parameters. According to Ngwuta *et al.* (2015), maize landrace varieties planted in southeastern Nigeria are usually significantly taller than improved varieties and phenotypic variations among maize genotypes are attributable to genetic and environmental control. The effect of sowing date x variety interaction was significant on plant height ($p=0.012$) and highly significant on number of leaves ($p=0.002$), stem dry matter ($p=0.001$) and leaf dry matter ($p=0.001$). The year x sowing date x variety interaction was however, highly significant on only number of leaves ($p=0.001$). This indicates that the vegetative development of maize varieties depended largely on the time of planting but this response of maize varieties to time of planting did not depend on the year. Therefore, the maize varieties used in this study differed in their sensitivity to moisture deficit at the vegetative stage within a season and this effect was largely the same from season to season. This suggests the existence of variability for development of drought tolerant maize genotypes adaptable to the rainforest agroecology.

V. CONCLUSION

Moisture deficit occurs in Owerri southeast Nigeria at the early season when maize is at the early

stage of vegetative development. As expected, vegetative development of maize was significantly reduced and this also led to reduction in dry matter accumulation. However, sensitivity to moisture deficit varied among maize varieties. Therefore exploitable variability exists for development of drought tolerant maize genotypes adaptable to the rainforest agroecology. From this study, we conclude that delaying planting and applying poultry manure for moisture conservation and nutrient supply are effective strategies to reduce the impact of moisture deficit on maize growth in the rainforest agroecology. Furthermore, landraces may be very important as genetic reservoir for the development of drought tolerant varieties in the region and therefore needs preservation.

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Table 1: Rainfall temperature and relative humidity in 2009 and 2010 at Owerri Nigeria

	Rainfall (mm)		Temperature (°C)				Relative humidity (%)	
	2009	2010	2009		2010		2009	2010
			Max.	Min.	Max.	Min.		
January	39.4	33.0	34	15	37	17	76	72
February	65.8	36.0	35	14	36	19	78	71
March	81.5	36.2	35	15	36	19	76	70
April	237.8	125.5	35	14	37	18	80	76
May	250.2	382.0	34	15	30	18	79	77
June	208.9	207.7	36	17	38	19	80	78
July	486.3	86.1	33	18	39	19	87	80
August	485.9	318.4	33	18	39	18	89	83
September	558.1	382.2	32	20	39	18	79	80
October	207.2	398.8	37	21	39	18	83	79
November	111.8	108.6	35	21	39	19	76	78
December	0.0	0.0	35	21	39	17	71	75

Table 2: Analysis of Variance for maize vegetative parameters at 6 weeks after planting

Sources of variation	df	Height	No. of Leaves	Leaf Area	Stem Dry Matter	Leaf Dry Matter
Replication	2	339.10	0.71	162124.00	3.41	13.40
Year (Y)	1	1618.30*	2.56	2333984.00**	202.49*	53.89
Error a	2	32.20	0.42	8996.00	3.01	4.35
Sowing Date (SD)	3	11460.50**	28.15**	9223812.00**	184.75**	478.68**
Y x SD	3	1409.40	1.07	1994467.00**	44.76**	14.90
Error b	12	466.30	1.16	80194.00	2.62	6.75
Poultry Manure (PM)	1	40299.60**	68.89**	42670399.00**	155.79**	536.27**
Y x PM	1	4.40	0.05	6459.00	25.35**	1.52
SD x PM	3	3429.20**	2.25**	3779076.00**	32.65**	85.53**
Y x SD x PM	3	2184.60**	3.10**	275023.00**	8.25**	0.44
Error c	16	108.40	0.13	126918.00	0.89	2.37
Variety (V)	2	604.40*	2.92**	928142.00**	1.95	0.08
Y x V	2	884.60**	2.18**	717457.00**	2.12	5.69
SD x V	6	410.40*	0.93**	223388.00	4.31**	9.44**
PM x V	2	2.10	0.97*	184835.00	0.66	2.46
Y x SD x V	6	235.70	1.88**	80775.00	1.06	3.60
Y x PM x V	2	183.80	1.97**	405798.00*	0.91	2.07
SD x PM x V	6	131.20	0.67*	185144.00	1.06	3.56
Y x SD x PM x V	6	121.90	0.94**	203053.00	0.91	2.59
Error d	64	137.60	0.23	112337.00	0.76	2.20
Total	143					

** and * indicate significance at 1 and 5 % levels of probability respectively

Table 3: Effect of sowing date and poultry manure on maize vegetative parameters at 6 weeks after planting

Sowing Date	Poultry Manure	Height (cm)		No. of Leaves		Leaf Area (cm ²)		Stem Dry Matter (g)		Leaf Dry Matter (g)						
		0	10	Mean	0	10	Mean	0	10	Mean	0	10	Mean			
FEB 28		17.79	41.20	29.49	4.43	6.39	5.41	312.00	887.00	599.00	0.44	1.37	0.90	1.14	3.60	2.37
MAR 15		31.44	42.40	36.92	5.78	6.60	6.19	819.00	1303.00	1061.00	0.60	0.99	0.79	1.42	2.30	1.86
MAR 30		42.64	90.61	66.62	6.14	7.76	6.95	941.00	2535.00	1738.00	3.41	5.74	4.58	6.76	10.81	8.78
APR 14		34.22	85.71	59.97	6.86	8.00	7.43	670.00	2371.00	1520.00	2.62	7.28	4.95	3.98	12.04	8.01
Mean		31.52	64.98		5.80	7.19		685.00	1774.00		1.77	3.85		3.33	7.19	
LSD (Sowing date)(SD)		11.09			0.55			145.40			0.83			1.33		
LSD (Poultry manure)(FM)		3.68			0.13			125.90			0.33			0.54		
LSD (SD X FM)		11.90			0.57			219.80			0.92			1.48		

Table 4: Differences in vegetative parameters among maize varieties at 6 weeks after planting

Maize variety	Height (cm)		No. of Leaves	Leaf Area (cm ²)		Stem Dry Matter (g)		Leaf Dry Matter (g)	
	0	10		0	10	0	10	0	10
TZE COMP3C3	49.90		6.35	1157.00	3.04	5.25			
TZL COMP4C3	44.18		6.36	1142.00	2.69	5.22			
OKA AWAKA	50.67		6.78	1390.00	2.69	5.30			
LSD	4.78		0.19	136.70	n.s	n.s			

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Growth Performance Evaluation of Doyogena Sheep under Community based Breeding Scheme in Doyogena Woreda

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Abstract- The aim of this study was to evaluate the growth performance of Doyogena sheep under community based breeding scheme in Doyogena district. The district was chosen purposively due to the existence of sheep breeding cooperatives. Data on birth weight (BW), 90-day weaning weight (WW) and six-month weight of 584 lambs born in Doyogena community based sheep breeding cooperatives over the period of 2013-2015 were collected and used for this study. Pre-and post weaning average daily gain were also estimated. Data were subjected to analysis of variance using the GLM procedure of SPSS. The overall least square mean weight of Doyogena sheep at birth, at 3 and 6 months of age were 2.9, 12.1 and 18.9 kg, respectively. The pre- and postweaning average daily weight gains were 103.6 and 67.3g/day, respectively.

Keywords: *breeding, community based, lamb, growthperformance, Doyogena sheep.*

GJSFR-D Classification: *FOR Code: 079999*



GROWTHPERFORMANCEEVALUATIONDOYOGENASHEEPUNDERCOMMUNITYBASEDBREEDINGSchemeDOYOGENAWOREDA

Strictly as per the compliance and regulations of:



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Growth Performance Evaluation of Doyogena Sheep under Community based Breeding Scheme in Doyogena Woreda

Addisu Jimma ^α, Mestawet Taye ^σ, Aberra Melesse ^ρ, Deribe Gemiyo ^ω, Asrat Tera [¥] & Aynalem Haile [§]

Abstract- The aim of this study was to evaluate the growth performance of Doyogena sheep under community based breeding scheme in Doyogena district. The district was chosen purposively due to the existence of sheep breeding cooperatives. Data on birth weight (BW), 90-day weaning weight (WW) and six-month weight of 584 lambs born in Doyogena community based sheep breeding cooperatives over the period of 2013-2015 were collected and used for this study. Pre-and post weaning average daily gain were also estimated. Data were subjected to analysis of variance using the GLM procedure of SPSS. The overall least square mean weight of Doyogena sheep at birth, at 3 and 6 months of age were 2.9, 12.1 and 18.9 kg, respectively. The pre- and post-weaning average daily weight gains were 103.6 and 67.3g/day, respectively. Birth type, sex and year had significant effect on birth weight (BW), weaning weight (WW) and six-month weight; whereas parity and birth type on year had significant ($P < 0.05$) influence only on BW. Similarly, birth type, sex and year significantly affected by pre-weaning average daily gain (ADG) and post weaning ADG. There was variability in growth traits within breed, which were significantly influenced by non-genetic factors. Therefore, further selection among the flock for preferred productive traits to achieve higher lamb crop with superior growth performance should be prioritized.

Keywords: breeding, community based, lamb, growth-performance, Doyogena sheep.

1. INTRODUCTION

Sheep is one of the most important livestock species in Ethiopia with an estimated number of 30.7 million (CSA, 2014) found in cool alpine climate of the mountains to the arid pastoral areas of the lowlands. Phenotypic characterization had categorized into 14 sheep breeds of Ethiopia (IBC, 2004; Workneh *et al.*, 2004) which later Solomon (2008) reduced it to 9 through molecular characterization.

In Ethiopia, the livelihood of smallholder households depends to a great extent on livestock production. Sheep contribute substantial amounts to income, food (meat and milk), and non-food products like manure, skins and wool. They also serve as a means of risk alleviation during crop failures, property

security, monetary saving and investment in addition to many other socio economic and cultural functions (Markos, 2006; Adane and Girma, 2008). The indigenous sheep breeds have immense potential to contribute to the livelihood of low input smallholder farmers, and the pastoral community (Kosgey and Okeyo, 2007). Moreover, sheep play a great role in the economy of the country through generation of foreign currency (Berhanu *et al.*, 2006). Although their contribution is great importance, sheep productivity in the country is constrained by lack of technical capacity, feed scarcity, diseases, poor infrastructure and lack of market information, besides lack of planned breeding program and policies (Solomon *et al.*, 2013).

The genetic improvement program of sheep in developing countries is less successful than developed countries due to implementation of the program without taking consideration the needs of the farmer and insufficient participation, as well poor adaptability of exotic breed (Kosgay and Okeyo, 2007; Duguma *et al.*, 2009; Markos *et al.*, 2010).

Increasing urbanization and income level increase the demand for animal source food. However, with incompetent production or low supply in both quality and quantity it is unlikely to satisfy the ever increasing demand for mutton and cheavon (Negasa and Jabar, 2008). To meet such huge demand for animal protein, implementation of improvement options like pure-breeding essentially in the form of selection within breed is crucial (Haile *et al.*, 2014). A new approach that has recently stimulated global interest is a community-based breeding strategy. Programs that adopt this strategy take into account the farmers' needs, views, decisions, and active participation, from inception through the implementation, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation, and ownership (Mueller 1991; Sölkner *et al.* 1998; Wurzinger *et al.*, 2011; Merkina *et al.*, 2011). Designing a community-based breeding program is much more than genetic theories and increased productivity. It is a matter of infrastructure, community development, and an opportunity for improved livelihood of livestock owners through productive and adapted animals and markets for their products (Haile *et al.*, 2011).

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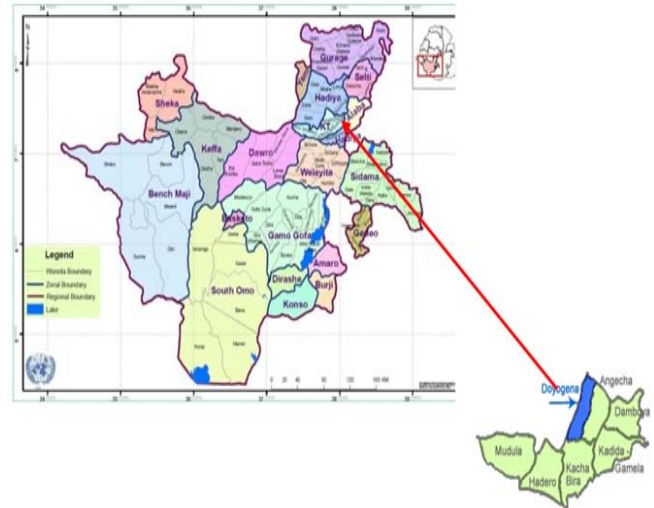
Doyogena sheep is one of the sheep types which have been considered for community based production in southern region. The sheep has high growth rate and prolificacy (Tsedeke, 2007; Deribe, 2009). Doyogena sheep is reared and characterized in the area where mixed crop-livestock production system exist (Tafesse, 2012). The breed has thick fat tailed and the male rams are usually horned. Great genetic diversity was observed within breed (Deribe, 2009). Thus, emphasis was given to explore the genetic potential of Doyogena sheep with respect to mutton production through undertaking performance testing.

For this, on-farm data collection on economic importance traits that includes reproduction and production attributes, focusing on objective traits has been takes place since 2013. However, data was not analyzed to evaluate the different traits considered. The aim of this study was to evaluate the growth performance evaluation of Doyogena sheep under community based breeding scheme level.

II. MATERIAL AND METHODS

a) Description of study area

The study was conducted in Doyogena district. The district is located in Kembata Tembaro Zone in the Southern Nation, Nationalities, and Peoples' region. It is bordered on the south by Kacha Birra district; on the west and north sides by Hadiya zone; and on east by Angacha district. The altitude of Doyogena ranges from 1900 to 2300 meters above sea level (m.a.s.l.). Agro ecologically, the district is divided into mid-altitude (30%) and highland (70%). The mean average annual rainfall is between 1200 and 1600 mm with average mean temperature variation of 10 – 16°C. The major farming system is mixed crop-livestock production. Types of livestock reared and population in the study area include cattle (46,703), sheep (13,822), goats (1,444), horses (6,343) and poultry (27,253) (BoA, 2013). The district is purposely chosen for the study because the area is known as a center of distribution for sheep to neighboring markets (Ashenaf *et al.*, 2013). The existence of community based Doyogena sheep breeding program in the area is also another reason for choosing the district.



b) Breed Description and management

According to previous studies, sheep type found in Kembata-Tambaro zone is known by different names. For instance it is called Arsi-Bale breed (Markos, 2006) and it is categorized as under Adilo sheep types (Tsedeke, 2007; Solomon *et al.* 2011; Deribe *et al.*, 2013) and Wolaita sheep ecotype (Tsedeke, 2007). According to Abera *et al.* (2013) based on morphometric and qualitative traits studies it was stated that sheep population which are found in Kembata Tembaro zone significantly differ from those of sheep in Wolaita area. However the study conducted by Ashenaf *et al.* (2013) indicates that, Adilo is huge sheep marketing place where 65% of sheep including lambs, ewes and rams from Doyogena sheep market are transported to and purchased by big and small traders. Also small holder farmers found in and around Adilo area purchase sheep for fattening and breeding purpose from Doyogena origin. The sheep breed was characterized as being large in size, where twining is common, and are horned with long tick tail and possess different coat color.

In the study area natural pasture, enset and crop residues are used as major feed sources. Farmers keep their sheep together with other livestock species around homestead, farm land after harvesting crop and road side during the day time. Tethering is common management practice in the study area due to shortage of communal grazing land. Controlled mating system was practiced by all sheep keepers due to the policy of the community based breeding program (CBBP). They assured that this practice is being used after the start of CBBP. by holding of selected rams in the area. It was stated that a selected breeding ram was shared by organized household group in the proportion of one ram to twenty ewes.

c) Source and management of Data

Data were collected from the productive (birth, weaning and six month body weight and date) and reproductive traits (sex, birth type and parity) by Areka Agricultural Research center since 2013 G.C.

The data were analyzed using the General linear model (GLM) procedures of SPSS, version 16.0. Fixed effect were evaluated for the growth traits (year of birth, season of birth, sex and birth type) and for the growth of lambs. The Tukey test was used to separate least square means with more than two levels. The following model was developed.

$$Y_{ijklm} = \mu + S_i + B_j + C_k + D_m + P_n (B \times D)_{jm} + e_{ijklm}$$

Where:

Y_{ijklm} = Weight at different ages and ADG of individual lamb

μ = overall mean

S_i = fixed effect of sex of lamb (i = male, female)

B_j = fixed effect of birth type (j = single, twin, triplet)

C_k = fixed effect of season of birth (k = Big rainy season (June-August), Small rainy season (May and September-November), dry (December-April))

D_m = fixed effect of year of birth (m = 2013, 2014, 2015)

P_n = Fixed effect of nth parity of dam (n=1.....≥5)

(B×D) $_{jm}$ = interaction between birth type and year

e_{ijklm} = residual effect

III. RESULT

a) Productive performance of Doyogena sheep

i. The effect of fixed factors on birth, weaning and six month weights of sheep

Coefficient of variance (CV %) was in the range of 15.5% for weaning weight to 20.4% for six month weight. Body weights at birth, weaning and six months of age are presented in Table 1. There was significant difference (P<0.001) between birth types along all ages of weight (at birth, weaning and six month). Single born lambs were significantly (P<0.001) heavier than those from multiple births (twins and triplets). Furthermore significant (P<0.001) variation in body weight among multiple birth was observed where twins were greater over triplets (P<0.001). The interaction between birth type by year was significant (P<0.05) on birth weight of lambs. The male lambs had heavier weight than those of the female lambs at birth (3.0 vs. 2.7), weaning weight (12.8 vs. 11.3) and at six month of age (20.3 vs. 17.4). Year of birth had significant (P<0.001) effect on the three studied traits. However, season of birth had no significant (P>0.05) effects at all stage of weights (at birth, weaning and six month age).

Parity had significant (P<0.05) effect on birth weight only.

Table 1: Least squares means (±SE) for effects of birth type, sex, year, season and parity on body weights

Source of Variation	BW(Kg)		WW(Kg)		WSM(Kg)	
	N	LSM ±SE	N	LSM ± SE	N	LSM ± SE
Overall	584	2.9 ± 0.02	352	12.1 ± 0.1	166	18.9 ± 0.3
CV%	-	16.6	-	15.5	-	20.4
Birth type		***		***		***
Single	195	3.2 ± 0.04 ^a	132	13.9 ± 0.2 ^a	75	20.9 ± 0.4 ^a
Twin	362	2.9 ± 0.03 ^b	202	12.0 ± 0.2 ^b	85	18.7 ± 0.4 ^b
Triplet	27	2.4 ± 0.08 ^c	18	9.4 ± 0.5 ^c	6	14.5 ± 1.1 ^c
Sex		**		**		***
Male	370	3.0 ± 0.03 ^a	240	12.8 ± 0.2 ^a	124	20.3 ± 0.3 ^a
Female	214	2.7 ± 0.04 ^b	112	11.3 ± 0.3 ^b	42	17.4 ± 0.5 ^b
Year		***		***		***
2013	125	2.7 ± 0.05 ^c	105	11.7 ± 0.2 ^c	57	17.2 ± 0.4 ^b
2014	375	3.0 ± 0.04 ^b	203	13.1 ± 0.2 ^b	96	20.7 ± 0.3 ^a
2015	84	3.2 ± 0.05 ^a	44	14.0 ± 0.3 ^a	13	20.7 ± 0.8 ^a
Season		Ns		Ns		Ns
Big rainy	80	3.1 ± 0.06	70	13.4 ± 0.3	31	20.3 ± 0.6
Small rainy	207	2.9 ± 0.04	125	12.8 ± 0.2	76	18.5 ± 0.4
Dry	297	2.9 ± 0.04	157	12.6 ± 0.3	59	20.4 ± 0.5
Parity		*		Ns		Ns
1	18	2.7 ± 0.09 ^c	17	13.1 ± 0.6	12	18.6 ± 1.1
2	24	2.9 ± 0.08 ^a	24	12.9 ± 0.5	20	18.1 ± 0.8
3	18	2.82 ± 0.09 ^b	16	11.6 ± 0.6	7	18.7 ± 1.4
4	26	2.91 ± 0.07 ^a	24	12.3 ± 0.5	16	17.2 ± 0.9
≥ 5	27	2.80 ± 0.1 ^b	26	12.9 ± 0.5	15	18.3 ± 0.8
Birth type x year	-	*	-	NS	-	NS

abcd = means with different superscripts in the same column within the same subclass group differ significantly, *p<0.05, **P<0.01, ***P<0.001, Ns = Not significant, SE = Standard error, BW = Birth weight, WW=weaning weight, WSM= weight at six month, Kg=kilogram, N=observation number.

b) The effect of fixed factors on average daily gain (ADG) of Doyogena sheep

Overall average pre- and post-weaning daily weight gain of lambs was 103.6 and 67.3 g/day respectively. It was shown that the mean pre-weaning growth rate was more (36.3 g/day) than the post weaning growth rate. Lamb growth from birth to weaning depend more on dam's milk whereas after weaning depends the type of feeds they graze since they are exposed to environment influence.

Factors influencing pre and post-weaning average daily weight gain are indicated in Table 2. Birth type had significant (P<0.001) effect only on pre-weaning average daily gain of sheep. Thus the highest (P<0.001) growth rate was attained in single birth followed by twin birth. However the post-weaning growth rate was not significantly different among the different

birth types. This was due to environmental factor and growth shock after weaning. Both pre- and post-weaning average daily gain of lambs was significantly affected by sex of lambs. Pre-weaning growth weight for male lambs (109.8g/day) was significantly higher (P<0.001) than female lambs (98.4g/day). Post-weaning average gain of ram lambs (72.7g/day) was also significantly higher (P<0.05) than ewe lambs (61.0g/day).

The result further indicated that birth year had significant effect on daily gain of lambs both pre- and post-weaning growth periods. Pre-weaning ADG was higher (P<0.01) in the year 2015 and 2014, whereas lower during 2013 period. The difference, however, was insignificant between birth year of 2014 and 2015. Season and parity did not significantly affect (P>0.05) growth rate of Doyogena sheep in the study area.

Table 2: LSM (±SE) and tests of significance of factors affecting pre and post- weaning average daily gain of Doyogena sheep

Source of variation	Birth to weaning		weaning to six month)	
	N	ADG(g/day)	N	ADG(g/day)
Overall	352	103.6 ± 1.7	166	67.3 ± 1.9
CV%	-	30		36.3
Birth type		***		Ns
Single	132	119.0 ± 2.6 ^a	75	71.6 ± 3.9
Twin	202	105.6 ± 2.0 ^b	85	68.4 ± 3.6
Triplet	18	81.5 ± 5.6 ^c	6	62.9 ± 10.6
Sex		**		*
Male	241	109.8 ± 2.5 ^a	124	72.7 ± 3.0 ^a
female	113	98.4 ± 3.6 ^b	42	61.0 ± 4.4 ^b
Year		**		*
2013	105	101.4 ± 2.8 ^c	57	57.5 ± 4.3 ^b
2014	203	111.1 ± 2.5 ^b	96	76.2 ± 3.5 ^a
2015	44	120.6 ± 4.2 ^a	13	73.9 ± 7.8 ^a
Season		Ns		Ns
Big rainy	70	114.9 ± 3.8	31	68.9 ± 5.9
Small rainy	125	110.4 ± 2.4	76	62.4 ± 3.7
Dry	157	106.2 ± 2.9	59	79.3 ± 4.6
Parity		Ns		Ns
1	17	115.7 ± 6.6	12	55.1 ± 7.0
2	24	112.6 ± 5.6	20	58.0 ± 5.49
3	16	98.8 ± 6.8	7	62.9 ± 9.2
4	24	105.6 ± 5.6	16	62.1 ± 6.1
≥5	26	111.5 ± 9.1	8	64.0 ± 5.7

abc = means with different superscripts in the same column within the same subclass group differ significantly, *p< 0.05, **P<0.01, ***P<0.001, Ns = Not significant, LSM=least square mean ,SE = Standard error, ADG = Average Daily Gain, N=observation number, g/day=gram per day.

IV. DISCUSSION

Growth performance

The birth weight of Doyogena sheep recorded under the current study is about 2.9kg. This is higher than birth weight reported by Deribe *et al.*, (2013) for Adilo sheep (2.3kg) reared under traditional management and Horro sheep reported as 2.4kg by Markos (2006) and 2.6kg by Solomon (2002) which was

managed under on-station management. This finding is also higher than that report by Haile *et al.* (2014) for Menz sheep (2.25kg) under community based breeding management. The observed differences may be attributed to breed and management condition. The current finding however is lower than the birth weight (3.55kg) reported by Momoh *et al* (2013) for Balami breed in a semi-arid region of Nigeria and Bonga sheep (3.4kg) which is also under community based breeding

(Haile *et al.*, 2014). The variation from these findings could be due to the length of time selection has been operating in the reported cases. Similar birth weights however, have been reported by Haile *et al.*, (2014) for Horro sheep (3.1kg) under community based breeding management; and Surafel *et al.* (2012) for Simein sheep (2.97kg) under traditional management. The current result figure out that the resulted birth weights is due to well planned, careful selection and breeding combined with good management can enable animals to express their genetic potential and thereby improving the productivity and reproductive potential of a given breed. This also is the best option for genetic improvement than depending on the exotic breeds which were also not successful under the Ethiopian condition (Duguma *et al.*, 2009; Markos *et al.*, 2010).

The weaning weight of lambs is an indicator of efficiency of maternal ability. The milking ability of the dam and maternal factors (high prolific, easy lambing and high milk production) are the most determinant elements in pre-weaning growth of lambs. The weaning weight recorded under the current study is greater than the report of Belete (2009) and Deribe *et al.* (2013) for Bonga and Adilo sheep respectively. The reason for this could be lambs with heavier birth weight will have possibility of having higher pre-weaning growth and weaning weight. Besides, Doyogena sheep is one of the fast growth sheep types in the country and the current community based breeding program should be another reason for recording higher weights. The finding of the current study however is more or less comparable with that of Getahun (2008) for Horro sheep under on-station management (12kg), Mengiste (2009) for Washira sheep (11.9kg), and Surafel *et al.* (2012) for Simien sheep (11.7).

The overall pre-weaning ADG found in the present study is higher than that reported by Haile *et al.* (2014) for Horro (90g/day) and Menz (80 g/day) sheep under community based breeding practices, Mengistie (2009) for Washira (59.1 g/day) and Surafel *et al.* (2012) for Simien sheep under traditional management. The pre-weaning ADG of Belami sheep breed (70g/day) in a semi-arid region of Nigeria was lower than the current finding (Momoh *et al.*, 2013). However, finding of the current study was lower than the result obtained by Haile *et al.* (2014) for Bonga breed under community based breeding. Bonga sheep have been under the community based breeding program over the last 8 years where as Doyogena sheep stayed only for 3 years in the selection program. The intensity of selection that was operating in Bonga sheep over the extended period should be reason for the recoded higher weight. The result of the current study is an additional proof for the efficiency of the community based breeding in improving the productivity of the indigenous breeds as also have been observed in Bonga sheep (Metsafe, 2015; Haile *et al.*, 2014) and Menz and Horro sheep (Haile *et al.*, 2014).

V. EFFECTS OF NON - GENETIC FACTOR ON GROWTH TRAITS

a) Effect of Birth type

The effect of type of birth on body weight of sheep observed in this study is similar to earlier findings of Haile *et al.* (2014) and Metsafe (2015) for Bonga sheep and Momoha *et al.* (2013) for Balami sheep, who reported significant effect of births on lamb's birth, weaning and six months of age weight. Similarly Haile *et al.* (2014) for Horro sheep and Surafel *et al.* (2012) for Simien sheep indicated significant effect of birth type on lamb weight at birth and weaning. The finding of current study (Table 1) also concurs with other studies although different values were reported (Ghangaboche *et al.*, 2006; Yilmaz *et al.*, 2007; Deribe *et al.*, 2013). The reason for this could be, when the fetus is still in the womb single births enjoy the available space and nutrition. After birth also, when the offspring depend on the dam's milk, single births enjoy milk without any completion while multiple births have to share and therefore single births weigh heavier than the multiple as also indicated by Markos (2006).

b) Sex effect

The current study shows male lambs have heavier weight than female lambs at birth, weaning and six month age. The difference in sexual chromosome, probably of in the position of gene, physiological characteristics and difference in endocrinal system must have led to variation in animal growth. Estrogen hormone has limited effect on the growth of long bones in females. The higher the surface area of the bone, the more space availability for muscle attachment and therefore, heavier weights. That could be one of the reasons in which females have lighter body weight than males (Rashidi *et al.*, 2008). Previous reports have confirmed similar results (Mousa, 2010, Gbangboche *et al.*, 2006, Momoh, 2013). In contrary to the current finding, non-significant effect of sex of lamb on the trait was reported by Getahun (2008) for Adilo and Hassen, (2002) for lambs in the cool highlands of Ethiopia.

c) Effect of birth year

Effect of year on body weight at different age was significant which is in agreement with reports from various studies (Gbanboche *et al.*, 2006; Akhtar *et al.*, 2012; Momoh *et al.*, 2013; Rahimi *et al.*, 2014). In addition to this, year of birth had significant effect on weaning weight. However, Berhanu and Aynalem (2009) reported that a non-significant effect of year on birth weight. Under the current study the effect of year could be due to selection effect that was operating over the three years while for the other studies, management and the other variables together with year might be the possible reasons. Similar reports have been given by Abbasi *et al.*, (2012), Akhtar (2012), Momoh (2013) and Mousa, (2013).

d) Effect of parity

There was a declining trend in birth weight after fourth parity, indicating the maximum productive periods might be before the fifth parity in the Doyogena sheep situations. This indicates that the dams should stay in a flock until the 4th parity and should then be culled. As the younger ewes are still growing, there is a competition between the fetus and the dam for nutrients, which has negative influence on birth weight (Gemedda *et al.*, 2002a, Deribe, 2009). Heavier birth weight could be obtained at late parities due to heavier dam weight and larger size (Kassahun, 2000) and physiological imprint in the uterus during the first pregnancy which will facilitate relatively greater foetal growth in the subsequent pregnancies (Gardner *et al.*, 2007). Markos (2006) also reported significant increment of birth weight from beyond first parity, which was similar to the current findings, and then with increment at a decreasing rate beyond parity four. Several reports are in agreement with the current study (Markos 2006; Gardner *et al.*, 2007; Taye *et al.*, 2010).

e) Average daily gain

The higher average daily gain from birth to weaning for single born lambs over their multiple counter parts found in the current study agrees with other reports for Horro (Gemedda *et al.*, 2002), Washira (Taye *et al.*, 2010) and Menz sheep breed (Markos, 2006). Similar findings with the current study have also been reported for other breeds (Getahun, 2008; Deribe *et al.*, 2013; Senou, 2009; Haile *et al.*, 2014, surafel *et al.*, 2014). However non significant variation of birth type on post weaning growth was observed. The reason for this could be lambs after weaning, whether single or multiple, will be equally exposed to the environmental effect.

Sex of lamb had significant effect on pre and post-weaning growth of Doyogena sheep which is in agreement with reported by Haile *et al.* (2014) for Bonga sheep. Differences in sexual chromosomes, probably in the position of genes related growth, physiological characteristics in endocrinal system (type and measure of hormone) lead to differences in animal growth. This could be one of the reasons in which females have smaller body and lighter weight than males (Rashidi *et al.*, 2008; Momoha, 2013). Studies have reported significant effect of birth year on pre- and post-weaning average daily gain for Horro, Bonga and Menz sheep under community based sheep breeding cooperatives in different production system, which is similar with present study (Haile *et al.*, 2014).

VI. CONCLUSION & RECOMMENDATION

From the study, it is concluded that growth performance of Doyogena sheep is fairly encouraging. There was higher within breed variability in growth traits which were significantly influenced by non-genetic

factors at one or the other stage. The higher variation within the breed indicates that there is a great possibility for genetic improvement through selection among the Doyogena rams and ewes. The established community based breeding program has given encouraging results. Therefore, further selection among the flock for desired reproductive and productive traits to achieve higher lamb crop with superior growth performance should be continued extensively. Effects of non-genetic factors need to be corrected for mixed model approaches and values are to be used for breeding value evaluation in Doyogena lambs. Selection of rams and ewes for multiple births should also be initiated and genes responsible for this should be identified. Molecular level of characterization is needed to identify its distinctiveness and prolificacy testing to confirm the potential of the breed.

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Improving Energy-Saving Irrigation Pumps

By N.R.Nasyrova, O.Ya. Glovatsky, R.R. Ergashev & Zh.I. Rashido

Abstract- The article describes the research results obtained in the process of working out the flow path of modernized centrifugal pumps. The authors proposed the device of new elements based on the calculation of the flow limited only by the side walls. The purpose of this work is to change and clarify in the calculations of the economic indicators of the modes of pumping units and the features of the performance of modern low-pressure pumps. They are developed on the basis of the results of a large number of tests carried out by the authors of the pumping unit assemblies and operational surveys of irrigation pumping stations in Uzbekistan. Determination of the economically feasible duration of the operating period of pumping units, taking into account changes in energy characteristics and energy-saving operating technologies, was clarified when measuring the efficiency of the modernized pump D2000-21 at various operating modes.

Keywords: *pumping units, flow path of pumps, pressure characteristics, impeller, guide elements, efficiency.*

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Improving Energy-Saving Irrigation Pumps

N.R.Nasyrova ^α, O.Ya. Glovatsky ^ο, R.R. Ergashev ^ρ & Zh.I. Rashido ^ω

Аннотация- В статье излагаются результаты исследования, полученные в процессе отработки проточной части модернизированных центробежных насосов. Авторами предложено устройство новых элементов на основе расчёта потока ограниченного только боковыми стенками. Целью данной работы является изменения и уточнения в расчетах экономических показателей режимов насосных агрегатов и особенности рабочих характеристик современных низконапорных насосов. Они разработаны на основании результатов большого числа произведенных авторами испытаний узлов насосного агрегата и эксплуатационных обследований ирригационных насосных станций в Узбекистане. Определение экономически целесообразной продолжительности периода эксплуатации насосных агрегатов с учетом изменения энергетических характеристик и энергосберегающих технологий эксплуатации уточнялась при замерах КПД модернизированного насоса D2000-21 при различных режимах работы. Создание ресурсосберегающих методов эксплуатации насосных агрегатов, ослабляющих или исключающих интенсивность кавитационно-абразивного износа, в том числе основанные на учете изменения скоростей потока в межлопастных каналах рабочего колеса показано на соответствующих характеристиках модернизированного насоса.

Ключевые слова: насосные агрегаты, проточная часть насосов, напорные характеристики, рабочее колесо, направляющие элементы, эффективность.

Abstract- The article describes the research results obtained in the process of working out the flow path of modernized centrifugal pumps. The authors proposed the device of new elements based on the calculation of the flow limited only by the side walls. The purpose of this work is to change and clarify in the calculations of the economic indicators of the modes of pumping units and the features of the performance of modern low-pressure pumps. They are developed on the basis of the results of a large number of tests carried out by the authors of the pumping unit assemblies and operational surveys of irrigation pumping stations in Uzbekistan. Determination of the economically feasible duration of the operating period of pumping units, taking into account changes in energy characteristics and energy-saving operating technologies, was clarified when measuring the efficiency of the modernized pump D2000-21 at various operating modes. The creation of resource-saving methods for the operation of pumping units, weakening or eliminating the intensity of cavitation-abrasive wear, including those based on taking into account changes in flow rates in the inter-hazard channels of the impeller, is shown on the corresponding characteristics of the modernized pump.

Keywords: pumping units, flow path of pumps, pressure characteristics, impeller, guide elements, efficiency.

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I. Введение

В последние годы резко возросла роль систем машинного водоподъема в Республике Узбекистан, построены и эксплуатируются около двух тысяч насосных станций (НС) и установок, которые орошают более половины всех поливных земель. В Республике площадь орошаемых земель составляет более 4,3 млн. га, из них 2,3 млн. га орошается с помощью 5301 насосных агрегатов мощностью 3616,7 мВт, которые перекачивают в год 62,9 млрд. м³ оросительной воды и являются крупнейшими потребителями электроэнергии в сельском хозяйстве.

Реконструкция и модернизация гидротехнических сооружений и водохозяйственных систем приобретают все большее народнохозяйственное значение. Особенно большие задачи стоят в области реконструкции действующих ирригационных систем, повышения коэффициента полезного действия машинных каналов для забираемой для орошения воды. Большие задачи по модернизации стоят перед гидроэнергетикой, эксплуатацией НС, поскольку на многих действующих НС большой и средней мощности насосные агрегаты (НА) и прочее оборудование отслужили свой срок и нуждаются в замене или модернизации.

Центробежные насосы обеспечивают плавную и непрерывную подачу перекачиваемой жидкости при высоких значениях коэффициента полезного действия (КПД). Конструкция проточной части горизонтальных центробежных насосов и отсутствие поверхностей трения допускает возможность перекачивания загрязненных жидкостей. Простота непосредственного соединения с высокооборотными приводными двигателями способствует компактности насосного агрегата и повышению его КПД.

Все эти положительные качества центробежных насосов привели к тому, что они являются, по существу, основными насосами всех сооружений ирригационных систем Республики.

II. Материалы и Методы

При выполнении данной работы использовались основные положения теории лопастных гидромашин. На основе этих теории предложены методика расчета интенсивности износа элементов проточной части насосов. При проведении экспериментальных исследований использованы общепринятые стандартные методы испытаний насосов.

Определение экономически оправданной продолжительности межремонтного периода эксплуатации с учетом изменения энергетических характеристик оборудования вследствие кавитационно-абразивного износа и стоимости капитально-восстановительного ремонта является очень важной и в то же самое время чрезвычайно трудной задачей.

Как показывает опыт эксплуатации, износ различных деталей НА происходит с разной интенсивностью. Поэтому наибольшую практическую важность представляет оценка износа НА в целом и сопоставление его с изменяющимися вследствие износа энергетическими характеристиками.

Для выявления закономерностей изменений гидродинамических характеристик и гидравлических сопротивлений в сопрягающих сооружениях машинных каналов авторами использован логарифмический закон распределения скоростей и методы учета средних по сечениям скоростей по длине [1,2]. Теоретические формулы, полученные для НА на основе энергетической теории учитывают особенности износа деталей НА [3-6].

III. Результаты Исследований

Цель работы: изучение износа гидромеханического оборудования на основе использования теоретических основ обоснования режимных факторов, влияющих на интенсивность изнашивания деталей насосов и улучшения гидравлических процессов их проточной части.

Если известна характеристика системы, в которую насос подает воду, то напор, развиваемый насосом, складывается из геометрической высоты подъема жидкости и суммы гидравлических сопротивлений. Величина потерь зависит от диаметра, шероховатости стенок проточной части, числа местных сопротивлений и расхода Q подаваемой жидкости

$$\Sigma h = SQ^2 = (A_l + A_m \Sigma \zeta),$$

где S - полное сопротивление системы;

A - удельное сопротивление по длине;

A_m - удельное местное сопротивление;

l - длина стенок проточной части;

$\Sigma \zeta$ - сумма коэффициентов местных сопротивлений.

Характеристика центробежных насосов (как правило, малой быстроходности) неустойчива. Кривая Q - H таких насосов имеет максимум в зоне небольших подач. Вначале насос работает с большой подачей и система заполняется водой. Если при этом расход воды, отбираемой потребителем, меньше подачи ($Q_{\text{пот}} < Q_n$), то подача насоса начнет уменьшаться.

При сохранении условия $Q_{\text{пот}} < Q_n$ уровень должен был бы расти и, но это невозможно, так как насос не в состоянии обеспечить больший напор.

При этом равновесие нарушается и система насос-сеть попадает в так называемый режим помпажа. Напор, развиваемый насосом, падает до значения напора холостого хода H_0 насос уже не может удержать давящий на него столб жидкости высотой H_m , и жидкость начинает течь в обратном направлении (если на напорном трубопроводе насоса не установлен обратный клапан). Как только уровень понизится, насос возобновит работу с подачей, соответствующей характеристике Q - H . Если режим работы системы к этому времени не изменится, то описанное явление повторится вновь. Неустойчивый режим работы насоса в системе приводит к колебаниям подачи и напора и может сопровождаться гидравлическими ударами в отводе и напорном трубопроводе.

Неустойчивый режим работы насоса в системе может наступить в том случае, когда в какой-либо период времени статический напор в сети поднимается выше напора холостого хода насоса, т.е. при условии $H_{\text{ст}} > H_0$. Кроме того, причиной возникновения неустойчивого режима работы центробежного насоса в системе является наличие аккумуляторной емкости.

Улучшение антикавитационных свойств по всей проточной части насоса и регулирование количества жидкости было достигнуто за счет новых элементов в корпусе центробежного насоса [7,8].

Корпус насоса снабжен направляющими перегородками на внутренней поверхности, в которых установлены нормально закрытые клапаны на шарнирах.

При вращении РК, жидкость поступает в спиральную камеру, через направляющие перегородки, в результате чего на шарнирах открываются нормально закрытые клапаны, которые перепускают жидкость, обладающую значительной энергией в напорный патрубок. При образовании водоворотных зон неустановившихся процессов эксплуатации, особенно при остановке насоса, обратные течения закрывают клапаны, ликвидируя водовороты и отрыв потока от внутренней поверхности корпуса.

Насосы в мелиоративных НС работают совместно, т.е. несколько насосов подают воду в одну систему [9,10]. Рабочая точка в этом случае будет находиться на пересечении суммарной характеристики насосов с характеристикой системы.

Если известны размеры колеса центробежного насоса и число его оборотов, остающиеся неизменными, то изменяться могут

только величины H, Q, η_m , причем величина манометрического КПД η_m предполагается определенной путем специальных опытов [11,12].

Вид кривой КПД показан на рис.1, причем КПД изменяется от 0 до 86%.

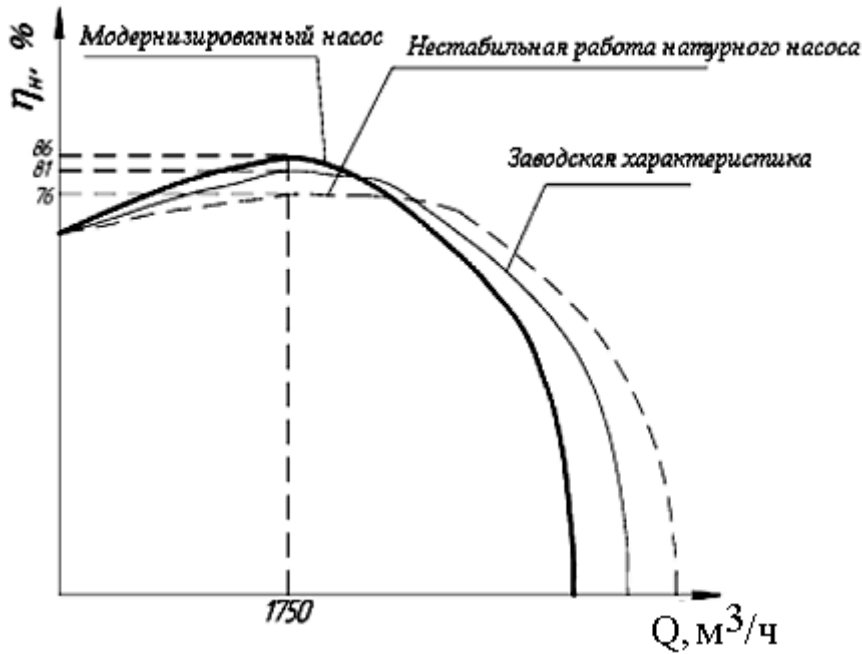


Рис. 1: КПД насоса Д2000-21 при различных режимах работы

При оптимальном режиме в сечениях проточной части действителен закон постоянства момента скорости, т.е $r v_u = \text{const}$.

Отсюда

$$Q = \int dQ = \int B/r dr;$$

где r - наружный радиус сечения.

Существующие методы изменения режимов мелиоративных насосов не полностью

учитывают функции сопрягающих сооружений НС для обеспечения надежности эксплуатации [13,14].

В статье рассматривается поток в системе, ограниченном только боковыми стенками в виде поверхности вращения. Чтобы получить ламинарное течение, достаточно поставить ограничивающую стенку, по форме найденной линии тока (рис.2).

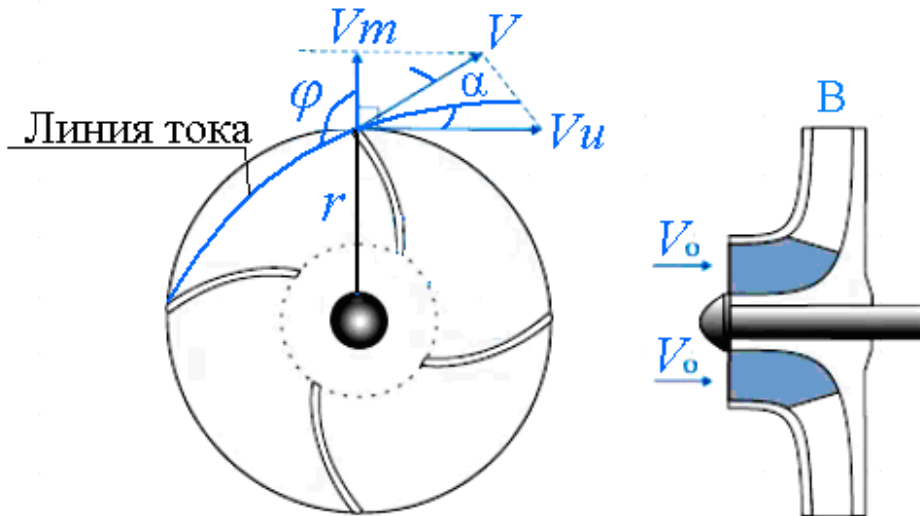


Рис. 2: Построение линии тока

При снижении геометрического напора кривые гидравлических сопротивлений опускаются вниз и рабочая точка переместится по кривой

вправо. Изменение напора насоса (динамический перепад напора) ΔH , возникающий в системе по мере её заполнения зависит от положения рабочей

точки насоса на кривой $H-Q$ и уменьшается по мере перемещения рабочей точки влево. По расчетным данным насос Д2000-100-2М-0, 730 оборотов в минуту характеристика которого представлена на рис.3 с рабочей точкой Е наносим на поле

характеристики рабочую точку А, соответствующую модернизированному колесу насоса с характеристиками Q и H_m , уменьшением диаметра колеса с 855 мм до $D_m=790$ мм, показанными на рисунке пунктирными линиями.

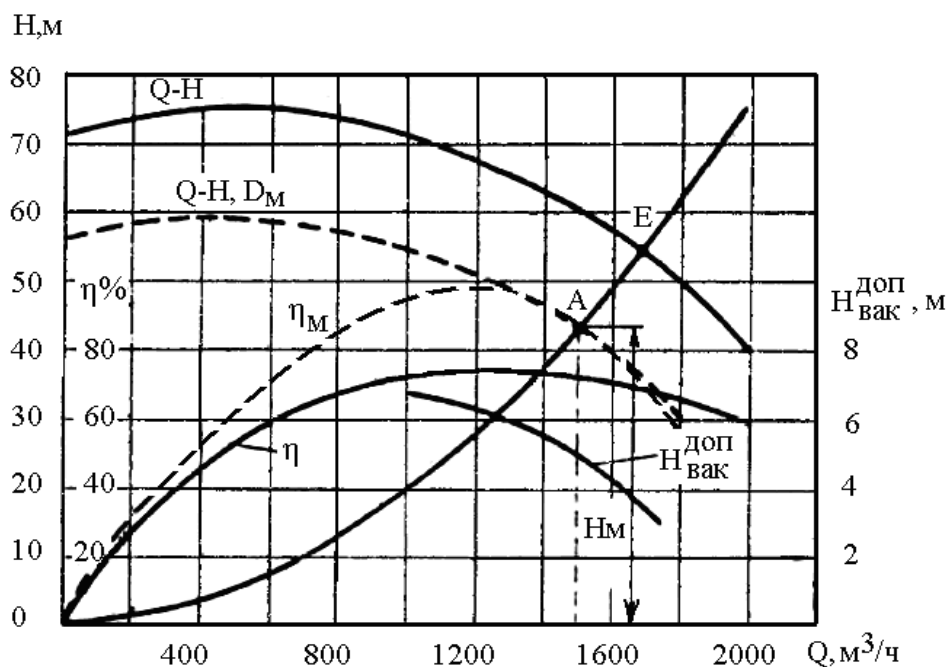


Рис. 3: Определение характеристик модернизированного насоса.

Так как рабочая точка насоса должна находиться в рабочей области на кривой, что имеет место при правильном подборе насоса при заполнении системы будет возникать динамический перепад напора, величина которого может быть проконтролирована.

Этот динамический перепад напора может быть использован как команда на отключение насосного агрегата при заполнении напорной части.

При использовании динамического перепада напора в качестве команды на отключение электрического двигателя насоса была исследована зависимость его величины от гидравлических сопротивлений, когда может иметь место случай, что динамический перепад напора будет равен нулю. Следовательно, контроль уровня верхнего бьефа предлагаемым методом не может быть осуществлен.

Нами же рассматривались случаи, когда точки пересечения характеристик системы с характеристиками насосов лежали на рабочих участках характеристик этих насосов, то есть в области максимальных коэффициентов полезного действия.

Во многих случаях обуславливают не минимальное, а максимальное значение напора при закрытой задвижке. Такое требование вызывается обычно соображениями, связанными с

экономией энергии с учетом того, что при более пологой кривой $Q - H$ уменьшаются потери от частичных подачах. Это не всегда верно, так как, наклон кривой мощности влияет форма кривой КПД, если заданное значение напора при закрытой задвижке слишком мало, то режим нормальной нагрузки должен быть смещен влево от подачи, соответствующей максимальному КПД насоса. В насосах высокого давления отмечено влияние нагрева воды из-за внутренних гидравлических потерь, включая дисковые, на ее плотность. Так, повышение температуры из-за потерь перекачивания воды при $t > 20^\circ\text{C}$ и $p = 125$ ат составляет около 1°C , что приводит к уменьшению плотности на 2,7% и к уменьшению давления на выходе при постоянном напоре на 3,5 ат. Поэтому и в насосах с устойчивой характеристикой $Q-H$ на холодной воде может наблюдаться при работе на теплой воде уменьшение давления вблизи режима нулевой подачи и кавитационные явления [15,16].

Рабочим органом центробежных насосов с участками, подверженным и наиболее сильной эрозии, является РК. Многочисленные экспериментальные исследования и большой опыт эксплуатации гидромашин различного типа позволяют довольно точно установить наиболее характерные участки насосов, подверженные кавитационной эрозии и абразивному разрушению установить границы этих участков. На практике

довольно трудно, так как в рабочих условиях один из видов износа, как правило, является преобладающим, а разрушенная поверхность

имеет присущие ему характерные особенности (рис.4).



Рис. 4: Износ рабочих колёс НС Амубухара-2

Турбулентное перемешивание потока, вызываемое конструктивными особенностями РК, а также содержание в воде нерастворенных воздуха и газов, являются причинами возникновения и развития кавитации при давлениях в потоке, превышающих давление паров воды при данной температуре. Развитые кавитационные явления приводят к эрозионным разрушениям элементов колес. Интенсивность этих разрушений резко возрастает при содержании в воде взвешенных наносов [17,18]. Наиболее сильному разрушению у насосов подвергаются стенки камер РК.

Из-за отрыва потока, вызванного несоответствием углов потока и лопаток, в отдельных случаях возможно усиленное разрушение лопаток выправляющего аппарата. В насосах со спиральным отводом кавитационной эрозии подвергаются стенки отвода в местах их сопряжения с камерой РК. Интенсивность износа элементов проточной части гидравлических машин вследствие кавитации и истирания взвешенными наносами находится в прямой зависимости от режимов работы.

Предлагаемый способ определения бескавитационной работы насосов предусматривает чтобы удельная энергия потока при входе его в РК, отнесенная к оси колеса, была достаточной для создания в этот момент скоростей и ускорений в потоке и преодоления сопротивлений без падения местного давления до величины, вызывающей начало кавитации. В связи с этим решающее значение приобретает не величина абсолютного давления на входе в РК, а превышение ее над величиной и энергией, соответствующей давлению насыщенного пара

жидкости. Эти положения использованы в современных инструкциях по эксплуатации насосов [19,20].

IV. Выводы

1. Авторами на основе многолетнего опыта эксплуатации НА в Республике Узбекистан разработаны мероприятия по уменьшению интенсивности их износа. Подтверждено, что интенсивность износа элементов проточной части гидравлических машин вследствие кавитации и истирания взвешенными наносами находится в прямой зависимости от режимов работы.
2. Выявление режимов работы НА наиболее опасных с точки зрения кавитационно-абразивного разрушения деталей было определено при проведении испытаний на надежность. При использовании динамического перепада напора в качестве команды на отключение насоса была исследована зависимость его величины от гидравлических сопротивлений.
3. Определение экономически целесообразной продолжительности периода эксплуатации НА с учетом изменения энергетических характеристик и энергосберегающих технологий его эксплуатации уточнялась при замерах КПД модернизированного насоса Д2000-21 при различных режимах работы.
4. Создание ресурсосберегающих методов эксплуатации НА, ослабляющих или исключаящих интенсивность кавитационно-абразивного износа, в том числе основанные на учете изменения скоростей потока в

межлопасных каналах РК и соответствующих характеристик модернизированного насоса.

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Effects of Long-Term Fertilization and Weather on Soil Properties and Spring Barley Yield

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Abstract- The purpose of the experiment was to determine long-term fertilization and the effects of weather on the soil properties and spring barley yields. A long-term field experiment—with crop rotations of potatoes (hemp oil from 2017), spring barley, spring barley with red clover (undersown), and red clover was established in 1960 Kuusiku, Estonia. Different barley varieties was used over the experimental period. With except the spring barley variety 'Anni', which was tested from 1995–2019. The experiment has three fertilizer treatments: the moderate dose of fertilization (NPK1), double NPK1 (NPK2), and moderate fertilization with farmyard manure (NPK1 + FYM). After harvest, the soil samples were collected from 0–0.2 m of topsoil and 0.2–0.4 m of subsoil from each plot, using a soil drill.

Keywords: *environmental safety, leaching, organic and chemical fertilizer, organic carbon, soil phosphorus.*

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Effects of Long-Term Fertilization and Weather on Soil Properties and Spring Barley Yield

V. Loide ^α & L. Edesi ^σ

Abstract- The purpose of the experiment was to determine long-term fertilization and the effects of weather on the soil properties and spring barley yields. A long-term field experiment—with crop rotations of potatoes (hemp oil from 2017), spring barley, spring barley with red clover (undersown), and red clover was established in 1960 Kuusiku, Estonia. Different barley varieties was used over the experimental period. With except the spring barley variety 'Anni', which was tested from 1995–2019. The experiment has three fertilizer treatments: the moderate dose of fertilization (NPK1), double NPK1 (NPK2), and moderate fertilization with farmyard manure (NPK1 + FYM). After harvest, the soil samples were collected from 0–0.2 m of topsoil and 0.2–0.4 m of subsoil from each plot, using a soil drill.

During the experimental period, soil organic carbon content increased from 1.3% (NPK1) to 1.9% and 2.5% when using mineral fertilizers (NPK2) and NPK1 + FYM, respectively. The use of manure increased soil microbial biomass by 9.7%, and the use of mineral fertilizers decreased by 23%. More nutrients—especially phosphorus, potassium, and magnesium—moved from the topsoil to the subsoil with the use of manure (NPK1 + FYM) than with the of mineral fertilizer alone (NPK2).

Phosphorus leaching was higher with manure (22% in subsoil) compared to that with mineral fertilizer. Of the period studied, 28% was under drought, which caused 60% spring barley yield loss and thus increased the risk of leaching of unused nutrients.

Keywords: environmental safety, leaching, organic and chemical fertilizer, organic carbon, soil phosphorus.

I. INTRODUCTION

Long-term field experiments with fertilizers make it possible to examine not only the yield of crops but also the impact of long-term fertilizer uses on soil properties, sustainability, and the environment. In soil, processes occur very slowly, and the results of various factors can only be evaluated in long-term experiments. Specifically, long-term fertilizer experiments are vital tools to examine the sustainability of modern intensive cropping systems and provide valuable information regarding the impact of continuous fertilizer applications on soil health and crop productivity (Meena et al., 2017). Microorganisms are crucial in soils, being responsible for nutrient cycling and fixation, organic matter decomposition, and biological suppressiveness. Therefore, soil stability and functioning in agriculture are

closely related to its microbiological diversity and activity (Griffiths & Philippot, 2013). Soil microorganisms are also sensitive to changing environmental conditions, which makes them good indicators of soil quality (Griffiths & Philippot, 2013; Schloter et al., 2018).

In several long-term studies, considerable attention is to the accumulation of available phosphorus (P) in soil, its movement to the lower soil horizons, and its leaching, and the elucidation of conditions conducive to such a phenomenon (Rubæk et al., 2013; Zicker et al., 2018). Manure is one of the sources of phosphorus, the overuse of which may saturate the soils with P. In Estonia, 50% of the P used in crop production comes from manure (ES...). Excess phosphorus in the soil has caused the eutrophication of water bodies, including the Baltic Sea in Europe. There is an increasing focus on protecting water bodies from eutrophication (Carpenter, 2008).

Weather conditions, i.e., temperature and precipitation, also change over long periods, affecting crop yields, nutrient uptake, accumulation, and leaching. These issues have been studied by many authors on the basis of long-term experiments (Körschens et al., 2013).

The aim of the experiment was to gain new knowledge as follows. 1) Effects of long-term mineral fertilizers, and in particular manure, on topsoil and subsoil properties and environmental safety. 2) The combined effect of air temperature and precipitation (hydrothermal effect) on the growth conditions of spring barley, on which nutrient consumption, yield and leaching of unused nutrients depend.

II. MATERIALS AND METHODS

a) Study site and soil

This study was carried out based on data from an ongoing long-term crop rotation and fertilization experiment, which was established in 1960 by E. Talpsep at the Kuusiku experimental station of the ECRI (Estonian Crop Research Institute), Northern Estonia; longitude 58.977554, latitude 24.725849, and altitude 55 m) on light Sandy Loam Calcisols (IUSS 2015). The experiment was redesigned reconstructed in 1975 and 1995–1997. The data used in this study have predominantly been from 1995 onwards.

Crop rotation: - potato (*Solanum tuberosum*)/ oil hemp (*Cannabis sativa*; since 2017); - spring barley (*Hordeum vulgare*); - spring barley with under sown red clover (*Trifolium pratense*); - red clover. Barley varieties

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varied according to the variety representation in practice, except the spring barley variety 'Anni', which was tested from 1995–2019. All cultures were presented every year. The size of each trial plot was 98 m² (14 × 7 m).

Traditional agro technical measures were used: the soil was plowing to a depth of 0.22 m, and chemical plant protection measures were also taken. Mineral fertilizers were applied during soil tillage before sowing. Manure was applied by autumn plowing for the potato or oil hemp of the following year.

Table 1: Test fertilisation of crops in a long - term experiment (since 1960) in Kuusiku

Treatment	N:P:K kg ha ⁻¹ ,+ FYM*, t ha ⁻¹			
	Crop rotation			
	Potato/hemp	S.barley u.show	Red clover	Spring barley
NPK1 (control)	90:27:116/35:0:0	40:8:30	-	80:16:60
NPK2	180:54:232/70:0:0	80:16:60	-	120:24:90
NPK1+FYM	90:27:116+60FYM/35:0:0+60 FYM	40:8:30	-	80:16:60

*- The nutrient content (kg t⁻¹) of manure (FYM): N (nitrogen), 2.8 kg⁻¹; P (phosphorus), 0.6 kg⁻¹; K (potassium), 4.7 kg⁻¹.

b) Soil sampling and analysis

After harvest, soil samples (1 sample consisted of 15 subsample) were collected from the topsoil, (0–0.2 m depth) and subsoil (0.2–0.4 m depth) layers from each using a soil drill. The soil samples were air-dried and sieved to <2 mm. The chemical properties of the soil samples were then determined in an accredited laboratory at the Agricultural Research Centre, Estonia, as follows: C_{org} (organic carbon), using the - sulfochromic method; pH_{KCl}, using the - ISO 10390:2005 methodology; available P, K, Ca, Mg, Al, and Fe, using the - Mehlich III extraction (Meh3) method (Mehlich, 1984). The determination was performed using the ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer). The total content of the elements P, K, Ca, and Mg: (P_{tot}, K_{tot}, Ca_{tot}, and Mg_{tot}) in the soil was determined using the EVS-EN 16170:2016 methodology. Water-soluble phosphorus, P_{H2O}, in the soil was determined by using the EVS-EN ISO 11885:2009 methodology.

Soil samples (0.5 kg) for soil dehydrogenase activity (DHA) analyses were taken from the 0–0.2 m layer in three replications under the early and late spring barley cultivation in spring 2016. Soil samples for DHA analyses were sieved (2 mm) and stored at four °C until they were analyzed in the ECRI's laboratory. Measurements of soil DHA were based on methods by Tabatabai (1982). Soil samples (5 g) were incubated at 30 °C for 24 h in the presence of an alternative electron acceptor (triphenyltetrazolium chloride). The red-tinted product, triphenylformazan (TPF), was extracted with acetone and measured using a spectrophotometer.

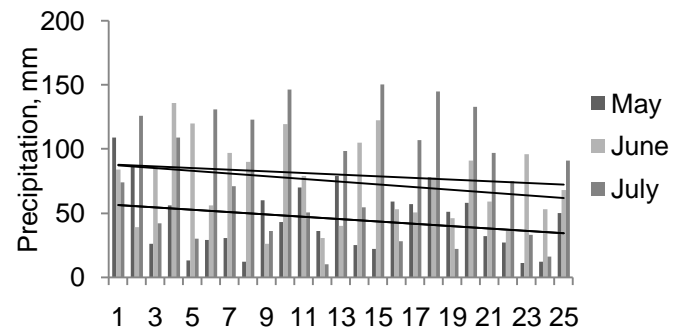
The experiment had three fertilizer treatments and five repetitions: a moderate dose of NPK (NPK1-control), double NPK1 (NPK2), and a moderate dose of fertilizer with farmyard manure (NPK1 + FYM). The fertilization dose is in Table 1. Cereal straw was returned to the soil by plowing. The applications of fertilizers, crop sowing (end of April), and harvesting was performed at the optimal time (August).

c) Sampling and analysis of crop yields

Trial plot yield and dry matter determination, 32.5 m² (2.5 m × 13 m) of the crop was harvested, of which 1 kg was taken for analysis. The current study includes long-term research data from 1975–2019.

d) Calculation of the hydrothermal coefficient

Estonia is characterized by a transitional climate from maritime to continental. The average annual air temperature is 6.7 °C, and the average precipitation is 696 mm. The average annual water evaporation is less than the precipitation. Temperatures and precipitation were measured during the vegetation period (Fig. 1) using an automatic weather station near the experimental area. The conditions (Keppart et al., 2009) for plant growth and development are more characterized by the Seljaninov.



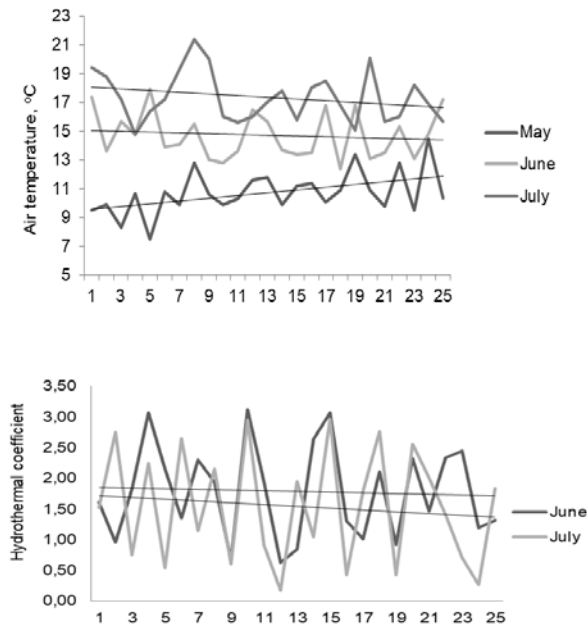


Figure 1: Characterization of the weather during the trial period 1–25 (1995–2019) in Kuusiku

Hydrothermal coefficient (HTC), also called conditional moisture balance, which takes into account the combined effect of temperature and precipitation. Plant stress is higher either in conditions of high temperature, and lack of water or conditions of low temperature and plentiful water. The hydrothermal coefficient (Kivi, 1998) was calculated using the sum of precipitation (P) and the sum of air temperatures (T) for the same period using the following formula (1):

$$HTC = \sum P / 0.1 \times \sum T_{\text{day}} \quad (1)$$

where $\sum P$ is- the sum of precipitation, and $\sum T_{\text{day}}$ is- the sum of air temperatures.

e) Statistical analysis

The period was considered dry if the HTC is between 1.0–0.6 and very dry if the HTC is 0.5 or less (Keppart et al., 2009). If the HTC exceeds 2.0, the period was considered to be too wet for crop cultivation.

The correlation and standard deviation (SD) for yield, weather, and soil chemical properties were calculated. The likelihood of a difference between treatments was found at a level of 95% confidence in the $LSD_{0.05}$ (LSD; least significant difference) test.

III. RESULTS AND DISCUSSION

a) Soil properties

This study (Tables 2, 3) showed that organic and mineral fertilizers had different effects on soil properties during long-term fertilization. Understandably, the use of manure increased the C_{org} content of the soil in the barn layer and also in the subsoil. Manure application also promoted soil microbiological activity (DHA) compared to the control test by 9.7%, while mineral fertilizer reduced by 23% (NPK1-control: 5.16; NPK1 + FYM: 5.66 and NPK2: 3.98 TPF $\mu\text{g/g/h}$; $LSD_{0.05}$: 0.72). From an environmental point of view, P deserves more attention. Additional P and K fertilizers were added in turn (every four years): P 51 and K 206 kg ha^{-1} in NPK2 test and 36 and 280 kg ha^{-1} in NPK1 + FYM test. Although less P was added with manure than with mineral fertilizer, the subsoil contained more P.

Table 2: Effect of long-term fertilisation on soil agrochemical parameters in 2019 in the top- and subsoil layers of the carbonate soil in Kuusiku

Treatment	C_{org} %	pH_{KCl}	Content of soil elements							
			P		K		Ca		Mg	
			mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	%	mg kg^{-1}	%
Content of soil available elements in the topsoil (0–0.2 m; $n=20$)										
NPK1-control	1.9	6.0	146	100	149	100	1850	100	64	100
NPK2	1.9	5.9	213	146	211	142	1810	98	68	106
NPK1+FYM	2.5	6.5	203	139	314	211	2350	127	131	205
$LSD_{0.05}$	0.17	0.22	25	-	48	-	205	-	22	-
Content of soil available elements in the subsoil (0.2–0.4 m; $n=20$)										
NPK1-control	1.1	6.0	56	100	88	100	1470	100	43	100
NPK2	1.4	6.1	125	223	152	173	1890	129	54	126
NPK1+FYM	1.9	6.4	152	271	306	348	1820	124	116	269
$LSD_{0.05}$	0.21	0.24	28	-	65	-	197	-	22	-
Content of soil total elements in the topsoil (0–0.2 m; $n=205$)										
NPK1-control	-	-	559	100	1581	100	3481	100	1741	100
NPK2	-	-	644	115	1608	102	3322	95	1708	98
NPK1+FYM	-	-	617	110	1662	105	3642	105	1728	99
$LSD_{0.05}$	-	-	22	-	51	-	279	-	42	-

Table 3: Correlative relationships between C_{org} and soil properties in the top- and subsoil layers of the carbonate soil in Kuusiku

Indicators	FYM	Min. fertiliser	C_{org} -topsoil	C_{org} -subsoil
C_{org} -topsoil	0.885**	-0.845**	-	-
C_{org} -subsoil	0.923**	-0.129	-	-
DHA	0.534	-0.845**	0.707*	-
pH _{KCl}	0.771**	-0.574	0.784**	0.628*
P	0.349	0.531	-0.069	0.635*
K	0.876**	-0.166	0.630*	0.929**
Ca	0.846**	-0.584*	0.836**	0.710**
Mg	0.933**	-0.437	0.810**	0.874**

* $p < 0.05$; ** $p < 0.01$; $n = 12$.

Organic matter plays a key role in the microbiological transformation of phosphorus compounds in soil and the promotion of plant phosphorus uptake (Richardson & Simpson, 2011). Organic substances are also a source of energy for the bacteria and fungi that break down manure. As a result of their activities, nutrients are released and become mobile and available to plants. However, the addition of mineral fertilizers hurt the biological activity of the soil. The positive interaction of organic manure and inorganic NP fertilizer on soil DHA was observed by Liu et al., (2010). The results of the present study clearly show that the amount of mineral fertilizer applied to the NPK2 treatment had a negative effect on the microbiological activity of the soil. This finding is supported by the Treseder (2008) review, where it was concluded that inorganic fertilizers suppress microbial biomass, with more evident effects in longer durations and with higher

total amounts of N added. Some studies have shown that repeated applications of inorganic fertilizers decrease soil pH (Liu et al., 2012), which, in turn, can reduce nutrient availability and soil microbial biomass.

Plants absorb phosphorus from the soil primarily as orthophosphoric acid anions soluble in water or as weak organic acids. In this experiment (Table 4), the content of P_{H_2O} in the soil increased 1.7–2 times, and that of P_{Meh3} increased 1.4–1.5 times in the NPK2 and NPK1 + FYM treatments as compared to the control (NPK1).

Typically, the proportion of water-soluble P compared to available P is relatively small, only 17–20%. Compared to the NPK1 experiment (Table 2), the P_{H_2O} content in the NPK2 and NPK1 + FYM experiments increased significantly by 170 and 203% (respectively). Excess P in the subsoil, however, is dangerous to the hydrosphere.

Table 4: Water-soluble phosphorus content in the topsoil layer of the carbonate soil in 2020 in Kuusiku depending on fertilisation

Treatment	Indicators				
	P_{H_2O} mg kg ⁻¹	P_{Meh3} mg kg ⁻¹	P_{H_2O} % in P_{Meh3}	Rel. P_{H_2O} %	Rel. P_{Meh3} %
NPK1-control	7.1	144	20.3	100	100
NPK1+FYM	12.1	205	16.9	170	142
NPK2	14.4	222	19.5	203	154
LSD _{0.05}	2.1	30.3	1.3	-	-

The association of organic matter with phosphorus retention and incorporation into soil has been described by several researchers. Pizzeghello et al. (2016) also found that mineral fertilization reduced P-sorption capacity by increasing the P content in soil and water samples, but to a lesser extent than that by manure. The outer surface of organic colloids is considerably larger than the outer surface of most other colloids and usually exceeds the corresponding value of clay minerals. At high pH, the cation exchange capacity of humus is significantly higher than that of clay minerals. The particles of organic matter, including manure, have a larger mass and thus occupy the free surface, and the free P in the soil-based solution leached with falling water.

Moreover, P leaching from soils with elevated P levels due to manure spreading is becoming an

increasing concern as a source of eutrophication in streams, lakes, and the Baltic Sea region (Hooda et al., 2001; Lehmann et al., 2005; Schick et al., 2020). In a radio labelled orthophosphoric acid sorption experiment, Vanden Nest et al. (2016) found that soil P availability and leaching were associated with a decrease in orthophosphate sorption in farmyard manure-modified soils, which was not observed in compost-modified soils. Nobile et al. (2019) found that using one-tenth of an organic fertilizer increased soil pH and C_{org} , but at the same time decreased P sorption. Ten years of application of mineral fertilizers reduced soil pH, and increasing the P sorption. Hooda et al. (2001) found that 85 mg P kg⁻¹ and 305 mg P kg⁻¹ of the Olsen and Mehlich-3 extractable P values were predicted for 25% DSSP (DSSP stands for the degree of soil saturation with P). Soil saturation with P is likely to

cause significant P losses to the environment. Saturation of the soil with P is caused by P unused by plants, which is one of the consequences of drought, and in case of heavy precipitation, P enters water bodies.

b) *Dependence of yields on the weather*

Spring barley yields (Table 5) did not differ between different fertilizer treatments but depended most on the weather. The weather conditions (Fig. 1) were very volatile. In our experiment, almost 1/3 (28%) of the years gave an average spring barley yield of 2.1–2.2 t ha⁻¹, 38% less than in the best years (48%). With the lost crop, an equivalent amount of fertilizer remains in the soil. The results of the correlation analysis ($p < 0.01$) showed that the spring barley yield was most positively affected by the June precipitation, and negatively by the high air temperature in July. However, given the air temperature and precipitation, HTC showed that spring barley yields currently depend on air temperature and precipitation in June and then in July. The highest spring

barley yields were obtained when the HTC was close to 2.2 in June and July, which implies that the barley needs a relatively moist June-July. Earlier investigations suggested that cooler, cloudier, and rainy weather occurs in June and in early July (the period for stem elongation to grain head formation), which has a positive impact on grain yield. May is particularly critical for spring barley growth, which often has high air temperatures (rising trend) and little rainfall. Depending on the June and July rainfall, the plant will recover from drought damage or not. Previous studies have shown that crop species with powerful and widespread roots that can collect water and nutrients more widely are more resistant to weather conditions, resulting in higher yields (Dempewolf *et al.*, 2014). Therefore, in the long run, one way to reduce the damage caused by water scarcity is to study the root system of the plant during the cultivation of the variety and its development during the growing season.

Table 5: Correlation between weather and spring barley yield in the years 1995–2019 in Kuusiku

Indicators	25 years average		Good harvest, weather (>5 t ha ⁻¹ , 10 y average)	Poor harvest weather (<4 t ha ⁻¹ , 7 y average)
	Correlative relationships	Results		
Yield _{NPK1} , kg ha ⁻¹	-	4510	5460	3350
Yield _{NPK2} , kg ha ⁻¹	-	4540	5680	3480
Yield _{NPK1+FYM} , kg ha ⁻¹	-	4590	5630	3540
Rel. yield _{NPK1} , %	-	100.0	100.0	100.0
Rel. yield _{NPK2} , %	-	100.7	104.0	103.9
Rel. yield _{NPK1+FYM} , %	-	101.8	103.1	105.7
Air temperature, °C; May	-0.401*	10.7	10.3	11.8
Air temperature, °C; June	-0.475*	14.7	13.8	15.1
Air temperature, °C; July	-0.775**	17.4	16.0	19.2
Precipitation, mm; May	0.013	45	46	45
Precipitation, mm; June	0.535**	77	92	49
Precipitation, mm; July	0.464*	80	109	60
HTC May	0.056	1.39	1.44	1.30
HTC June	0.632**	1.78	2.25	1.08
HTC July	0.528**	1.54	2.18	1.05

* $p < 0.05$; ** $p < 0.01$; $n = 25$.

Therefore, not only in terms of yield stabilization but also in terms of environmental safety, it is necessary to use more and more weather-resistant varieties. For more environmentally friendly use of manure, it is to monitor the properties of soil which leaching depends, such as soil saturation with P. The P in manure is released more slowly. Still in the case of imbalances, it is easily subjected to leaching. To reduce the negative impact of the weather on crop yields and environmental safety, it is recommended to use more reliable weather varieties and to limit fertilization in the year following the drought, especially P.

IV. CONCLUSIONS

The following were observed during the experimental period, (1) soil organic carbon content increased from 1.3– to 1.9% when using mineral fertilizers and from 1.3– 2.5% when using NPK1 + FYM. (2) The use of manure increased soil microbial biomass by 9.7%, and the use of mineral fertilizers decreased by 23%. (3) More nutrients — especially phosphorus, potassium, and magnesium — moved from the topsoil to the subsoil when manure was used than when mineral fertilizer was used. Phosphorus leaching was higher with manure (22% in subsoil) than with mineral fertilizer. (4) Of the period studied (25 y), 28% was affected by drought, which caused 60% spring barley

yield loss and thus increased the risk of leaching of unused nutrients.

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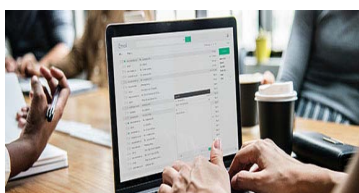
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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.



Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

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

A research paper must include:

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

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

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

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

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



FORMAT STRUCTURE

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

All manuscripts submitted to Global Journals should include:

Title

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

Author details

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

Abstract

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

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

Keywords

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

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

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

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

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

Numerical Methods

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

Abbreviations

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

Formulas and equations

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

Tables, Figures, and Figure Legends

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



Figures

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

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

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

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

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TIPS FOR WRITING A GOOD QUALITY SCIENCE FRONTIER RESEARCH PAPER

Techniques for writing a good quality Science Frontier Research paper:

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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

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

Final points:

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

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

The discussion section:

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

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

General style:

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

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



Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

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

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

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

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

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

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

Approach:

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

Introduction:

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



The following approach can create a valuable beginning:

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

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

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

Procedures (methods and materials):

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

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

Materials:

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

Methods:

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

Approach:

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

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

What to keep away from:

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



Results:

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

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

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

Content:

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

What to stay away from:

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

Approach:

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

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

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

Figures and tables:

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

Discussion:

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

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



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

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

Approach:

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

Describe generally acknowledged facts and main beliefs in present tense.

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BY GLOBAL JOURNALS

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



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