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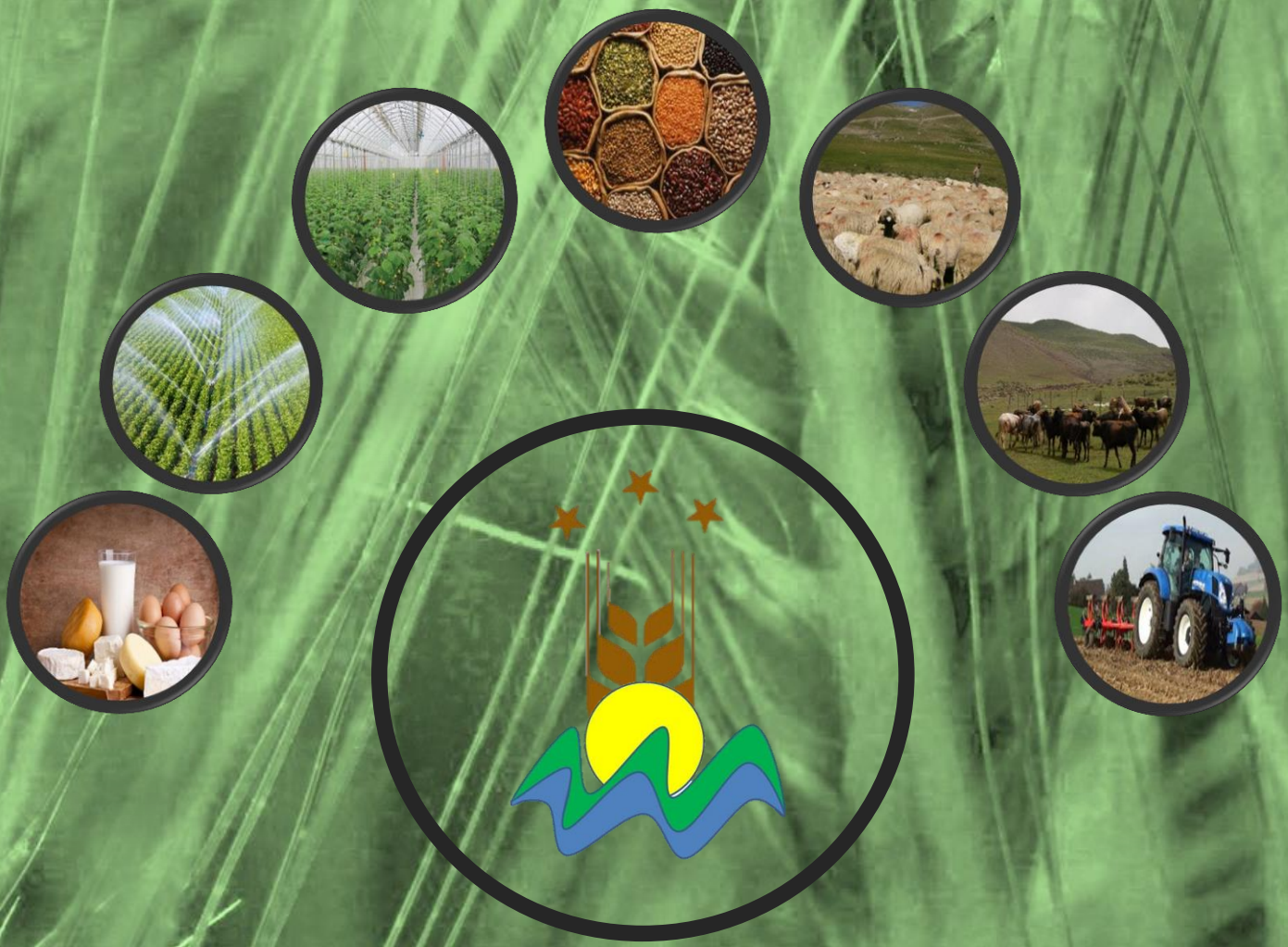

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Research Article
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FUNCTIONALITY OF AQUACULTURAL TECHNIQUES IN DELTA STATE, NIGERIA: ADOPTION APPROACHES

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Abstract: Appropriate adoption techniques in aquaculture contribute to food security. The study appraised the functionality of aquacultural techniques in Oshimili South Local Government Area of Delta State, Nigeria using adoption approaches. The objectives were to ascertain the level of adoption management techniques, examine the pond types of adoption, assess fish farmers' technological needs and identify constraints affecting adoption. A quota sampling technique was used to select respondents to acquire a sample size of 82 who were administered with questionnaire to elicit information. Data obtained were analyzed statistically. Results revealed that respondents were male (83%) with mean age of 44 years, mean household size 5 persons, married (65%) and had mean farming experience of 7 years. Majority (92%) had annual extension visit. Majority (78%) adopted earthen pond management techniques with high adoption score = 5.4. Again, majority (88%) adopted earthen pond over plastic (79%), concrete (71%) and wooden pond (59%). Majority (90.2%) indicated that integrated techniques were their prioritized need and respondents (80.5%) pointed out that high feed cost was their most serious constraint (mean = 3.06). It was concluded that there was a high adoption rate of aquacultural techniques in the study area. It is recommended that extension visits should be monthly and training on integrated techniques, feed formulation among others is needed.

Keywords: Adoption, Aquaculture, Extension, Farming, Fish farmers, Techniques

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1. Introduction

Aquaculture in Nigeria enables man to culture his desired fish species. Other advantages of aquaculture include the utilization of vast available untapped land and water resources that abound in swamps and burrow pits, reduction of pressure on fishing in natural waters, ease of getting fish from a pond relative to catching fish from the river, obtain healthier fish relatively free of pesticides and additional harmful toxicants, and the control of fish growth through supplementary feeding (Agbamu and Orhorhoro, 2007)

The economic status, age, scale of production, education level, cosmopolitans and socio-cultural situation of farmers are possible factors that could affect adoption of innovations. The rate of adoption of innovations differs greatly according to place and circumstances of farmers (FAO, 2011). Water management plays a vital role in fish farming. To help the fish farmer better understand the properties of water as they affect fish culture. These properties include: physical characteristics of water, water balance in fish, sources of water, water quality, water physical and factors and chemical factors (Singh, 2007).

Following the dissemination of information on assistance to aquaculture technologies by the Delta State Agricultural and Rural Development Agency (DARDA) over a decade ago, through farm inputs and assets supports, the provision of loans for aquaculture development in Delta State and the activities of non-governmental organizations on fisheries extension which have created awareness on aquaculture technologies, it has become necessary to examine the level of adoption of aquaculture management techniques in the state (MANR, 2017).

There are needs to assess the functionality and success of the existing aquaculture business whether Nigerians are satisfied with the currently available or usable techniques. If farmers seem satisfied with their own technique, then there is need to evaluate their annual yield in relation to technological inputs. If maximum productivity is not attained then there is need for a change and this change will have to go with the farmers' willingness to adopt the technology brought before them (Donye et al., 2008).

Why technology adoption in aquaculture? It has been observed that, there is low level of production, poor storage facilities, lack of awareness of rural farmers, low adoption rate of this farmers to new techniques and inconsistent trade policies have been found to be responsible for the insufficient market supply of

aquaculture products (Akindele and Alabi, 2010).

Land and Location has to be considered first because most villages in Oshimili South LGA are distant from the natural water source and thus farmers in this region have to create their own water source by sinking boreholes or channel water from nearby river and land is quite expensive for local fish farmers (Palash, 2015). In addressing these gaps, this study was proposed and was achieved by some set objectives.

The objectives were as follows to:

I. Describe the socio-economic characteristics of the farmers.
II. Ascertain the level of adoption of aquaculture management techniques.
III. Determine the types of pond contributing to aquacultural techniques adoption.
IV. Assess the needs of fish farmers on new fishing techniques.
V. Identify the constraints affecting the adoption of aquaculture management techniques.

2. Material and Methods

The study was conducted in Oshimili South Local Government Area of Delta State. Delta State is located in the coordinates of latitude 6°34' – 645'E and longitude 5°59' - 608'N (MLSUD, 2013).

Sample Size and Sampling Technique: A pre-field survey revealed that there were registered fish farmers in Oshimili South Local Government Area which were found in Asaba, Okwe and Oko (Table 1). A quota sampling technique was used to select 50% of registered fish farmers. This resulted in a sample size of 82 fish farmers.

Table 1. Selection of respondents from workers*

Fish farm communities (Stage 1)	Registered fish farmers (Stage 2)	Selection of respondents (50%) (Stage 3)
Asaba	95	47
Okwe	47	24
Oko	22	11

*Delta State Agricultural Procurement Agency, Asaba

2.1. Methods of Data Collection

Data were collected by administering questionnaires.to the fisher folks and through field observations.

2.2. Measurement of Variables

Some socioeconomic variables such as ages, fish farming experience of respondents were measured in years. Education level options were made available for respondents to indicate as applicable: no formal education, primary or secondary school, OND/NCE, and HND/First Degree. Income generated was measured in the Naira amount as realized annually. Contact with extension agent was measured as applicable to weekly, monthly, quarterly, biannual or annual visits.

The scale used for measurement of the level of adoption of aquaculture management techniques was designed as positive (Yes) and negative (No). In order to standardize adoption scores, percentages obtained were translated to sigma score in the statistical Table of normal deviates (Ovharhe, 2020)

Factors that significantly contribute to adoption of the techniques were measured using location parameters such as Asaba, Okwe and Oko were listed alongside with selected technologies such as earthen pond, concrete pond, plastic pond and wooden pond for respondents to indicate as applicable.

The need assessments of fish farmers on new fishing techniques were measured on multiple response patterns. While constraints affecting adoption of aquaculture management techniques was measured by asking the respondents the level of seriousness of possible constraint affecting the adoption. This will be measured on a four (4) Likert-type scale of very serious=4, serious=3, not very serious=2, not serious=1. The mean value is 2.50 (4+3+2+1=10/4=2.5) was used as a cut-off point such that constraints with mean value of 2.50 and above will be regarded as serious and vice versa. However, the percentage scores and means from the Likert-type scale computation were used for results interpretation.

2.1. Ethical Consideration

The study was approved by Delta State University local ethics committee with the number S177/029.

3. Results and Discussion

The result in Table 2 shows that mean age of the respondents was 44. This is in agreement with the findings of Agbamu and Orhorhoro (2007) on the adoption of aquaculture management techniques in Delta State. Male respondents (83%) were more in participation. These findings are not agreement with the findings of Nwabueze, (2010) who reported that women were more than men in sustainable aquaculture development in Delta State. Respondents (65%), were married. This aligned with the findings of Okoedo-Okojie and Ovharhe, (2012) on assessment of information needs of fish farmers in Delta State that most farmers were married. Majority of respondents (44%) had HND/ First Degree as educational attainment. These results show that majority of the respondents had formal education and are literates which are in agreement with the findings of Ofuoku et al. (2008) and Ovharhe (2019) on the determinants of adoption of improved fish production technologies in Delta State.

Respondents (44%) farming experience mean was 7 years. This is in disagreement with the findings of Agbamu and Orhorhoro (2007) on adoption of aquaculture management techniques in Delta State that the mean farming experience was 10 years. On average, respondents (56.1%) household size was 5 persons; this is in agreement with the findings of Ifejike et al (2013) on emerging income-generating of fisher folks in riverine communities of Delta State whose results showed a mean household size of 5 persons. Respondents (49%) annual

mean income size was 125,277.14, which is in agreement with the findings of Ovharhe (2016) on income generation of fish farmers in Delta State discovered that farmers earned between 35,000 and 135,000 Naira only annually on small scale basis. Respondents (92%) got annual extension visit. These poor findings were reported by Ovharhe and Gbigbi (2016) on socioeconomic determinants of youth empowerment by Fadama III projects in Delta State.

Table 2. Respondents' socio economic profile (n= 82)*

Variables	Frequency	Percentages (%)	Mean/Mode
Age			
21-30	9	11	
31 -40	13	16	
41-50	45	55	44
51 -60	15	18	
Gender			
Male	68	83	
Female	14	17	
Marital status			
Single	28	34.1	
Married	53	65	Married
Separated	1	1.2	
Educational status			
Primary	3	4	
Secondary	17	21	
OND/NCE	21	26	
HND/ First Degree	36	44	HND/First Degree
Post graduate	5	6.1	
Farming Experience			
1-5	29	35.4	
6-10	36	44	7 years
11-15	7	9	
16-20	6	7.3	
21-25	2	2.4	
26-30	2	2.4	
House Hold Size			
1-3	33	40.2	
4-6	46	56.1	5
7 – 9	3	4	
Income/annum			
35,000 – 135,000	40	49	125,277.14
136,000 – 236,000	17	21	
237,000 – 337,000	16	20	
338,000 – 438,000	4	5	
439,000 – 539,000	3	4	
540,000 – 640,000	2	2.4	
Extension Contact			
Monthly	3	4	
Quarterly	3	4	
Biannually	1	1.2	
Annually	75	92	Annually

*Field responses

3.1. Adoption of Aquaculture Management Techniques

Entries in Table 3 show that respondents (78%) adopted earthen pond technique while respondents (15.9%) had the lowest adoption rate in integrated technique. This is not in agreement with the findings of Agbamu and Orhorhoro (2006) on the Adoption of Aquaculture Management Techniques in Delta State which followed that respondents adopted the integrated technique which enabled them to culture different fish species in the same pond. This sigma method was used by Ovharhe (2016) to assess the adoption level of Fish Farmers in the Niger Delta.

3.2. Pond Types Contributing to Aquacultural Techniques Adoption

Across the study area, data displayed in Table 4 shows that earthen pond (88%) had the highest adoption rate followed by the plastic pond (79%), concrete (71%) and wooden ponds (59%) respectively). This outcome is not in accordance with the findings of Okoedo-Okojie and Ovharhe (2012) who reported that fish farmers in Delta State practice more of plastic and concrete ponds than earthen ponds. Rouhani and Britz (2004) cautioned that adoption of pond types contributes to the success of any fish farming.

3.3. Needs Assessment Techniques of Fish Farmers

The data in Table 5 shows that integrated techniques (90.2%) had the highest value whereas record keeping (24.4%) had the lowest value. There is a need to supply farmers with affordable feed formulation techniques and training on how to keep farm records in order to boost the productivity of fish and to improve protein intake in Delta State and in Nigeria at large. This is in line with the findings of Ovharhe (2016) who asserted that farmers in Delta State need adequate funding.

Table 3. Respondents' adoption level of aquaculture management techniques (n=82)*

	Techniques	Yes	No	Total number of adopters and its %	Adoption score	Adoption level
1	Earthen pond	64	18	64 (78.0)	5.4	High
2	Concrete pond	34	48	34 (41.5%)	4.4	Medium
3	Plastic pond	41	41	41 (50%)	4.7	Medium
4	Wooden pond	21	61	21 (25%)	3.7	Low
5	Pond treatment technique	61	21	61 (74.4%)	5.35	High
6	Water treatment technique	59	23	59(71.95%)	5.3	High
7	Feed formulation	58	24	58 (70.7)	5.3	High
8	Integrated technique	13	69	13 (15.9)	3.2	Low
	Overall mean adoption level				5.0	

*Field responses

Table 4. Respondents' perceptions on pond types contributing to adoption of the techniques (Multiple responses)*

	Parameter	Earthen pond	Concrete pond	Plastic pond	Wooden pond
1	Asaba	70 (85.36%)	57 (69.51%)	62 (75.6%)	57 (69.51%)
2	Okwe	76 (92.68%)	65 (79.26%)	69 (84.14%)	65 (79.26%)
3	Oko	71 (86.58%)	54 (65.85%)	64 (78.0%)	54 (65.85%)
	% mean	88	71	79	59

*Field responses

Table 5. Respondents' needs assessment (Multiple responses)*

	Parameters	Frequency	Percentage (%)
1	Integrated techniques	74	90.2
2	Pond preparation	64	78.1
3	Storage	54	65.9
4	Feed formulation	52	63.4
5	Spawning	45	54.9
6	Land	30	36.6
7	Water source	25	30.5
8	Market stategies	27	32.9
9	Equipment	22	26.8
10	Record keeping	20	24.4

*Field responses

3.4. Constraints Affecting Adoption of Aquaculture Management Techniques

Result in Table 6 shows that high feed cost with the highest percentage of 80.5% and a mean of 3.06 above the cut-off mean of 2.5 is the most serious constraint militating against adoption while poaching with the lowest percentage of 20.73% and a mean of 1.37 below the cut off mean of 2.5 is the least constraint. This assertion corroborates with that of Anene et al (2010) who reported that poor funding is the major constraint affecting the adoption of aquaculture techniques hence insufficient funds to handle the high cost of foreign feeds feed purchased. Therefore, farmers should be trained on how to formulate feed to supplement the exotic feeds. However, the pooled mean 2.40, which depict a management situation that the constraints are generally below average in theory and can be easily managed not to hamper fish farming adoption practices in agricultural productivity.

Table 6. Respondents' constraint militating against adoption (n=82)

	Parameter	*Percentage (%)	*Mean	Remark
1	High feed cost	80.5	3.06	Serious
2	High take off fund	75.6	2.89	Serious
3	Insufficient knowledge	65.8	2.78	Serious
4	Scarcity of feed	47.5	2.57	Serious
5	Costly technique	43.9	2.56	Serious
6	Labor cost	36.6	2.39	Not serious
7	Transportation	24.3	1.54	Not serious
8	Poaching	20.73	1.37	Not serious
		Pooled mean = 2.40		

*Implies values from Likert-type scale converted to % and means. Cut off mean = 2.5.

4. Conclusion

The study was guided by five objectives. Results obtained, besides the socio-economic characteristics, revealed that majority of fish farmers adopted earthen pond management techniques than plastic, concrete and wooden pond. Pond types contributed to aquacultural techniques adoption. The most prioritized need on assessment scale was integrated techniques and high cost of feeds was the most serious constraint. It was concluded that despite the prevailing constraints, there was a high adoption rate of aquacultural techniques among fish farmers in Oshimili South LGA of Delta State, Nigeria.

Based on the findings of the study, it is recommended that more awareness should be created among youths to increase participation in aquaculture, extension visit should be monthly and training on integrated techniques, feed formulation amongst others are needed.

Author Contributions

OJO; project supervisor, ON; fish expert and manuscript vetting, VO; data collection and analysis. All authors reviewed and approved the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Agbamu JU, Orhorhoro WC. 2007. Adoption of aquaculture management techniques in Delta State. Nigeria J Food Agri Environ, 5(2): 243-246.

Akindele LA, Alabi OE. 2010. Use of information communication technologies. ICTs among fish farmers in Oyo State. J Agri Extens, 14(1): 4-12.

Anene A, Ezeh CI, Oputa CO. 2010. Resources use and efficiency of artisanal fishing in Oguta, Imo State, Nigeria. J Dev Agri Econ, 2: 94-99.

Donye AO, Usman IS, Nuhu HS, Ogunbameru BO, Mustapha SB. 2011. Assessment of women participation in fish farming in Maiduguri Metropolis, Borno State, Nigeria. J Agri Sci, 1: 6-13.

FAO. 2011. Food and Agriculture Organization, Fishery and aquaculture country profiles Nigeria. Fisheries and Aquaculture Department, http://www.fao.org/fishery/countrysector/FI-CP_NG/3/en (accessed date: December 01, 2020).

Ifejika PI, Belonwu EN, Malagwi YY, Odunuga AO, Mbah AA. 2013. Emerging income generating activities of fisher folks n riverine communities of Niger State, Nigeria. J Fisheries Aquatic Sci, 8(6): 706-713.

MANR. 2017. Delta State ministry of agriculture and natural resources, annual report.

MLSUD. 2013. Ministry of lands, survey and urban development. The Delta State Coordinate.

Nwabueze AA. 2010. The role of women in sustainable aquacultural development in Delta State. J Sustainable Develop Africa, 12: 284-293.

Ofuoku AU, Enakle M, Nnodim AU. 2008. Cohesiveness of fish farmers groups in Southern Nigeria. J Agri Biol Sci, 3(4): 16-21.

Ofuoku AU, Olele NF, Emuh GN. 2008. Determinants of adoption of improved fish production technologies among fish farmers in Delta State, Nigeria. J Agri Edu Exten, 14(4): 297-306.

Okoedo-Okojie DU, Ovharhe JO. 2012. Assessment of information needs of fish farmers in Delta State, Nigeria. Nigerian J Agri Food Environ, 8(3): 72-77.

Ovharhe OJ, Gbigbi MT. 2016. Socio-economic determinants of youth empowerment by fadama III project in Delta State, Nigeria: Implications for agricultural transformation. Inter J Agri Extension Rural Develop Stud, 3(1): 12-20.

Ovharhe OJ. 2016. Aquaculture technologies adoption by Fadama III aquaculture farmers in Niger Delta. J Northeast Agri Univ, 23(4): 78-81.

Ovharhe OJ. 2019. Determinants of the socioeconomic profile of fadama III project beneficiaries in three states of Niger Delta Area of Nigeria. Inter J Agri Sci, 4: 29 – 34.

Ovharhe OJ. 2020. Poultry technologies adoption by farmers in the Niger Delta Area of Nigeria. FUW Trends Sci Technol J, 5(3): 813-815.

Palash S, Hunayun K, Bauer S. 2015. Fish farming land allocation in Northern Part of Bangladesh: Exploring Causes across the farm size. World J Agri Res, 3(6): 208-217.

Rouhani QA, Britz PJ. 2004. Contribution of aquaculture to rural livelihoods in South Africa: A Baseline Study. Water Research Commission, Gezina, 1st Edition, pp: 105-107.

Singh AP. 2007. Water quality management. J Water Res Manage, 21(2): 525-532.

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Research Article
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BREEDS, AGE AND SEX EFFECT ON HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS OF DUCKS IN RIVERS STATE, NIGERIA

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Abstract: This study was carried out to investigate breeds, age and sex effect on haematological and biochemical profiles of ducks. A total of one hundred and twenty (120) day old ducklings of two breeds (60 Muscovy and 60 Mallards) were used for the study. The ducks were divided into four (4) groups centered on the breeds and sexes designated as Muscovy males, Muscovy females, Mallard males and Mallard females. At 4 and 8 weeks, blood samples were collected from the experimental group and analysed. The experiment was 2 × 2 × 2 factorial in a Randomized Complete Block Design with two breeds (Mallard and Muscovy), sex and age. Results obtained showed significant effect ($P < 0.05$) of breeds on Packed Cell Volume, Haemoglobin, Red Blood Cells (RBC), White Blood Cells, Platelets, Total Proteins, Albumin, Globulin and Tryglycerides while no significant effect of breeds ($P > 0.05$) was observed on Urea, Creatinine and Glucose in the two breeds of ducks. Result indicated that Muscovy recorded higher values for Haemoglobin (10.35 ± 0.52g/dl) and RBC (4.62 ± 0.24 × 1012/ L) than Mallard which recorded Haemoglobin (10.10 ± 0.62 g/dl) and RBC (4.43 ± 0.27 × 1012/ L). Significant effects of Sex and age ($P < 0.05$) were observed on haematological and biochemical profiles. It is therefore concluded that the two breeds of ducks studied can be successfully raised in Rivers State, Nigeria without adverse effect on their health since their haematological and biochemical values compared favorably with standard reference values. Values obtained in this investigation could also serve as a baseline data of these breeds in humid tropical environment.

Keywords: Age, Duck breeds, Sex, Haematological and Biochemical parameters

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1. Introduction

Farmers as well as Animal scientists are observing different varieties of domesticated ducks which have suitable potential to grow fast and supplement the availability of meat on economic basis. Under this situation, duck industry has been gaining impulse in Rivers State, Nigeria, as well as providing all essential substances as in comparatively low percentage of fat and high percentage of protein. Therefore, haematology denotes the study of the quantities and morphology of the cellular components of the blood- the red cells (erythrocytes), white cells (leucocytes), platelet and the usage of these results in the diagnosis and observing of disease (Merck Manual, 2012).

Biochemical refers to the study of chemical processes within and relating to living organism. Haematological and biochemical tests have not widely been useful for diagnosis of avian species, but these tests could be an appropriate diagnosis mechanism for monitoring health status or for following of sickness ducks responses to therapeutic regimes, and giving a prognosis to some duck diseases. In animal health, blood analyses have been performed much less often in avian in contrast to its predictable use in mammalian species (Oladele, 2001). Haematological and biochemical profiles will help to screen the blood profiles in order to discover the health position of the animals. For animal to be certified healthy, its blood profile has to meet certain standards. Haematological and serum biochemical profiles offer dependable information on the health status of animals (Cetin et al., 2009). They also reveal the sensitivity of an animal to its internal and external environments treatment (Esonu et al., 2001).

The blood profile could be influenced by sex, age, genetic makeup, climatic factors and management practice among others (Oladele et al., 2000). By establishing the haematological and biochemical values of Mallard and Muscovy at different ages and sexes, valuable indices will be obtained for assessing their health status. The indices may also be used as biomarkers for selection and improvement purposes. This research will also help to provide baseline information on haematological and biochemical parameters for breed identification on mallard and Muscovy breed of duck in the humid tropic environment. The objective of this study was to

determine the effect of breeds, age and sex on haematological and biochemical parameters of ducks.

2. Material and Methods

A total of 120 day old ducklings (i.e. 60 Muscovy and 60 Mallard) were used for the study. Each breed consists of 30 males and 30 females which were replicated into three. The ducks were given routine vaccination during the period of the experiment. Lasota and Gomboro vaccines were administered to the ducks periodically at 7 days and 14 days via drinking water. Commercial feed was provided in adequate quantity to the ducks twice a day, drinking water was given adlibitum. The ducks (0-4weeks) were fed ad libitum with starter mash containing 21-22% crude protein and 2,850 – 2,900kcal ME/kg and finishers (5-8weeks) were fed 19% crude protein and 3000kcal ME/kg. Individual identification of the ducks was done by marking wing banding. The experimental animals were kept in a confined pen under intensive system at ambient temperature of 32^0c – 37^0c with relative humidity of 68 – 74%. The experimental animals were sexed using their body weight and present of bright red and larger combs for separating males from females.

A total of 120 blood samples were collected from two breeds of ducks (i.e. 60 from Muscovy and 60 Mallards) at 4 and 8 weeks and these were used to determine haematological and biochemical studies based on breeds, age and sex. Blood samples (2.5 ml) were collected aseptically with sterile syringe and needles from the wing vein of the different breeds of duck into labeled bottles without anti-coagulant to allow for clotting in serum biochemical and samples for hematological studies was collected in bottles treated with ethylene di amine tetra-acetic acid (EDTA) done immediately after the wing had being damped with methylated spirit to disinfect the area and expose the vein. Determination was done based on sex of the ducks for packed cell volume (PCV), Hemoglobin (Hb), white blood cells (WBC), RBC, platelet, total protein, albumin, urea, creatinine, glucose, globulin and triglyceride. Evaluation was conducted according to the methods already described by Ahemen, et al (2015).

2.1. Statistical Analysis

The experiment was designed as a 2×2×2 factorial in a Randomized Complete Block Design (RCBD). Duncan's multiple range test (Duncan, 1955) was used to compare means of the two breeds, age and their sexes. Data obtained were statistically analysed with SPSS (2011) package version 20. The statistical model (equation 1) is as follows;

$$Y_{ijk1} = \mu + B_i + S_J + A_K + BSA_{ijK} + e_{ijkL} \quad (1)$$

Y_{ijk1} = Single observation on the i^{th} breed,
μ = Population mean,
B_i = effect of i^{th} breed,
S_J = effect of J^{th} Sex,
A_K = Effect of k^{th} Age,
BSA_{ijK} = Effect of interaction among the breeds, age and sex,
e_{ijk} = random error, which is assumed to be identically and independently distributed with zero, error and constant variance.

2.2. Ethical Consideration

The research was approved by the University of Port Harcourt research ethics committee for care and use of animals for research.

3. Results and Discussion

Table 1 showed breeds effect on Haematological and biochemical parameters of Muscovy and Mallard Breeds of Duck. The results showed that significant effects ($P < 0.05$) of breeds were observed in all the hematological and biochemical profiles of ducks.

Table 1. Mean + standard error effect of breeds of ducks on haematological and biochemical parameters

Blood Parameters	Muscovy	Mallard	Reference values
Packed Cell Volume (%)	31.00 ± 1.56[b]	31.167 ± 1.26[a]	22 ± 40
Hemoglobin (g/dl)	10.35 ± 0.52[a]	10.10 ± 0.62[b]	8 ± 12
Red Blood Cell ($x10^{12}$/L)	4.62 ± 0.24[a]	4.43 ± 0.27[b]	2.85 ± 5.63
White Blood Cell ($x10^9$/L)	12.21 ± .7.17[b]	12.31 ± 0.91[a]	10.4 ± 15.2
Platelet($x10^9$/L)	249.41 ± 4.91[b]	257.91 ± 7.91[a]	209 ± 314
Total protein (g/l)	48.41 ± 1.44[b]	53.41 ± 1.04[a]	40 ± 75
Albumin (g/l)	25.66 ± 1.44[b]	30.00 ± 0.84[a]	25 ± 28
Urea (mol/l)	2.78 ± 0.19[b]	3.29 ± 0.42[a]	2 ± 5.74
Creatinine(mol/l)	130.75 ± 3.77[b]	141.16 ± 3.27[a]	92 ± 141
Glucose (mol/l)	5.87 ± 0.50[b]	6.61 ± 0.35[a]	3.8 ± 7.2
Globulin (g/l)	21.91 ± 1.40[b]	23.41 ± 1.22[a]	20 ± 45
Triglyceride (g/l)	1.42 ± 0.09[b]	1.62 ± 0.07[a]	1.20 ± 4

[a,b]Means within the same row with different superscript differ significantly ($P < 0.05$).

The results revealed that Muscovy had higher values in Hb and RBC than Mallard breed of duck. While, Mallard recorded higher values in PCV, WBC and Platelets (PLT), Total Protein (TP), Albumin (ALB), Urea (UR),Creatinine (CRT), Glucose (GLU) Globulin (GLO) and Triglyceride (TRG). The results also indicated that Mu recorded higher

values for Hb (10.35 ± 0.52g/dl) and RBC (4.62 ± 0.24 × 10^{12}/ L) than Ma which recorded Hb (10.10 ± 0.62 g/dl) and RBC (4.43 ± 0.27 × 10^{12}/ L). The significant difference ($P < 0.05$) of breeds on haematological and biochemical profiles observed in Table 1, this study may be in response to differences in adaptations of these improved breeds of ducks as there are overlaps between the different adaptation in animals to meet the requirements of their given environment (Horton, 2005). According to these authors, animal populations are genetically modified in response to environmental challenge to shape their unique characteristics in an adaptive manner. The result also revealed that mallard recorded higher value of WBC and PCV. Thus may indicate its higher immunity status against diseases where the lower WBC value of the Muscovy may indicate its lower status. Animals with lower WBC are exposed to high risk of disease infection while those with high counts are capable of generating antibodies in the process of phagocytocis and have high degree of resistance to disease (Soetan et al., 2013) and enhanced adaptability to local environmental and disease prevalent condition (Kabir et al., 2011) the result obtained was similar to that of (Soetan et al., 2013) where they also observed similar significant ($P < 0.05$) different in haematological and biochemical indices. The high values reordered for mallard in PCV shows that this breed has better blood status. Increase PCV of the mallard shows a better transportation and thus result in an increased primary and secondary polycythemia.

Table 2 shows effect of sex on haematology and biochemical of Muscovy and Mallard breeds of duck. The results shows that significant ($P < 0.05$) effect of sex was observed in all the hematological and biochemical profiles studied except in ALB. The results also revealed that the female Mu had higher values in PCV, Hb, RBC, TP, UR, CRT, GLU and GLO than the male counterpart. While, the male Muscovy had higher values in WBC, PLT and TRG than the females. It was also revealed that no significant effect of sex was observed ($P > 0.05$) on Glucose (6.56 mol/l) male, Glucose (6.66 mol/l) female; triglyceride (1.77g/l) male, Triglyceride (1.47 g/l) female Mallard duck. The results also revealed that sex effect on male mallard on hematological and biochemical parameters were higher in values of PCV, WBC, PLTL, TP, Hb, UR, CRT, GLO, TRG than that of female mallard while the (hemoglobin, red blood cell, Glucose) of the female Mallard are higher compared to the male breed.

Table 2 revealed that significant effects of sex ($P < 0.05$) were observed on haematological and biochemical profiles of Muscovy and Mallard breeds of duck in this study. This result was in line with the findings of (Yaqub et al, 2013) where they observed significant effect of sex on haematological and biochemical parameters of farm animals but contrary to the findings of Olayemi et al. (2006) where they observed no significant in sex difference in PCV, RBC and WBC.

Table 2. Mean + Standard Error Effect of sex on haematological and biochemical parameters of Muscovy and Mallard breeds of duck

Blood Parameters /Breeds	Sex	Packed Cell Volume (%)	Hemoglobin (g/dl)	Red Blood Cell ($x10^{12}$/L)	White Blood Cell ($x10^{9}$/L)	Platelet ($x10^{9}$/L)	Total protein (g/l)	Albumin (g/l)	Urea (mol/l)	Creatinine (mol/l)	Glucose (mol/l)	Globulin (g/l)	Triglyceride (g/l)
Muscovy	Male	25.83 ± 2.20^{b}	8.68 ± 0.74^{b}	3.80 ± 0.34^{b}	14.53 ± 1.01^{a}	268.5 ± 11.19^{a}	46.66 ± 3.04^{b}	25.66 ± 1.61	2.44 ± 0.31^{b}	125.83 ± 5.34^{b}	5.40 ± 0.61^{b}	21.00 ± 1.73^{b}	1.45 ± 0.10^{a}
	Female	36.16 ± 1.19^{a}	12.01 ± 0.50^{a}	5.45 ± 0.70^{a}	9.90 ± 1.30^{b}	230.3 ± 10.00^{b}	50.16 ± 2.04^{a}	25.66 ± 1.38	3.12 ± 0.27^{a}	135.66 ± 5.24^{a}	6.35 ± 0.71^{a}	22.83 ± 1.71^{a}	1.39 ± 0.12^{b}
Mallard	Male	31.50 ± 2.18^{a}	9.93 ± 0.60^{b}	4.40 ± 0.20^{b}	12.83 ± 1.01^{a}	267.00 ± 11.19^{a}	56.83 ± 2.04^{a}	32.66 ± 1.38^{a}	3.72 ± 0.27^{a}	146.16 ± 5.34^{a}	6.56 ± 0.71^{b}	24.16 ± 1.70^{a}	1.77 ± 0.10^{a}
	Female	30.83 ± 2.20^{b}	10.26 ± 0.74^{a}	4.46 ± 0.34^{a}	11.80 ± 1.31^{b}	248.83 ± 11.01^{b}	50.00 ± 2.01^{b}	27.33 ± 2.31^{b}	2.87 ± 0.31^{b}	136.16 ± 4.34^{b}	6.66 ± 0.51^{a}	22.66 ± 1.20^{b}	1.47 ± 0.10^{b}

According to Oladele et al. (2001), the male ducks recorded higher haematological values than female ducks. This is in line with the findings of this study where male mallard recorded higher haemotological and biochemical value than that of female mallard. The mean haemoglobin values which were higher in in male ducks than in females are involved in maintaining haemostasis as they help to preserve vascular integrity (Olayemi et al., 2006). The effect of sex on plasma proteins has been shown to vary in birds, depending on the breed of the birds. Significantly higher total protein level had been reported in the females than in male guinea fowls (Oladele et al., 2005) and chickens (Oladele et al., 2000). However, no significant sex variation in total protein was observed in local ducks (Oladele et al., 2001) The rise in blood parameters in male in compare with females is often attribute to the effects of androgens, which stimulates enthropoiesis and the cause increase in the number of circulating RBC, PCV and HB concentration (Villier and Dunn, 1998). The result obtained also fall within the reference values of haematological and biochemical profile of ducks (Rajashree, 2017). The discrepancies observed between haematological and biochemical parameters in this investigation as influenced by sex may be owed to inherent sex differences among male and female breeds of duck. While, the variations observed in this study and those reported by other authors could be due to differences in breeds, species, age, climate, season, blood collection procedures, animal housing, nutrition and subclinical illness.

Table 3 shows effect of age on haematology and biochemical parameter of Muscovy and Mallard breeds of duck. The result revealed significant ($P < 0.05$) age effect on haematological and biochemical profiles of Muscovy and Mallard breeds of duck at 4 and 8 weeks. The results showed that Muscovy had higher values of haematological and biochemical values at 4 weeks in PCV (34.66 ± 2.22 %), Hb (11.50 ± 60 %), RBC (5.11 ± 0.20 $x10^{12}$/L), PLTL, TP, ALB, UR, CRT, GLU, GLO and TRG than at 8 weeks. This showed that the mentioned parameters decreased with age. While, WBC, TP, ALB and GLO recorded higher values at week 8 in Muscovy ducks, this indicates that the mentioned blood profiles increased with age. The result also showed that Mallard duck recorded higher values of haematological and biochemical parameters in RBC, Hb, PCV, PLT, URE, CRT, GLU and TRG at age 4 weeks than at 8 weeks, this also showed that the mentioned blood profiles decreased with age. While, Mallard ducks recorded higher values in WBC, TP, ALB and GLO at 8 weeks than at 4 weeks, this indicates that the mentioned blood profiles increased with age.

Table 3. Mean + standard error effect of age on haematology and biochemical parameters of Muscovy and Mallard breed of ducks

	Muscovy		Mallard	
Blood Parameters	4 weeks	8 weeks	4weeks	8 weeks
Packed Cell Volume (%)	34.66±2.22[a]	27.33±2.20[b]	32.33±2.23[a]	30.00±2.20[b]
Hemoglobin (g/dl)	11.50+0.60[b]	9.20±0.74[a]	10.20±0.94[a]	10.00±.74[b]
Red Blood Cell ($x10^{12}$/L)	5.11±0.20[b]	4.13±0.74[a]	4.56±0.61[a]	4.30±0.34[b]
White Blood Cell ($x10^{9}$/L)	9.41±1.01[a]	15.01±1.13[b]	11.61±1.00[a]	13.01±1.01[b]
Platelet($x10^{9}$/L)	251.66±11.19[a]	247.16±10.19[b]	267.00±11.13[a]	248.83±11.10[b]
Total protein (g/l)	42.16±2.04[a]	54.66±1.04[b]	42.50±2.07[b]	64.33±2.04 [a]
Albumin (g/l)	24.33±1.38[a]	27.00±1.26[b]	25.50±1.41[b]	34.50±1.38 [a]
Urea (mol/l)	3.32±0.27[a]	2.24±0.30[b]	4.02±0.13 [a]	2.57±0.27[b]
Creatinine(mol/l)	138.33±4.34[a]	123.16±5.34[b]	153.00±5.61 [a]	129.33±5.34[b]
Glucose (mol/l)	7.36±0.61[b]	4.38±0.71[a]	7.70±0.91 [a]	5.53±0.71[b]
Globulin (g/l)	17.83±1.71[a]	26.00±1.73[b]	17.00±1.62[b]	29.83±1.73 [a]
Triglyceride (g/l)	1.73±0.10[a]	1.11±0.10[b]	1.92±0.12 [a]	1.33±0.10[b]

[a,b]Means within the same row with different superscript differ significantly ($P < 0.05$).

According to Olayemi et al. (2003); PCV, HB and RBC indices were similar in young and adult animals. This was contrary to the finding of Kral and Suchy (2000) where haematological profile of domestic animals more in young animals than older animals but in this study, since haematological and biochemical profile where higher at week 4 than week 8, it was in agreement with the findings of Devi and Kumar (2012) where they observed increase in haematological values in growing animals as compared to adults which is apparently due to high basal metabolic rates.

Olayemi et al. (2006) reported that concentration of Total Protein in serum of ducks showed significant ($P < 0.05$) growth with ageing which is also in accord with the finding of this study. Talebi et al. (2005) showed that age effect significant ($P < 0.05$) the haematological profile of

ducks at 8 weeks which is also steady with the significant influence of age observed in this study. Hemandez et al. (2008) revealed an age dependent gradual decline in Total Protein concentration which is consistent with this study. Olayemi et al. (2006) also reported significant differences in Total Protein among difference ages in ducks which is in agreement with the present findings. The reduction in blood glucose in the two breeds of ducks observed in this study may implies that the ducks metabolic function may be hampered since glucose provides energy production through cellular oxidation, glycogen synthesis in liver and glycolytic muscles, fatty acid synthesis as well as synthesis of nonessential amino acid, vitamin C and other metabolites (Hemandez et al., 2008). The decline in the blood glucose may again depend on the balance between the intake of carbohydrates and the endogenous glucose synthesis and release by the liver on one hand and storage, utilization and excretion on the other hand. WBC is higher with age in Muscovy; this gives the impression of a better resistance and survival as the age.

4. Conclusion

The two breeds of duck (Muscovy and Mallard) examined have some differences in respect to breeds, age and sex on blood parameters indicating that the two duck breeds are not similar to each other. Significant main effect was observed in PCV, Hb, RBC, WBC, Total Protein, ALB, GLO and TRG which suggest genetic dissimilarities. Non-significance was observed in urea, creatinine and glucose which suggested genetic similarity among them. The similarity and differences obtained between the two breeds should be subjected to further analysis; however, the haematological and biochemical parameters variation in this study might also be due to gene in breed of ducks used. This will aid in planning breeding programme for selection of economic traits. The heamatological and biochemical values obtained in this study could serve as a baseline data of these breeds of duck in Rivers state, Nigeria. The results from this study fill an important gap in the literature by providing reference intervals for hematology and biochemistry parameters in breeds of ducks for commercial purposes. The breeds selected appeared to be in good health and the ducks chosen lacked clinical signs or physical abnormalities on physical examination, thus the variation in parameters may reflect what is expected in Rivers State, Nigerian commercial ducks. It is important to continue to assess and publish hematological and biochemical blood parameters for these animals, as well as for other stages of production, to aid veterinarians and researchers in the identification of clinical or subclinical disease or metabolic and nutritional problems. Haematological and biochemical parameters of ducks are significantly influenced by breeds, sex and age. These factors should be considered when interpreting the parameters in order to ensure accuracy.

Author Contributions

FO designed the study, supervised the research, carried out the statistical analysis and wrote the first manuscript. DS carried out the field work. Both authors read, corrected and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Ahemen T, Bitto II, Oluremi OIA, Anugwa FOI. 2015. Genital tract morphometric and haematological of male rabbits fed graded levels of cassava leaf meal. Nigerian J Anim Prod, 42: 50-59.

Cetin N, Bekyurek T, Cetin E. 2009. Effects of sex, pregnancy and season on some haematological and biochemical blood values in Angora Rabbits. Scand J Lab Anim Sci, 36: 155-162.

Devi R, Kumar MP. 2012. Effect of ageing and sex on the cerulo-plasmin (Cp) and the plasma protein levels. J Clin Diagno Res, 6(4): 577-580.

Duncan DB. 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.

Esonu BO, Emenalom OO, Udedebie U, Herbert DF, Ekpori IC, Iheukwuemere FC. 2001. Performance and blood chemistry of weaner pigs fed raw mucuna bean (velvet bean) meal. Trop Anim Prod Invest, 4: 49-54.

Hernandez AM, Satue K, Lorente C, Garces C, Oçonnor JE. 2008. The influence of age and gender on haematologic parameters in Spanish Horses. In: Proceedings of Veterinary European Equine Meeting, Jan 25-27, Venice, Italy.

Horton TH. 2005. Fetal origins of developmental plasticity: Animal models of induced life history variation. Am J Human Biol, 17(1): 34-43.

Merck Manual. 2012. Haematologic reference ranges. Mareck Vet Manual, http://www.merckmanuals.com/ (accessed date: March 23, 2012).

Oladele SB, Ayo JO, Esievo KAN, Ogundipe SO. 2000. Effect of season and sex on packed cell volume, haemoglobin and total protein of indigenous chickens in Zaria, Nigeria. J Med Allied Sci, 3: 173-177.

Oladele SB, Ayo JO, Esievo KAN, Ogundipe SO. 2001. Seasonal and sex variations in packed cell volume, haemoglobin and total protein of indigenous duck in Zaria, Nigeria. J Trop Biosci, 1(1): 84-88.

Oladele SB, Ayo JO, Ogundipe SO, Esievo KAN. 2005. Seasonal and sex variations in packed cell volume, haemoglobin and total protein of the guinea fowl (Numida meleagris) in Zaria, Northern Guinea Savannah zone of Nigeria. J Trop Biosci, 5(2): 67-71.

Olayemi FO, Oyewale JO, Omolewa OF. 2002. Plasma chemistry values in the young and adult Nigerian duck (*Anas platyrhynchos*). Israel J Vet Med, 57: 1-5.

Olayemi F, Oyewale J, Rahman S, Omolewa O. 2003. Comparative assessment of the white blood cell values, plasma volume and blood volume in the young and adult Nigerian duck (*Anas platyrhynchos*). Vet Archiv, 73(5): 27-276.

Olayemi FO, Ojo EO, Fagbohun OA. 2006. Haematological and plasma biochemical parameters of the Nigerian laughing dove (*Streptopelia senegalensis*) and the Nigerian duck (*Anas platyrhynchos*). Vet Archiv, 76 (2): 145-151.

Kabir M, Akpa GN, Nwagu BI, Adeyinka IA, Bello UI. 2011. Sexual dimorphism, breed and age characteristics of rabbits in Zaria, Nigeria. In Proceedings of the 16th Annual Conference of Animal Science Association, Nigeria, p.133-137.

Kral I, Suchy P. 2000. Haematological studies in adolescent breeding cocks. Acta Vet Brno, 69: 189 - 194.

Rajashree R, Bhajirathi P, Mishra SK. 2017. Comparative serum biochemical profile for different breeds of ducks versus white leghorn chickens in peak laying period. Indian J Anim Res, 53(3): 327-331.

Soetan KO, Akinrinde AS, Ajibade TO. 2013. Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn (*Sorghum bicolor*). In Proceedings of 38th Annual Conference of Nigerian Society for Animal Production, Nigeria, pp. 49-52.

Talebi A, Asri-Rezaei S, Rozeb-Chai R, Sahraei R. 2005. Comparative studies on Haematological values of Broilers Strain (Ross, Cobb, Arbor –acres and Arian) Inter J Poultry Sci, 4: 573-579.

Villiers E, Dunn JK. 1998. Basic haematology. In: Davidson M, Else Rand Lumsden, J. editors. Manual of small animal clinical pathology, Shurdngton, Cheltenham, United Kingdom, pp. 33-60.

Yaqub LS, Kawu MU, Ayo JO. 2013. Influence of reproductive cycle, sex, age, and season on haemtologic parameters in domestic Animals: A review. J Cell Anim Biol, 7(4): 37-43.

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FINANCIAL BENEFITS ANALYSIS OF BROILER CHICKEN FARM OPERATORS IN DELTA STATE NIGERIA

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Abstract: This study examined financial benefits of broiler chicken farm operators in Delta State, Nigeria. Data were collected from 168 randomly selected broiler farm operators with the aid of structured questionnaire and analyzed using descriptive statistics, cost and return analysis and regression analysis. The result showed that 58.3% of the farmers were between age brackets of 31-40 years with 82% of them male and 76.2% were married with 67.9% having household size of 6-10 persons. About 96.4% of the broiler chicken farmers were literate with 66.7% of them having between 11-15 years of experience. The average net profit, gross margin and average net profit per bird as well as return per naira invested were N928720, N1034606, N 1254.82 and N 2.89 respectively. This implies that broiler production is profitable. Poultry droppings/litters were also essential by-products that generate enough income to the broiler chicken farmers. The result of the regression model showed that cost of chicks, cost of feed, cost medicine and veterinary cost positively influenced profit while labour cost, water supply cost , transportation cost and mortality rate had inverse relationship with profit. High cost of feeds, bird mortality and inadequate capital were the major constraints associated with broiler chicken production. It is recommended that if these aforementioned constraints are tackled will help boost broiler chicken production in the study area.

Keywords: Broiler chicken, Production, Profit, Farmers, Gross margin analysis

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1. Introduction

The growth of the poultry industry is one of the fastest avenues of narrowing the dearth gap in protein prevailing in most of the developing countries. The business of poultry enterprise, if appropriately supported can be a source of foreign earnings which has the capacity to complement crude oil that forms the most important source of foreign earnings in Nigeria (PSN, 2009). Livestock production plays a great role in the agricultural economy of developing countries with respect to activating socio economic change, improved income and quality of rural life in Nigeria (Aromolaran et al., 2013). The poultry industry serves as sources of income through employment opportunities for the people.

Broiler production is exceptional in that it gives livestock enterprises the highest turnover rate and the fastest return on investment (Gbigbi, 2017). The money invested in broiler production is recovered more rapidly than any other livestock business. In addition, the meat of broilers has high nutritional value. Broiler had short gestation periods, cholesterol content of the meat very low, returns from broiler investment is fast, need little capital to start, it doesn't requirement large space, good converter of feed and vegetables into meat compared to other animals (Onubuogu and Nnadozie, 2005).

Broiler production involves the keeping of heavy meat breed chickens, in order to obtain high quality meat products, which are generally sold live or processed at age 10 to 12 weeks (Amos, 2006). They need enough feeds to maintain their body weight. Once the supply of feeds becomes unsteady, business expansion is curtailed and in extreme cases, poultry producer are forced to sell their birds pre-maturely. Poor quality of feeds on the other hand, lead to high mortality rate, low productivity and consequently, low rate of returns to investment. Broiler production is conducted in every part of the world with no established political, social or cultural inhibitions associated with their use. In particular, investments in broiler enterprises are attractive, since the production cost per unit is low in comparison to other livestock, the meat is tender and the broiler firms have short cycles of production (Nwajiuba and Nwoke, 2000).

In Nigeria, there is a growing demand for broiler chickens because the interest of meat consumers gradually shifts from red to white meat. At the moment, however, this situation is threatened by high production costs due to the increasing cost of important ingredients required to produce feed. The outputs of broiler production could not meet their demand adequately. The production system for broiler chicken needs to be improved by the use of improved technologies by farm

operators. It is understood that technology adoption has a certain degree of correlation to the farmers' socio-economic qualities.

Broiler chicken production may be linked to farmers' characteristics such as size of farm, availability of labour, risk attitude and level of income (Achoja, 2013). The predicted income flow is one of the drivers of technology adoption. Profit is therefore the fundamental of investment in the decision of farmers to produce broiler chicken. According to Duffy and Nanhou (2003) Farm profitability is influenced by, age of farmer, period devoted to farming activities, machinery usage, economy of scale, productivity of land, management technologies applied, market distance to consumers, plants for processing, environmental conditions, such as soil, relief, weather, prospect of displaying the product in the market and likelihood of using labour.

Adepoju (2008) in his view said that the average per capita animal protein intake in Nigeria was 6.8g. The only way of solving this malnutrition problem with a view to improving the level of daily consumption of animal protein in the country is by increasing broiler production. Broiler production which is part of the livestock sub-sector needs to be a priority area because it holds the key to the problem of protein calorie malnutrition all over the world because of the high quantity and quality of protein content of meat products.

The major difficulties in this research include inadequate markets, high feed and chick-cost, insufficient finance, timely delivery of farm input and inadequate extension services (Rahman et al., 2005). Despite the high nutritional value and importance of broiler chicken production, the production pattern and profitability of broiler chicken is restricted. For increased output, broiler chicken production technology is required. Previously, insufficient research has been given to the cost and profitability of broiler chicken production. This study aims to close the knowledge gap in the development of broiler chicken in Delta, Nigeria with regard to costs, return and profitability.

Although broiler chicken production is highly nutritious and important, the pattern of production and profitability evidence are limited. For increasing production, broiler chicken production technology is necessary. Previous work has not given adequate attention to cost and profitability of broiler chicken production. This study was conceived to close the knowledge gap in the development of broiler chicken in Delta State, Nigeria with regard to costs, return and profitability.

In spite of the large investment in agriculture by the government and individuals to make Nigeria food sufficient, particularly animal protein and income generation, No research to assess its profitability has so far been performed. The situation now seems that people no longer engage in poultry business, those that are still in the business are threatening to withdraw or are diverting to other quick money making ventures. Empirical knowledge on profitability can draw investors into the development of broiler chicken. In addition, where serious constraints are identified and addressed, the production of broiler could gain popularity and growth. The correct policy structure for the poultry-based agricultural economy in Nigeria is explained by a thorough analysis of profitability determinants and constraints on the broiler chicken production.

The study revealed the opportunities that abound in broiler chicken production with a view to engage private investors who desire to go into livestock business to invest more on broiler chicken production or incorporate broiler chicken production into other agricultural practices. It will also be beneficial to policy makers and researchers. Presently, little or no information exist regarding the viability of broiler chicken farm operators in Delta State, Nigeria. The study's broad aim was to analyze the financial benefits of producing broiler chicken in Delta State, Nigeria.

2. Material and Methods

This study was conducted in Delta State, located between longitudes 5° 50` and 6° 45` east of the Greenwich meridian and latitudes 5°, 25` and 6° 30` north of the equator. It is surrounded by way of mangrove forest in the Southern part, rain and fresh water forest in the central and derived savannah in the north. It is delineated into three agricultural zones namely Delta north (9 LGAs), Delta central (8 LGAs) and Delta South (8 LGAs). Firstly, 50% of the LGAs in each agricultural zone were randomly picked. Secondly, two communities were carefully chosen from each LGA, resulting in the choice of 26 communities. Seven (7) broiler chicken farm operators were selected from each of the community to give a total sample size of one hundred and eighty (182) operators. However, 14 questionnaires could not be retrieved for the data analysis resulting to 168 operators used for the study. Data were collected using structured questionnaire. The study covers between 2014-2018 production periods

2.1. Measures of Financial Success

Analysis of data was by cost and return analysis. Mathematically, it is stated as follows (equals 1, 2 and 3):

$$NFI = TR - TC \quad (1)$$

Where;
NFI= net profit
TR= total revenue
TC= total cost

$$TR = Pq \quad (2)$$

Where;
P= Price per unit of output
q= quantity of output.

$$TC = TVC + TFC \quad (3)$$

Where;
TVC= total variable cost
TFC= total fixed cost

2.2. Regression Analysis

In order to ascertain the factors influencing broiler chicken operators' profit, multiple regression analysis was employed. The model is specified as follows (equals 4 and 5):

$$Y = f(X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + \ldots\ldots + Xn + e) \quad (4)$$

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + Xn + e \quad (5)$$

Where;

Y= profit (₦/broiler production cycle)

X_1= cost of day-old chicks (₦)

X_2= cost of feed (₦)

X_3= cost of labour (₦)

X_4= cost of drugs and medication (₦)

X_5= equipment (depreciation) (₦)

X_6= cost of water supply (₦)

X_7= transportation cost (₦)

X_8=mortality rate (%)

a = constant term

b= regression coefficients

e= error term.

2.3. Ethical Consideration

The research was carried out with approval of the Ethical Committee of the Department of Agricultural Economics and Extension, Delta State University, Asaba campus, Asaba, Nigeria. I hereby declare that this research does not include any experiments with human or animal subjects.

3. Results and Discussion

Result in Table 1 showed that 58.3% of the respondents fall within the age bracket of 31-40 years, 23.8% constituted age bracket of 41-50 years and 3.6% fall within 21-30 years. Only 14.3% were above 50 years of age. This implies that majority of the respondents are in their active age of production. The finding corroborates that of Nwankwo (2007) who reported that majority (83%) of the farmers are in their active age bracket of 21-40 years. The result revealed that 82.1% of the respondents were male as against 17.9% female respondents. It implies that the males dominated the business of broiler production because of the tedious nature of the job. This finding is in line with that of (Gbigbi 2017) who reported male dominance in broiler production. The result is similar to the findings of Jabil (2009) who reported that men are more into agricultural production activities.

Table 1. Socio-economic characteristics of broiler chicken operators (N = 168)

Category	Frequency	Percentage
Age (years)		
21-30	6	3.6
31-40	98	58.3
41-50	40	23.3
Above 50	24	14.3
Sex		
Male	138	82.1
Female	30	17.9
Marital status		
Single	24	14.3
Married	128	76.2
Divorced/widow	16	9.5
Household size		
1-5	38	22.6
6-10	114	67.9
11-15	12	7.1
Above 15	4	2.4
Educational level		
No formal education	6	3.6
Primary education	32	19.0
Secondary education	120	71.4
Tertiary education	10	6.0
Broiler experience (years)		
1-5	2	1.2
6-10	42	25.0
11-15	112	66.7
Above 15	12	7.1

The result indicated that majority (76.2%) were married, 14.3% of the respondents are single while the remainder (9.5%) were divorced/widow. This finding is in line with the report of Adamu (2005) who said that 95% of the

peasant farmers in Nigeria are married. The result showed that 67.9% of the respondents had household size of 6-10 and 1-5 constituted 22.6%. About 7% had household size of 11-15 while only 2.4% had household size above 15 persons. The result showed that 71.4% of the respondents had secondary education, 19% had primary education and 6% had tertiary education while only 3.6% had no formal education. This suggests that the broiler producers in the study area are educated. The result showed that 66.7% of the respondents had between 11-15 years of experience while 25% had between 6-10 years of experience. Those with 1-5 years of experience constituted 1.2%. Only 7.1% had above 15 years of experience in broiler production. This implies that the broiler farmers are not novice in the poultry business. This support Gbigbi (2019) who pointed out that farming experience enhances efficiency in resource use.

The result in Table 2 showed the costs incurred on operating inputs and fixed cost over a five-year period for the production of broiler birds under deep litter system. The differences in the total costs incurred in the purchase of day-old chicks are attributed to the differences in the unit price of day-old chicks over the years. While the unit cost of day-old chicks was ₦100 in 2014, the corresponding amount in 2018 was ₦150. Therefore, from these unit costs of purchasing a day-old broiler, the total amount required for the purchase of day-old chicks in 2014 and 2018 were ₦30,000 and ₦70,000 respectively, showing a price increase between 2014 and 2018. The cost of feeding broilers was ₦102, 980 in 2014 as against ₦129, 840 in 2018, showing an increase between 2014 and 2018. The continued increase in the cost of feeds may be attributed to the scarcity and high cost of raw materials used in compounding poultry feeds.

Table 2. Variable and fixed costs of broiler chickens enterprise (2014-2018)

Variable inputs (₦)	2014	2015	2016	2017	2018	Average
Stock	30000	40000	50000	60000	70000	50000
Feeds	102980	113000	113000	121100	129840	115984
Labour	36000	36000	43200	43200	48000	41280
Drugs, veterinary services	4000	6000	6000	8000	10000	6800
Electricity bill	2000	2000	2000	2500	2500	2200
Marketing cost	900	900	950	1000	1000	950
Total variable cost (₦)	175880	188900	215150	235800	261340	215414
Fixed cost depreciation	39235	35401.26	31946.41	28832.75	26026.42	32288.37
Fixed asset interest, stock (₦)	67097.5	65947.76	65837.5	70597.5	68597.5	66847.5
Tax	3500	6150	7760	4500	8000	6750
Total fixed cost	109832.5	107498.76	105543.91	103930.25	102623.92	105885.9
Total cost (₦)	285712.5	296398.8	320693.9	339730.3	363963.9	321299.9

It could also be observed from the Table 2 that the cost of feeding broilers continually increases from 2014 and 2018, The increase in the cost of feeds was probably due to the no emphasis placed on the use of cheaper brewery waste and other local source of feed formulation to be adopted by the farmers in the area of study thereby forcing the cost of feeds to rise as a result of increase in the quantity of feeds demanded. However, as the cost of feeds rise, many farmers were force to invent other ways to supplement the quantity of feeds purchased. This result is in consonance with Haruna et al (2007) findings that cost of feed constituted more than half of the total variable cost of broiler enterprise.

In 2014, the total cost of labour employed for the production of broilers per batch was ₦36, 000 paid to the two poultry attendants that were needed to raise broilers per annum. The amount increased to ₦43, 200 between 2016 and 2017 and ₦48, 000 in 2018, resulting in a total increase over the years. In the case of cost incurred in drugs and veterinary services, the respective amounts over the years under consideration were found to be increasing due to increase in the price of drugs. The result showed that the total variable cost and total fixed cost was ₦215,414 and ₦105,885.9 respectively.

The result in Table 3 revealed that 583 broilers were produced in 2014 with an average price of ₦1500. The total revenue from the sale of matured broiler produced in 2014 amounted to ₦ 874,500 but in 2015, the total revenue was ₦1,039,500. The increase in the total revenue in 2015 was attributed to good management due to rise in the number of broilers produced and rise in price of broiler. 1n 2018, the total mature broiler produced was 838 which was more than the previous years and with a price of ₦2000 per broiler. The average amount realized from the sale of poultry droppings/litters in 2014-2018 was ₦8200. This is an added advantage to the poultry industry. This support a study by Dunkley et al (2010) in South Georgia that cost per ton of litter ranged from $10 to $55. The study found that 27.42% of growers bought litter for $10 to $20 per

ton while 43.55% purchased litter for $21 to $35 per ton. According to Cunningham and Fairchild (2012) opined that between 2008 to 2009 poultry litter for crop production in Georgia was sold for $40 to $60 per ton delivered. Further study showed that litter use in the southern coastal plains based on value of a harvested crop, a ton of stack-house broiler litter added $103.74 acre per year to the crop value (Dunkley et al., 2010). Therefore, the average revenue realized from broiler production between 2014 and 2018 was ₦1,250,020.

The result in Table 4 indicated that the gross margin of broiler production increase from ₦705,620 in 2012 to ₦ 860,100 in 2015 and further increase in 2016 to ₦ 998,350 and 2017 to ₦1,172,300 and also increase to ₦1,436,660 in 2018. It could be observed that operating costs, the number of broilers kept up to market weight had a marketed effect on the magnitude of the gross margin.

Table 3. Revenue from broiler chicken enterprise

Items	2014	2015	2016	2017	2018	Average
No. of day old chicks	962	980	900	992	996	966
No. of mature broilers	583	693	750	772	838	727.2
No. of dead birds	379	287	150	220	158	238.8
Mortality rate (%)	39.4	29.3	16.7	22.2	15.9	24.7
Price per broiler (₦)	1500	1500	1600	1800	2000	1680
Revenue from broilers (₦)	874500	1039500	1200000	1389600	1676000	1235920
Sales of used feed bags (₦)	2000	3500	6000	8000	10000	5900
Poultry droppings/litters (₦)	5000	6000	7500	10500	12000	8200
Total revenue (₦)	881500	1049000	1213500	1408100	1698000	1250020

Table 4. Gross margin analysis for the production of broiler chickens (2014-2018)

Items	2014	2015	2016	2017	2018	Average
Total variable cost (₦)	175880	188900	215150	235800	261340	215414
Total revenue from broiler (₦)	881500	1049000	1213500	1408100	1698000	1250020
Gross margin (₦)	705620	860100	998350	1172300	1436660	1034606
Gross margin/bird (₦)	1210.3	1241.1	1331.1	1518.5	1714.4	1403.08

The result in Table 5 revealed that broiler production was profitable over the years under consideration. The average net profit of ₦928,720.1 and average net profit per bird of ₦1254.82 derived between 2014 and 2018 showed that the farmers gained maximally from broiler production in the study area. This implies that poultry business especially broiler production has the tendency to generate income to improve the living conditions of people in Delta State, Nigeria. Every broiler was found to generate an average net profit of ₦1254.82 and every naira invested on broiler production generated an average return of ₦2.89. The result supports a study by Ironkwe and Ajayi (2007) on broiler production which reveals that it was a profitable business venture, yielding a net farm income of ₦2000/bird.

3.1. Determination of Factors Influencing Profit of Broiler Chicken Farm Operators

Multiple regression analysis was applied to determine the factors influencing broiler chicken operators. The result in Table 6 showed that the double-log functional form was chosen as the lead equation based on the high number of variables that were found significant and high value of R-squared. The result showed that the variation in the output of broiler production is jointly explained by all the explanatory variables accounting for 0.5061. This means that the variables explained only 51% of the total variation in the output of broiler production. The F-value showed that the joint influence of all these variables on output is statistically significant at 1% level.

The study results showed that the relationship between chicks and profitability is positive and significant at 1%. This could lead to the conclusion that the profitability of broiler chicken strongly depends on the price of broiler sold and the number of chicks bought. This finding suggests that the higher the broiler chicken price per unit, the greater the profitability. The result of the study shows that the coefficient of feed cost bore negative sign and has a significant relationship with profitability at 1% level.

This implies that a unit increase in the cost of feed would lead to a corresponding decrease in profitability of broiler chicken production. This could imply that farmers are using high feeds of high quality for their broiler production. The quality of feeds has very high effect on output. The more the quantity of high-quality feed, the more the expenses incurred in response to facilitate the growth of chicken for quick return of higher revenue. This result indicates that higher feed costs will increase

the overall cost to produce broiler chicken, thereby reducing the farmer's net farm income. Work such as Emenyonu et al. (2005) is in agreement with the findings in this study regarding feed cost.

The coefficient of drugs and medication was negative and significant at 1% showing that the more the broiler farmers have preventive measures to avoid death of broilers the more money they will spend. This may result that increase in cost of drugs and medication will lead to high cost, which could reduce profitability. Increase in cost of drugs and medication could lead to use of little quantity by farm operators, thereby affecting the level of profitability. This disagrees with the earlier findings of Tsado et al. (2015), who found out that a successive increase in the cost of medication/vaccine, access to information, quantity of feed, capital items and access to credit will lead to a successive increase in value of poultry production.

Table 5. Net profit of broiler chicken production (2014-2018)

Items (₦)	2014	2015	2016	2017	2018	Average
Sales of broiler (₦)	874500	1039500	1200000	1389600	1676000	1235920
Sales of used feed bags	2000	3500	6000	8000	10000	5900
Sales of droppings (₦)	5000	6000	7500	10500	12000	8200
Total Revenue (₦)	881500	1049000	1213500	1408100	1698000	1250020
Total variable cost (₦)	175880	188900	215150	235800	261340	215414
Gross margin (₦)	705620	860100	998350	1172300	1436660	1034606
Total fixed cost (₦)	109832.5	107498.76	105543.91	103930.25	102623.92	105885.9
Total cost (₦)	285712.5	296398.8	320693.9	339730.3	363963.9	321299.9
Net profit (₦)	595787.5	752601.2	892806.1	1068369.7	1334036.1	928720.1
Net profit/bird	1021.9	1086.0	1190.4	1383.9	1591.9	1254.82
Return/naira investment	2.09	2.54	2.78	3.14	3.67	2.89

Table 6. Determination of factors influencing broiler chicken operators profit

Variable	Coefficient	Standard error	t	p>/t/
Cost of chicks	0.705301***	0.2089285	3.38	0.001
Cost of feed	-0.5261068***	0.1141303	4.61	0.000
Drugs and medication	-0.2532651***	0.0827003	3.06	0.003
Labour	-0.233822**	0.0885902	2.64	0.010
Equipment (depr)	0.0153 NS	0.052254	0.29	0.770
Water supply cost	-0.2980873**	0.144181	2.07	0.042
Transport cost	-0.1711529**	0.0818895	2.09	0.040
Mortality	-0.0158143**	0.0053933	2.93	0.005
Constant	14.8416**	0.6380048	23.26	0.000
R-squared	0.5061			
Adj R-squared	0.4574			
F- value	10.38			

The coefficient of labour cost was negatively significant with profitability of broiler chicken production at 5% level. This result indicates that higher labour costs in the production of broiler chicken could lead to higher overall production costs and a reduction in profitability. The coefficient of cost of water supply was negative and significant at 5% level. Given that if the money spends on supply of water is high it could make the farmer to supply lower quantity which could result to low output and as well low profit. This is a maintenance culture to keep the birds healthy and marketable.

The coefficient of transportation cost was negative and significant at 5% level. This suggests that the cost of transportation incurred during broiler production is inversely related to the profit. This finding could be justified from the distance a farmer will travel to acquire the production inputs. Similarly, the coefficient of mortality rate is negative in the model in line with a prior expectation that the higher the mortality rate, the lower the profit in broiler production. Mortality rate is significant at 5% probability level.

3.2. Constraints Faced by Broiler Chicken Farm operators

The result presented in Table 7 showed the constraints broiler chicken farm operators faced.

3.2.1. High cost of feeds

Most of the broiler chicken operators (88.1%) described high feed cost as their key profitability concern. The results show that lack of ample bird feed would lead to low yields, thereby reducing farmers ' income.

3.2.2. Bird mortality

The study shows that 81.0% of broiler chicken farm operators regard the mortality of birds as an impediment to profitable production of broiler chicken. Profit is the objective and incentive for doing business. The low profit margin due to the high mortality rate could severely discourage current and potential broiler chicken producers.

3.2.3. Inadequate capital

Most of broiler chicken operators (77.4%) agreed that inadequate financing poses a problem in broiler chicken production. In conformity with Gbigbi's previous findings (2017), his study previously indicates that lack of capital is one of the biggest problems of production and profit.

3.2.4. High cost of drugs and medication

About the broiler chicken farm operators (64.3%) agreed that their biggest problem in the field of research was the high cost of drugs and medication. This could be due to few dealers on livestock and veterinary drugs and transaction costs for their services. This causes the sale of their birds at a discount price to adversely affect their profitability.

3.2.5. Poor feed quality

The results show that broiler chicken farm operators (53.6%) agreed that their main issue is poor feed quality. Many farmers have not yet known how to formulate and use modern feed manufacturing technology thereby reducing their operators' profit, as low profit margin could strongly dissuade current and potential broiler producers.

Table 7. Constraints of broiler chicken production

Constraints	Frequency	Percentage
High cost of feeds	148	88.1
Bird mortality	136	81.0
Inadequate capital	130	77.4
High cost of drugs/inaccessibility to veterinary	108	64.3
Poor feed quality	90	53.6

4. Conclusion and Recommendations

This study examined the financial advantages of broiler chicken production amid farm operators. The results show that the production of broiler chicken has significant financial rewards. The gross margin from broiler chicken producers was sufficient to promote current and potential investors in the production of broiler chicken in the study area for the period 2014-2018. The average net profit of ₦928, 720.1 and average net profit per bird of ₦1254.82 derived between 2014 and 2018 revealed that the farmers gained maximally from broiler production in the study area. The major constraints were high cost of feeds, bird mortality and inadequate capital. Base on the findings government should subsidize the cost of feeds, provide good management system through training of farmers on handling of broiler activities to reduce the high mortality rate. Veterinary doctors should be made accessible to the farmers. This will draw investors into the industry and also expand the existing production. Government and NGO's should provide agricultural credit to broiler farmers to ease the financial constraint confronting them. Finally, the government should help the farmers with a programme for proper utilization of the poultry droppings/litters to generate additional income to the broiler chicken farm operators in the study area.

Author Contributions

All tasks have been performed by single author.

Conflict of Interest

The author declares that there is no conflict of interest.

References

Achoja FO. 2013. Financial risk threshold determination in broiler enterprise in Delta State in Nigeria. Agri Tropica et Subtropica, 46(14): 111-117.

Adamu AA. 2005. Efficiency of resource-use in irrigated wheat production among farmers in Hadejia-Jama'are River Basin Nigeria. MSc thesis, Abubakar Tafawa Balewa University, Agricultural Economics and Extension Programme, School of Agriculture and Agricultural Technology, Bauchi, pp. 133.

Adepoju AA. 2008. Technical efficiency of egg production in Osun State. Inter J Agri Econ Rural Develop, 1(1): 7-14.

Amos TT. 2006. Analysis of backyard poultry production in Ondo State Nigeria. Inter J Poultry Sci, 5(3): 247-250.

Aromolaran AK, Ademiluyi IO, Itebu OJ. 2013. Challenges of small poultry farms in layer production in Ibadan Oyo State Nigeria. Global J Sci Frontier Res Agri Vet Sci, 13(2): 1-9.

Cunningham DL, Fairchild B D. 2012. Broiler production systems in Georgia costs and returns analysis. University of Georgia cooperative extension Athens: UGA cooperative extension bulletin, https://secure.caes.uga.edu/extension/publications/files/pdf/B%201240_3.PDF (accessed date: March 23, 2012).

Duffy M, Nanhou V. 2002. Factors of success of small farmers and the relationship between financial success and perceived success. 30th National Small Farm Conference; 2002; Albuquerque New MexicoUSAp.17.

Dunkley CS, Cunningham DL, Harris GH. 2010. The value of poultry litter in South Georgia. URL https://secure.caes.uga.edu/extension/publications/files/pd

f/B%201386_3.PDF (accessed date: March 23, 2012).

Emenyonu CA, Odii MACA, Obih U, Anaeto CF. 2005. Determinants of sustainable broiler meat production in Imo State. In Proceedings of the 1st Annual Conference on Developments in Agriculture and Biological Sciences, 27 April 2005, Akure, Nigeria, pp. 300.

Gbigbi TM. 2017. Measurement of profit efficiency among broiler producers in Delta State Nigeria. J Agri Technol Environ, 6(2): 64-74.

Gbigbi TM. 2019. Resource use efficiency and misery of sweet potato production window into financial surplus for households in Delta State Nigeria. Inter J Agri Sci, Res Technol Extension Edu Systems, 9(2): 83-89.

Haruna U, Jibril SA, Kalla DJU, Suleiman H. 2007. Evaluation of egg production in Jos North local government area Plateau State Nigeria. Inter J Poultry Sci, 6(8): 604-607.

Ironkwe MO, Ajayi FO. 2007. Profitability analysis of broiler production in Oyibo LGA of Rivers State Nigeria. Global J Agri Sci, 6(2): 195-200.

Jabil IY. 2009. Marketing of selected processed dairy products in Bauchi State Nigeria. MSc thesis, Abubakar Tafawa Balewa University, Agricultural Economics and Extension Programme, School of Agriculture and Agricultural Technology, Bauchi, pp. 113.

Nwajiuba C, Nwoke E. 2000. Inflation and poultry in Nigeria: Implication for profitability re-inventing animal production in the 21st Century. In Proceeding of the 5th annual conference of the Animal Science Society of Nigeria Port, Harcourt, Nigeria, pp 206-208.

Nwankwo F. 2007. Factors affecting farmers access to agricultural loans in Anambra State. In proceeding of ninth annual national conference of the Nigerian Association of Agricultural Economists, November 5-8, 2007, Abubakar Tafawa University, Bauchi, pp. 496-504.

Onubuogu GC, Nnadozie BC. 2005. Socio-Economic Factors Affecting Broiler Bird Brooding in Obowu LGA of Imo State Nigeria. Proceedings of the 39th Annual Conference of the ASN University of Benin, October 9-13, Benin, Nigeria, pp.132-135.

PSN. 2009. Poultry site news. http://'poultry newsdesk.com (accessed date: April 19, 2016).

Rahman SA,Yakubu A. 2005. Analysis of poultry production distribution and consumption in parts of Nassarawa State Nigeria. Inter J Nat Appl Sci, 1(1): 1-4.

Tsado JH, Ibrahim M, Ajayi OJ, Fatoki P, Momo J. 2015. Effects and constraints associated with ICT use by yam farmers in Benue State Nigeria. J Agri Rural Develop, 15: 22-31.

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EFFECT OF THERMAL FORCING OF CORMS ON THE FLOWERING OF SAFFRON (*CROCUS SATIVUS* L.)

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Abstract: Among all environmental factors, the temperature is considered one of the key elements that control the growth and development of saffron. This study was undertaken to investigate the effect of thermal forcing of corms on saffron growth and development. To this end, mother corms were collected at four different periods: late March (T2) , mid-April (T3) , late April (T4), and after leaf senescence (Control, T1) . The corms of each period were then pretreated at three successive temperature levels: at 25 °C for 2 weeks, at 15 °C for 2 weeks and finally at 4 °C for 12 weeks. The results showed that the thermal pretreatment of corms had a significant effect on some saffron parameters. The flowers of the corms that underwent thermal treatment were later than those of the control. Similarly, the flower numbers and stigma yield were negatively affected by thermal forcing of corms. Overall, the thermal forcing of corms under the proposed regime was unfavorable for the growth and development of saffron.

Keywords: Forcing, Vegetative growth, Late flowering, Stigma yield, Daughter corms

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1. Introduction

The saffron crocus (*Crocus sativus* L.; F/ Iridaceae), is a sterile geophyte with autumnal flowering, which reproduces exclusively by vegetative means (Mzabri et al., 2017). It is cultivated for its red stigmas which, after drying, are the most expensive and valuable spice in the world (Zhang et al., 2019). More recently, the demand for stigmas has increased dramatically, especially with the discovery of new pharmacological applications, especially those based on cytotoxic and antitumor properties (Cavusoglu 2017; Mzabri et al., 2019). Saffron is adapted to various environmental conditions, it grows well in arid and semi-arid areas (Gresta et al., 2008) but it can also adapt to temperate and subtropical climates. Despite these characteristics, the average productivity of saffron in Morocco remains modest with a significant annual fluctuation, of which drought during the critical stages of this species is the main cause of this fluctuation. This is in addition to traditional anthropogenic practices that have not changed since ancient times. It is also worth noting that the large burden of workforce makes the production of saffron unprofitable despite its high price on the market. Flowering saffron lasts only 2-3 weeks, and flower picking is required daily. For these reasons, research on the valorization of saffron production (Erkel 2005; Ipek et al., 2009) and the extension of harvest time (Molina et al., 2005; Erkel 2005) are gaining importance.

Some previous studies have reported that saffron production is affected by the characteristics of the growing area and the storage temperature of the corms (Turhan et al., 2010). Among all environmental factors, the role of temperature during the growth and development of saffron is very important (Ghorbani and Koocheki 2017; Agha-Hosseini et al., 2008). Similarly, spring temperatures had the greatest impact on saffron yield. In general, saffron does not need cold to lift dormancy of corms as in other geophytes (Dole 2003). On the other hand, flowering requires a warm-intermediate temperature regime (Molina et al., 2005). High temperatures (23-27 °C) are required to break bud dormancy and for flower initiation, which takes place from early spring to mid-summer, depending on location (Greenberg-Kaslasi 1991; Molina et al., 2005).

Previous research has tested the thermal pretreatment effect of corms on saffron production (Gómez et al., 2002). The same authors stated that storing bulbs at 30 °C for 45 days increased the number of flowers compared to bulbs forced to germinate directly at 17/10 °C after leaf wilting. In this work, this is part of a series of experiments that aim at the agronomic valorization of saffron in the semi-arid region of Eastern Morocco. The effect of pre-treatment of corms with a new thermal regime on the harvest period, stigma yield and reproduction of corms was evaluated in the open field.

2. Material and Methods

This study was conducted at the Faculty of Science of Oujda during the year 2018-2019. The climatic data of the site showed that rainfall, average monthly temperature were respectively 226 mm, 18 °C respectively. The corms used in this trial were taken from the breeding squares within the experimental research station of the Faculty of Science of Oujda planted on 21/09/2015.

To study the effect of heat pre-treatment of the corms on the floral initiation of saffron, the corms were carefully unearthed at four different periods: late March (T2), mid-April (T3), late April (T4) , and after leaf senescence (control, T1). The corms from each period were then placed in black plastic bags containing the same culture substrate before being incubated at 3 successive temperatures: 25 °C for 2 weeks, 15 °C for 2 weeks and 4 °C for 12 weeks. The control group, collected after leaf senescence (mid-May, T1), was kept in the dark at room temperature until planting.

When filling the pots, the substrate composed of a mixture of peat and sand (2/3 and 1/3 v/v respectively) was prepared, and then the well-decomposed sheep manure was incorporated at a rate of 180 g / pot (30*35 cm) equivalent to the dose recommended for saffron cultivation, i.e. 20-30T / ha. On August 28, 2018, the corms that underwent the different treatments were planted, with a distance of 5cm between the corms (in all directions) and at a depth of 7cm.

The first irrigation was carried out at the end of September, and then due to the favorable and sufficient rainfall during the month of October, no irrigation was carried out. Subsequently, the plants were irrigated with a quantity of water equivalent to 100% ET0 (reference evapotranspiration) from the city of Oujda.

When the flowers were opened, the stigmas were manually separated and dried in the shade to constant weight to determine the spice yield (mg). Then the first and last dates of flowering were noted in order to determine the total harvest period in the number of days of flowering. Then at the end of the growing cycle, the daughter corms were counted (corms/plant), weighed using a scale (g), and calibrated using a caliper (cm/daughter corm).

The trial was conducted under a complete randomized block design with 4 treatments and 9 replicates, totaling 36 pots, each containing five saffron plants for a total of 180 plants. The treatments studied were: T1: control (no pre-treatment), T2: corms collected at the end of March, T3: corms collected mid-April, and T4: corms collected at the end of April. The significance of the differences was tested by the ANOVA. Where appropriate, mean separation was performed using the Duncan test at the 5% significance level.

3. Results

3.1. Flowering Period

Field observations show that thermal forcing of the corms has a very remarkable effect on the flowering date of saffron. The control corms flowered during the usual flowering period of this species under the climatic conditions of the eastern region of Morocco, namely between October and November. However, the flowers of the corms that underwent a heat treatment flowered late, the first flowers were observed on December 20, 25 and 27 respectively for the treatments T2, T3 and T4, the flowering period spread until January (Table 1).

Table1. The forcing effect of saffron corms on flowering dates

Treatment	Treatment Date of the first- last bloom				
	October	November	December	January	February
Control					
T2 (FM)					
T3 (MA)					
T4 (FA)					

3.2. Performance Parameters

Yield is considered to be the result of the coordination of several components such as the number of flowers and the weight of stigmas. The results of the performance components are shown in Figure 2B, show that flower number and stigma yield were negatively affected by thermal forcing of corms. Comparison of means showed that the control had the highest number of flowers and therefore the highest stigma yield with respective averages of 0.85 flower / corm and 68.5 mg / 380cm^2.

Figure 1. Aborted saffron flower observed in the T4 treatment.

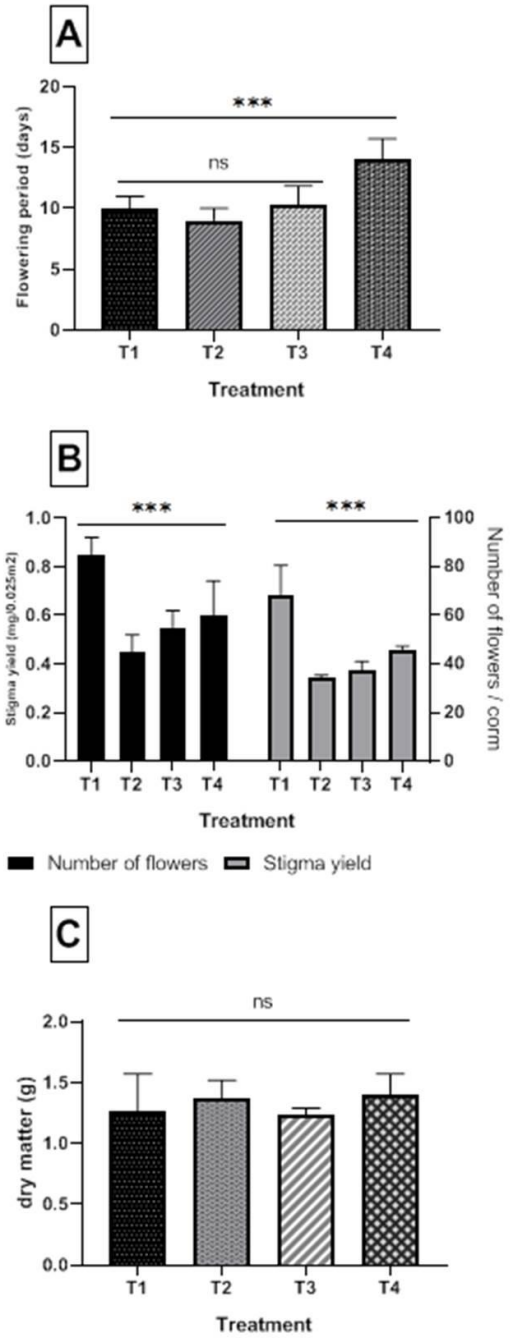

Figure 2. Effect of thermal forcing of saffron corms on the flowering period (A), number of flowers and weight of stigmas (B) and aerial dry matter (C). The values are the averages of 9 replicates. ***= P ≤ 0.001.

While T2 and T3 treatments showed the lowest values of these measured parameters. Similarly, the results showed that the T4 treatment (corms collected at the end of April) showed the abortion of some flowers (Figure 1) and a longer harvest period, i.e. 14 days compared to other treatments which recorded an average period of 9 days. These results were confirmed by analysis of variance which revealed a highly significant difference between T4 treatment and other treatments in terms of precocity and harvest duration (P = 0.015). At the end of the crop cycle, before the total wilting of the leaves, the aerial dry matter of each treatment was measured.

The highest values were recorded for the corms collected at the end of April (T4) with 1.4 g / pot, an increase of 14% compared to the control. However, this observed difference was not statistically significant between different treatments (Figure 2C).

3.3. Parameters of the Underground Part

According to the results of the parameters of the underground part, the number, weight and diameter (Figure 3) of daughter corms were also affected by the different treatments applied.

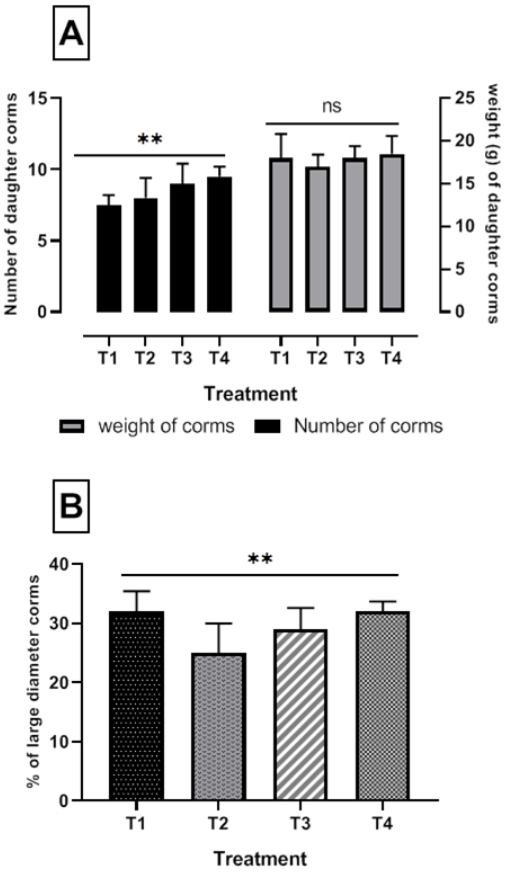

Figure 3. Thermal forcing effects of the rudder horns on the parameters of the underground part. A. number and weight (g) of daughter corms; B. large daughter corms (%). The data are the average of 9 repetitions. **= P ≤ 0.05.

Thermal forcing induced an increase in the number of daughter corms produced regardless of the sampling period of the mother corms. In addition, the highest

number of corms was obtained in the case of T3 and T4, with respective values of 8 and 9 corms per plant. While, despite this increase which was highly significant ($p=0.01$), the total weight of corms did not show a significant difference between treatments ($p>0.05$). The results also show that the percentage of large diameter corms varies according to the treatment applied. The control scored the highest percentage with a value that exceeded 30%. While the corms that underwent thermal forcing showed lower values than the control, a reduction of 22% was recorded in the T2 treatment (corms collected at the end of March).

4. Discussion

Saffron is an autumnal flowering plant whose production is affected by several environmental and anthropogenic factors. Several previous studies (Molina et al., 2005; Dror 1983; Plessner et al., 1990) have been used to define several methods to control flowering and vegetative reproduction of saffron Crocus. Corm storage temperature is one of the factors influencing saffron production (De Mastro and Ruta 1993; Molina et al., 2004). In this study, saffron corms were collected at four different periods: late March (T2), mid-April (T3), late April (T4), and after leaf senescence (control, T1). The corms from each period were then pre-treated at three temperature levels 25 °C for 2 weeks, 15 °C for 2 weeks, and 4 °C for 12 weeks. According to the data, the thermal pre-treatment of the corms had a significant effect on certain parameters of the saffron. The results showed that thermal forcing at different temperatures induced late flowering with a delay of almost two months compared to the control. These results are in agreement with those of (Molina et al., 2004) where the increase in cold storage duration induced a further extension of the flowering period but with a significant loss of saffron yield.

It should be noted that despite the loss of yield, this new extension of the flowering period could be economically interesting. However, our results disagree with other spring-flowering bulbous species such as *Crocus flavus* (Wilkins 1985), Muscari, Iris (Gómez et al., 2002) which require a sequence of warm-cold-warm temperatures to flower (Wilkins 1985). *C. sativus* flowers best in a warm-intermediate temperature sequence (Molina et al., 2004). Indeed, the direct storage at a low temperature of the corms acts on the precocity and extension of the saffron flowering season (Molina et al., 2005; Cavusoglu 2010; Mzabri et al., 2017; Hajyzadeh et al., 2017) which invalidates the results found in this trial. In addition, the results showed that flower number and stigma yield were negatively affected by the thermal forcing of the corms. This has been confirmed by most of the experiments that have studied the effect of corm forcing on the growth of saffron, where storage at low temperature led to a reduction in the number of flowers formed in saffron and thus a reduction in stigmas. Similarly, (Molina et al., 2004) found that the transfer of bulbs after floral initiation at a temperature below 15 °C, caused a drastic reduction in the number of flowers formed. While (Hajyzadeh et al., 2017) proved that corms stored in cold storage showed a better yield of saffron and had positive effects on all components of the plant. The reduction of yield parameters (number and size of flowers) due to low-temperature storage was closely dependent on the stage of development of the mother corms, storage conditions, and duration (Molina et al., 2005). This is in perfect agreement with the results of the present research where corm forcing affected yield parameters differ depending on the stage of mother corm removal, where corm removal at the end of March resulted in flower abortion. While (Amooaehaie 2007) elucidated that saffron corms removed after leaf wilting and stored at 2 °C for 60 days could be forced to flower from early November to late December with the same spicy saffron yield as non-cold stored corms. The forcing also influenced the parameters of the daughter corms, it induced an increase in the daughter corm produced but of small diameter. Similar results were found by (Çavuşoğlu 2010; Mzabri et al., 2017) who reported the negative effects of cold storage on the weight and diameter of daughter corms in saffron.

5. Conclusion

The results of the present study highlighted the effect of forcing saffron corms with a new thermal regime on the agronomic parameters of the crop. This experiment aimed to stagger the saffron harvesting period in order to minimize the high demand for the workforce. The results showed that the thermal forcing of the corms whatever the harvesting period induced a late flowering coupled with a significant decrease in the yield of the spice. The effect on the subterranean part resulted in an increase in the number of daughter corms with a small diameter (< 1.5cm). Nevertheless, a high number of corms, whatever their size, can be exploited as propagation material by nurserymen.

Author Contributions

IM; conceptualization and wrote the manuscript, MR and KCH; writing original draft preparation, SO; review and editing, NK and AB; supervision.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Agha-Hosseini M, Kashani L, Aleyaseen A, Ghoreishi A, Rahmanpour H, Zarrinara A R, Akhondzadeh S. 2008. *Crocus sativus* L. (saffron) in the treatment of premenstrual syndrome: A double-blind, randomised and placebo-controlled trial. BJOG-Int J Obstet Gy, 115(4): 515-519.

Amooaehaie R. 2007. Low temperature storage of corms extends the flowering season of saffron (*Crocus sativus* L.). Acta Hortic, 739: 41–47.

Çavuşoğlu A. 2010. The effects of cold storage of saffron (*Crocus*

sativus L.) corms on morphology, stigma and corm yield. Afr J Agric Res, 5(14): 1812-1820.

Cavusoglu A. 2017. The Effect of Exogenously Applied Plant Growth Regulators on Plant Development of Saffron (*Crocus sativus* L.). J Inst Sci Technol, 7(1): 17–22.

De Mastro G, Ruta C. 1993. Relation between corm size and saffron (*Crocus sativus* L.) flowering. Acta Hortic, 344(58): 512-517.

Dole J. 2003. Research Approaches for Determining Cold Requirements for Forcing and Flowering of Geophytes. Hort Sci, 38(3): 341-346.

Dror A. 1983. The control of flowering and vegetative reproduction of the saffron *Crocus* (*Crocus sativus*). M.Sc. thesis, Faculty of Agriculture, Hebrew University of Jerusalem.

Erkel E İ. 2005. Kocaeli ili koşullarinda safran (*Crocus sativus* l.) yetiştiriciliğinde yetişme yeri ve korm çapi'nin verim ve erkencilik üzerine etkisi. Akdeniz Univ Ziraat Fak Derg, 18(2): 179-184.

Ghorbani R, Koocheki A. 2017. Sustainable Cultivation of Saffron in Iran. J Sustain Agr, 25: 169–203.

Greenberg-Kaslasi D. 1991. Vegetative and reproductive development in the saffron *Crocus* (*Crocus sativus* L.). MSc. Thesis, The Hebrew University of Jerusalem, Isreal.

Gresta F, Lombardo G M, Siracusa L, Ruberto G. 2008. Saffron, an alternative crop for sustainable agricultural systems. A review. Agron Sustain Dev, 28(1): 95-112.

Hajyzadeh M, Asil H, Yildirim M U, Sarihan E O, Ayanoglu F, Khawar K M. 2017. Evaluating effects of corm circumferenc and storage temperatures on yield and yield components of saffron at different elevations. Acta Hortic, 1184(6): 39-46

Ipek A, Arslan N, Sarihan E O. 2009. Effects of different planting depth and bulb sizes on yield and yield components of saffron (*Crocus sativus* L.). Ankara Üniv, Ziraat Fak, Tarım Bilim Derg, 15(1): 38-46.

Molina R V, Valero M, Navarro Y, García-Luis A, Guardiola J L. 2004. The effect of time of corm lifting and duration of incubation at inductive temperature on flowering in the saffron plant (*Crocus sativus* L.). Sci Hort, 103(1): 79-91.

Molina R V, Valero M, Navarro Y, García-Luis A, Guardiola J L. 2005. Low temperature storage of corms extends the flowering season of saffron (Crocus sativus L.). J Hortic Sci Biotechnol, 80(3): 319-326.

Molina R, Valero M, Navarro Y, Guardiola J, García-Luís A. 2005. Temperature effects on flower formation in saffron (*Crocus* sativus L.). Sci Hort, 103(3): 361-379.

Muñoz Gómez R M, de Juan Valero J A, Botella Miralles O, Moya Aparicio A. 2002. Efectos del mantenimiento a elevadas vegetativa y la producción de flores y cormos huos en el azafrán (*Crocus sativus* L .). Int Technol Ed Assoc, 98(3): 200-212.

Mzabri I, Addi M, Berrichi A. 2019. Traditional and modern uses of saffron (*Crocus sativus*). Cosmetics, 6(4): 1-11.

Mzabri I, Legsayer M, Chetouani M, Aamar A, Kouddane N, Boukroute A, Bekkouch I, Berrichi A. 2017. Saffron (*Crocus sativus* L.) yield parameter assessment of abiotic stressed corms stored in low temperature. J Mater Environ Sci, 8(10): 3588-3597.

Plessner O, Ziv M, Negbi M. 1990. In vitro corm production in the saffron crocus (*Crocus sativus* L.). Plant Cell, Tissue and Organ Cult, 20(2): 89-94.

Turhan H, Kahriman F, Egesel C O, Gul M K. 2010. The effects of different growing media on flowering and corm formation of saffron (*Crocus sativus* L.). Afr J Biotechnol, 20(6): 2328-2332.

Wilkins H F. 1985. Crocus vernus: Crocus sativus. In Halevy, AH. Handbook of flowering. CRC Press, Vol. 2, Boca Raton, FL, 350-355.

Zhang A, Shen Y, Cen M, Hong X, Shao Q, Chen Y, Zheng B. 2019. Polysaccharide and crocin contents, and antioxidant activity of saffron from different origins. Ind Crops Prod, 133: 111-117.

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THE IMPACT OF ORGANIC LIQUID NITROGEN FERTILIZER APPLICATION ON GROWTH AND PRODUCTIVITY OF BARLEY (*HORDEUM VULGARE* L.) VARIETIES

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Abstract: Barley is a cereal used extensively in animal nutrition in the world. Nowadays, Organic practices have an important place in healthy nutrition of people and animals and protection of agricultural lands. This study was conducted to determine the effect of organic applications such as organic liquid nitrogen and barn manure on yield and quality values of barley during 2018-2019 and 2019-2020 growing seasons according to the randomized complete block design with split plot arrangements. This two-year study inferred the impact of organic liquid nitrogen fertilizer application at different growth stages on growth and productivity of barley. Organic liquid nitrogen fertilizer was applied at different phenological periods (control, tillering, beginning of booting, end of booting and heading) of spring barley varieties, Akhisar and Samyeli. Parameters such as Plant height (cm), number of heading (number m^{-2}), hectoliter weight (kg hl^{-1}), 1000 grain weight (g), grain yield (kg ha^{-1}), chlorophyll content (SPAD values) and protein ratio (%) were determined in the study. All parameters investigated were significantly different ($P \leq 0.01$) between the years. Compared to the first year, higher temperature and drier weather conditions during the second year increased protein ratio in seed, while decreased starch ratio; thus, yield and yield components were lower. Yield and yield parameters of barley varieties had a negative correlation between protein ratios, while had a positive correlation with chlorophyll content. The results concluded organic liquid nitrogen application at the end of booting phenological period of Akhisar variety resulted in higher yield and improved the related traits. It has been concluded that the organic liquid fertilizer to be applied in this phenological period will increase both yield and quality in barley plants. Another result of this study was that as a result of organic applications, the yield and quality levels obtained from barley was close to conventional agriculture.

Keywords: Barley, Spad, Organic liquid nitrogen, Protein ratio, Grain yield

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1. Introduction

Barley (Hordeum *vulgare L.*) is one of oldest cultivated plants in the world. The existence of genetic sources and the first wild forms of barley have been reported in the Middle East. Barley which is extremely important for animal nutrition in the world and Turkey is used extensively as protein source in in animal production and feed rations, although not directly used in human nutrition. Barley is also consumed for human nutrition as flour and various products, although the share is too little. Barley matures earlier than wheat; therefore, preferred in areas where two crops are harvested in a year. Low yields are obtained in non-irrigated lands with irregular and insufficient rainfall (Dogan et al., 2014).

The latest FAO data showed that approximately 150 million tons of barley is produced in the world with 7.4 million tons produced in Turkey. Out of the total barley produced in Turkey, 10% is produced in the region where the study has been carried out (Anonymous, 2020). Majority (92%) of barley produced in Turkey is two-row barley varieties. The barley varieties used in this experiment are used for feed and widely cultivated in the country. The use of organic fertilizers instead of inorganic substances in agriculture will provide benefits for human and animal health. Studies revealed that grain yield of barley with manure and liquid nitrogen fertilizer applications was close to those obtained in conventional agriculture. In addition, the application of manure increased dry matter production, protein ratio and grain yield of cereals (Butler and Muir, 2006). Organic liquid fertilizers, which contain one or more nutrients required by plants, are applied by spraying on the leaves. Studies have reported that application of nutrients by spraying acts faster than soil application (Danisman and Belliturk, 2006).

Low soil fertility is reported as the reason for low barley

yield; however, soil fertility increased with organic fertilization (Abera et al., 2018). Therefore, organic fertilizers are assumed to replace chemical fertilizers in crop production (Ahmadi et al., 2018). Alinezhad et al. (2013) reported that organic liquid nitrogen fertilizer applied during the final stage of barley growth improves grain quality and increases grain yield. Similarly, yield obtained for ten-year organic fertilizer application was equivalent to the yield obtained with chemical fertilizer application. Farm manure improved soil structure and increased water holding capacity (Edmeades, 2003). The positive effect of manure applications on cereal crops has been reported in numerous studies (Barzegar et al., 2002).

Livestock breeding and crop production should be integrated to adapt organic fertilizer application practices in a farm. Organic practices will conserve soils and provide a healthier food in the long run. This study was carried out to determine the effects of organic liquid nitrogen fertilizer applied at different phenological periods on grain yield, yield components and chlorophyll content of spring barley varieties.

2. Material and Methods

Sanliurfa province is located one of the hottest regions in Turkey. Climatic conditions of growing season in 2019-2020 were drier for plant growth compared to 2018-2019. Relative humidity in the second year of study was lower and temperature was higher than the first year. Total rainfall in the second year was lower than that occurred in the first year. The rainfall in both growing seasons was not equal distributed; therefore, supplemental irrigation was applied according to plant needs, especially during grain filling period (Table 1).

Table 1. Important climatic values of the trial location

	Mean temperatures (°C)		The highest temperatures (°C)		The lowest temperatures (°C)		Mean humidity (%)		Total precipitation (kg/m^{-2})	
	Years (2018, 2019, 2020)									
Months	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20	18-19	19-20
October	28.4	30.7	34.2	37.0	5.6	7.3	54.3	50.6	28.8	12.8
November	18.1	22.6	28.0	28.1	3.3	0.5	81.0	47.2	177.6	2.6
December	12.8	13.5	18.1	19.6	-1.2	0.7	89.4	85.1	125.4	126.2
January	11.6	11.8	17.5	14.2	-3.8	-2.0	79.3	76.8	75.6	25.2
February	14.0	12.5	17.9	20.6	0.4	-7.8	79.3	71.5	79.6	3.0
March	16.4	19.8	21.3	26.9	0.5	1.9	75.5	70.5	115.6	83.6
April	20.6	24.2	26.7	29.2	4.5	4.2	73.1	64.1	104.8	18.4
May	32.2	31.0	40.0	38.8	9.5	10.1	42.3	45.9	10.2	0.2
June	37.9	36.5	44.2	41.6	17.4	13.2	34.4	33.9	0.8	0.0
Average	21.33	22.51	27.54	28.44	4.02	3.12	67.62	60.62	718.4	272.0

The study was conducted in the organic experimental field of Akçakale Vocational High School, Harran University during 2018-2019 and 2019-2020 growing seasons. 'Samyeli' and 'Akhisar' two-rowed spring barley varieties were used in the experiment. Certified barn manure and organic liquid fertilizer were applied in the experiment. The farm manure used in the experiment is a certified fertilizer of *Ecofarm*, and an organic liquid fertilizer is a certified fertilizer of *Merkez Anadolu Kimya*. Organic liquid fertilizer contains free nitrogen-nitrogen bonds, organic nitrogen and other microelements. The chemical content of both farmyard manure and organic liquid fertilizer are given in Table 2.

The experiment had four replications and laid out according to randomized complete block design with split-plot arrangement. Barley varieties were main plots, where phenological phases (control, tillering, beginning of booting, end of booting and heading) where organic liquid nitrogen was applied were subplots. Sowing was carried out in the third week of November during both years of the study. Seeds were manually planted in the opened lines. Each experimental unit was 5 m long and 1.2 m wide. To minimize mixing of experimental units, a buffer zone of 1 m and 3 m between the units was created. The plot area was 6 m^2 (5 m × 1.2 m). The interrow distance was 20 cm and each experimental unit had 6 rows. The seeds were placed 4 to 6 cm deep and seeding density was 475 plants m^{-2} (Akkaya, 1994). Inorganic fertilizers and herbicides were not applied in the experiment.

Table 2. Some chemical properties of the barnyard manure and organic liquid fertilizer

Chemical contents	Barnyard manure	Organic liquid fertilizer
Total organic matter (%)	40.12	20.34
Organic nitrogen (N, %)	1.00	1.23
Ph (%)	7.23	7.12
Humic-fulvic ratio (%)	28.23	
Potassium (K, %)	2.04	1.78
Phosphorus (P, %)	2.43	2.23
Mg (%)	1.13	1.12
Fe (%)	0.24	0.26
Zn (ppm)	129.08	121.67
Mn (ppm)	90.67	82.32
Free amino acids (%)		8.09

Farm manure at the rate of 20 tons' ha^{-1} was applied to all experimental units before sowing (Tan and Serin, 1995). After farm manure application, equal amounts of organic liquid nitrogen fertilizer were sprayed during

tillering, beginning of booting, end of booting and heading stages. Organic liquid fertilizer was not applied in control treatment. The 100 *CC* of organic liquid nitrogen fertilizer and 1 kg of sugar were added into 20 liter of water, kept at room temperature overnight, and then applied to experimental units.

Plant height (cm), number of heading (number/m^{-2}), hectoliter weight (kg hl^{-1}), 1000-grain weight (g), grain yield (kg ha^{-1}), chlorophyll content (SPAD values) and protein ratio (%) of barley varieties were determined in study. Spike characteristics were examined from 10 spikes randomly selected from each experimental unit during harvest period and averaged (Kutlu et al., 2015). The plant heights of 10 plants were measured in each parcel and averaged. Protein ratios of grain samples taken from each plot were determined using Celdhl NIT (Near Infrared Transmittance) spectroscopy technique according to the ICC standard method (AACC Method 46-30) (Anonymous, 1990). The 1000-grain weight was determined according to the AACC 55-10 method (Koksel et al., 2000). The weight of hectoliters was measured with 4 replications using a Loyka brad instrument (1 L) and calculated in kg (Unal, 2002). The yield per hectare was calculated using the grains collected from the experimental unit after harvest. Chlorophyll contents were measured using a portable chlorophyll meter (Minolta SPAD-502, Osaka, Japan). Measurements were carried out in the open air during afternoon (14:00 and 16:00). The chlorophyll contents were measured from the flag leaf of ten randomly selected plants from each experimental unit, averaged and expressed as SPAD values (Yildirim et al., 2009).

The collected data were subjected to two-way analysis of variance using JMP 13.0 statistical program. LSD post-hoc test was used to compare the averages of the varieties and phenological stages. Correlation analysis was performed between all parameters examined (95%).

3. Results and Discussion

Statistical analysis of two years separately and combined was performed for all studied parameters. The combined year analysis indicated statistically significant differences ($P \leq 0.01$) in plant height between year, variety, periods and cultivar × period interaction. The highest plants (78.15 cm) were recorded in organic liquid fertilizer application during the end of boating period of Akhisar variety; while the shortest plant height (54.08 and 50.65 cm) was recorded for fertilizer application at tillering and control treatment in Samyeli variety, respectively (Table 3).

Table 3. Means and multiple comparison test results related to plant height (cm) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	57.93^{e}	65.97^{d}	61.95^{cd}	47.77	42.20	44.9^{e}	52.85^{e}	54.08^{e}	53.46^{d}
T	65.77^{d}	52.87^{e}	59.32^{d}	52.53	48.43	50.48^{d}	59.15^{d}	50.65^{e}	54.90^{d}
BB	73.53^{b}	57.63^{e}	65.58^{c}	58.50	59.90	59.2^{c}	66.01^{c}	58.76^{d}	63.39^{c}
BE	82.37^{a}	72.20^{bc}	77.28^{a}	73.93	67.93	70.9^{a}	78.15^{a}	70.96^{b}	74.10^{a}
H	75.87^{b}	67.90^{cd}	71.88^{b}	66.07	63.90	64.98^{b}	70.96^{b}	65.90^{c}	68.43^{b}
Mean	71.09^{a}	63.31^{b}	67.20^{A}	59.76^{a}	56.47^{b}	58.11^{B}	65.42^{a}	59.89^{b}	62.65
CV (%)	4.54			5.85			5.16		
LSD (0.05)	V(lsd): 2.36** PP (lsd): 3.73** VxPP:(lsd): 5.28**			V(lsd): 2.63** PP(lsd): 4.16** VxPP:(lsd): NS			Y(lsd): 1.70** V(lsd): 1.70** PP(lsd): 2.68** VxPP (lsd): 3.80**		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

The combined year analysis revealed statistically significant differences ($P \leq 0.01$) in number of heading, hectoliter weight, 1000 grain weight, protein ratio, chlorophyll content and grain yield between years, varieties, and phenological periods, while the differences in variety × phenological stage interaction was not significant. The highest number of heading were obtained for Akhisar variety with fertilizer application at end of booting stage, while the lowest value was recorded for Samyeli variety with control treatment (Table 4). In the combined year analysis, the highest hectoliter weight (63.31 kg hl^{-1}) was measured for Akhisar variety with organic liquid fertilizer application at end of booting stage, while the lowest hectoliter weight (50.43 kg hl^{-1}) was obtained for Samyeli variety in control treatment (Table 5).

Table 4. Means and multiple comparison test results related to number of heading (number/m-2) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	339.10	334.50	336.80^{d}	340.20	319.80	330.00^{c}	339.65	327.15	333.40^{e}
T	353.33	346.67	350.00^{c}	348.73	330.37	339.55^{c}	351.03	338.52	344.78^{d}
BB	384.67	376.37	380.52^{b}	370.67	362.12	366.39^{b}	377.67	369.24	373.45^{c}
BE	410.60	405.20	407.90^{a}	404.10	389.10	396.60^{a}	407.35	397.15	402.25^{a}
H	401.33	399.93	400.63^{a}	396.70	375.75	386.23^{a}	399.02	387.84	393.43^{b}
Mean	377.81^{a}	372.53^{b}	375.17^{A}	372.08^{a}	355.43^{b}	363.75^{B}	374.94^{a}	363.98^{b}	369.46
CV (%)	1.63			2.59			2.15		
LSD (0.05)	V(lsd): 4.73* PP(lsd): 7.48** VxPP:(lsd): N.S			V(lsd): 7.29** PP(lsd):11.54** VxPP:(lsd): N.S			Y(lsd): 4.18** V(lsd): 4.18** PP(lsd): 6.61** VxPP(lsd): N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Table 5. Means and multiple comparison test results related to hectoliter weight (kg hl-1) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	59.00	51.17	55.08^{d}	51.80	49.70	50.75^{d}	55.40	50.43	52.92^{d}
T	60.67	54.10	57.38^{c}	54.17	52.87	53.52^{c}	57.42	53.48	55.45^{c}
BB	62.00	58.00	60.00^{b}	56.34	56.90	56.62^{b}	59.17	57.45	58.31^{b}
BE	65.33	61.24	63.29^{a}	61.28	60.07	60.67^{a}	63.31	60.66	61.98^{a}
H	62.83	58.10	60.47^{b}	57.03	57.33	57.18^{b}	59.93	57.72	58.82^{b}
Mean	61.97^{a}	56.52^{b}	59.24^{A}	56.12	55.37	55.75^{B}	59.05^{a}	55.95^{b}	57.50
CV (%)	2.53			2.87			2.69		
LSD (0.05)	V(lsd): 1.16** PP(lsd): 1.83** VxPP(lsd): N.S			V(lsd): N.S PP(lsd): 1.96** VxPP(lsd): N.S			Y(lsd): 0.81** V(lsd): 0.81** PP(lsd): 1.29** VxPP(lsd): N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Similar to the hectoliter weights, the highest value for 1000 grain weight (42.63 g) was obtained in the Akhisar variety at the end of booting phenological period, while the lowest value (32.23 g) was obtained with Samyeli variety in control treatment (Table 6). The lowest grain yield (3464.8 kg ha^{-1}) in two-year data was recorded for Samyeli variety in control treatment, while the highest grain yield (4187.1 kg ha^{-1}) was obtained for Akhisar variety with organic liquid fertilizer application at the end of booting phenological period (Table 7).

The lowest chlorophyll content (39.32 spad) which is an important physiological parameter was obtained for Samyeli variety in control treatment, while the highest value (49.46 spad) was recorded for Akhisar variety with organic liquid fertilizer application at the end of booting period (Table 8). In contrast to the other parameters, the highest protein ratio (15.23%) was obtained for Samyeli variety with organic liquid fertilizer application at the end of booting period, and the lowest protein ratio (9.71%) was obtained for Akhisar variety with control treatment (Table 9). The higher temperature and lower relative humidity in the second year caused a decrease in all parameters except protein ratio. In the second year of the experiment, high temperatures and dry weather suppressed the harvest of barley plants reduced starch ratio and increased protein ratio. In general, the highest values of all parameters were recorded for Akhisar variety with organic liquid fertilizer application at the end of booting phenological period, while the lowest values were recorded for Samyeli variety without any organic liquid nitrogen application.

Table 6. Means and multiple comparison test results related to 1000 grain weight (g) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	36.05	33.76	34.91^{d}	33.85	30.70	32.28^{d}	34.95	32.23	33.59^{e}
T	37.89	36.41	37.15^{c}	35.81	33.78	34.79^{c}	36.85	35.10	35.97^{d}
BB	40.32	38.71	39.51^{b}	38.99	35.69	37.34^{b}	39.65	37.20	38.43^{c}
BE	43.20	41.65	42.43^{a}	42.07	38.83	40.45^{a}	42.63	40.24	41.44^{a}
H	41.11	40.84	40.97^{ab}	40.18	36.53	38.36^{b}	40.64	38.69	39.67^{b}
Mean	39.71^{a}	38.27^{b}	38.99^{A}	38.18^{a}	35.11^{b}	36.64^{B}	38.95^{a}	36.69^{b}	37.82
CV (%)	3.74			3.77			3.76		
LSD (0.05)	V(lsd): 1.13** PP(lsd): 1.79** VxPP(lsd): N.S			V(lsd): 1.07** PP(lsd): 1.69** VxPP(lsd): N.S			Y(lsd): 0.75** V(lsd): 0.75** PP(lsd): 1.18** VxPP(lsd):N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Table 7. Means and multiple comparison test results related to grain yield (kg ha^{-1}) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	3883.5	3494.7	3689.1^{d}	3623.3	3435.0	3529.2^{d}	3753.4	3464.8	3609.1^{e}
T	4072.4	3690.3	3881.4^{c}	3772.0	3622.7	3697.3^{c}	3922.2	3656.5	3789.4^{d}
BB	4174.2	3773.0	3973.6^{bc}	3861.8	3693.7	3777.7^{b}	4018.0	3733.3	3875.7^{c}
BE	4330.8	3982.3	4156.6^{a}	4043.3	3914.3	3978.8^{a}	4187.1	3948.3	4067.7^{a}
H	4152.4	3895.7	4024.1^{b}	4009.6	3849.0	3929.3^{a}	4081.0	3872.3	3976.7^{b}
Mean	4122.7^{a}	3767.2^{b}	3944.9^{A}	3862.0^{a}	3702.9^{b}	3782.5^{B}	3992.3^{a}	3735.1^{b}	3863.7
CV (%)	2.35			1.55			2.01		
LSD (0.05)	V(lsd): 71.68** PP(lsd): 113.34** VxPP(lsd): N.S			V(lsd): 45.50** PP(lsd): 71.94** VxPP(lsd): N.S			Y(lsd): 40.79** V(lsd): 40.79** PP(lsd): 64.49** VxPP(lsd): N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Table 8. Means and multiple comparison test results related to chlorophyll content (spad values) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	45.19	40.68	42.94^{d}	42.62	37.96	40.29^{c}	43.91	39.32	41.61^{e}
T	47.05	43.00	45.03^{c}	44.37	38.67	41.52^{c}	45.71	40.84	43.27^{d}
BB	47.90	44.05	45.98^{b}	45.81	41.55	43.68^{b}	46.86	42.80	44.83^{c}
BE	50.35	46.57	48.46^{a}	48.56	44.92	46.74^{a}	49.46	45.75	47.60^{a}
H	48.19	44.28	46.24^{b}	48.96	45.18	47.07^{a}	48.58	44.73	46.65^{b}
Mean	47.74^{a}	43.72^{b}	45.73^{A}	46.06^{a}	41.66^{b}	43.86^{B}	46.90^{a}	42.69^{b}	44.79
CV (%)	1.59			3.13			2.45		
LSD (0.05)	V(lsd): 0.56** PP(lsd): 0.89** VxPP(lsd): N.S			V(lsd): 1.06** PP(lsd): 1.68** VxPP(lsd): N.S			Y(lsd): 0.58** V(lsd): 0.58** PP(lsd): 0.91** VxPP(lsd): N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significiant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Table 9. Means and multiple comparison test results related to protein ratio (%) in different varieties and phenological periods

Years	2018-19			2019-20			(2018-19)-(2019-20)		
Phenological Periods/Variety	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean	Akhisar	Samyeli	Mean
C	9.16	10.97	10.07^{c}	10.26	12.36	11.31^{d}	9.71	11.67	10.69^{d}
T	9.77	12.06	10.92^{bc}	11.42	14.05	12.73^{c}	10.59	13.06	11.82^{c}
BB	10.67	13.04	11.86^{b}	12.44	15.19	13.82^{b}	11.56	14.11	12.84^{b}
BE	11.86	14.24	13.05^{a}	14.41	16.21	15.31^{a}	13.13	15.23	14.18^{a}
H	10.81	12.98	11.90^{b}	13.71	15.37	14.54^{ab}	12.26	14.17	13.22^{b}
Mean	10.45^{b}	12.66^{a}	11.56^{B}	12.45^{b}	14.63^{a}	13.54^{A}	11.45^{b}	13.65^{a}	12.55
CV (%)	7.69			5.72			6.64		
LSD (0.05)	V(lsd): 0.69** PP(lsd): 1.09** VxPP(lsd): N.S			V(lsd): 0.60** PP(lsd): 0.95** VxPP(lsd): N.S			Y(lsd): 0.44** V(lsd): 0.44** PP(lsd): 0.69** VxPP(lsd): N.S		

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significant, V= variety, PP= phenological periods, Y= year, C= control, T= tillering, BB= beginning of boating, BE= end of boating, H= heading.

Many studies conducted in accordance with our findings stated that application of organic liquid nitrogen fertilizer increased yield, yield components and dry matter in grains (Ozcan and Brohi, 2000). Many researchers reported that liquid fertilizer application at different phenological periods (Kettlewell et al., 1998), distribution of precipitation during the year, temperature during growing period (Smith and Googing, 1999) and differences in variety affect yield and quality. The 1000 grain and hectoliter weight are defined as the important yield components affecting grain yield of cereals (Korkut et al, 1993). Similar to our findings, Poehlmen (1987) stated that grain weight was negatively affected by hot and dry weather conditions. Ofosu-Anim and Leitch, 2009 indicated a 1.5 to 4 fold higher grain yield in spring barley varieties with the increase in plant height, leaf chlorophyll content and dry matter accumulation due to the application of organic origin fertilizers.

3.1 Correlation Analysis

A combined data of two years was subjected to a correlation analysis to determine the relationships between investigated parameters (Table 10).

Table 10. Correlation coefficients and significance levels of yield components and grain yield and physiological parameter

Traits	Traits	Correlation coefficients	Count	The lowest coefficients	The highest coefficients	Significance levels	Correlation levels
PH	GY	0.800	60	0.686	0.876	<.0001**	
CC	GY	0.793	60	0.675	0.871	<.0001**	
CC	PH	0.709	60	0.556	0.817	<.0001**	
HN	GY	0.774	60	0.648	0.859	<.0001**	
HN	PH	0.812	60	0.703	0.884	<.0001**	
HN	CC	0.692	60	0.532	0.805	<.0001**	
HW	GY	0.704	60	0.548	0.812	<.0001**	
HW	PH	0.639	60	0.461	0.769	<.0001**	
HW	CC	0.499	60	0.281	0.669	<.0001**	
HW	HN	0.630	60	0.448	0.762	<.0001**	
GW	GY	0.769	60	0.639	0.856	<.0001**	
GW	PH	0.695	60	0.536	0.807	<.0001**	
GW	CC	0.628	60	0.445	0.761	<.0001**	
GW	HN	0.827	60	0.726	0.893	<.0001**	
GW	HW	0.673	60	0.505	0.791	<.0001**	
PR	GY	-0.076	60	-0.324	0.182	0.565NS	
PR	PH	0.084	60	-0.174	0.331	0.525NS	
PR	CC	-0.078	60	-0.326	0.179	0.552NS	
PR	HN	0.315	60	0.066	0.526	0.014*	
PR	HW	-0.029	60	-0.281	0.227	0.825NS	
PR	GW	0.028	60	-0.227	0.280	0.831NS	

GY= grain yield (t ha^{-1}); CC= chlorophyll content (spad); HN= number of heading (number/m-2); PH= plant height (cm); PR= protein ratio (%); GW= 1000 grain weight (g); H= hectoliter weight (kg hl^{-1})

*,** significant at 0.05 and 0.01 levels of probability respectively, NS= not significant

Negative and non-significant relationships were found between PR and GY, CC, HW, while positive and non-significant relationships were recorded between PR and GW. Positive and significant relationships were noted between PR and HN. Significant positive relationships were determined among different parameters except protein ratio. Positive and important relationships were obtained between chlorophyll content, which is one of the important physiological parameters, and yield and yield components. The increase in chlorophyll content increased photosynthesis; thus plants with increased photosynthesis produced more nutrient, and consequently increased the yield and yield components. In addition, the increase in yield components increased the grain yield. Jianren et al. (2000) reported that organic liquid fertilizer applied to barley leaves during late-ripening period promotes the transmission of organic matter from stem to the leaves and ears, accelerates grain filling in the spike, helps the formation of filled grains and increases grain weight.

4. Conclusions

The results recorded in this study concluded that higher temperatures and drier weather conditions experienced during the second year of the study caused a decrease in starch accumulation and an increase in protein accumulation. The decrease in starch accumulation reduced yield and yield components. In general, the organic liquid nitrogen fertilizer application at the end of booting phenological period had significant effects on all parameters except protein ratio of Akhisar barley variety. The highest values of all studied parameters except protein ratio were recorded for Akhisar variety with fertilizer application at the end of booting stage, whereas the lowest values were recorded for Samyeli variety with control treatment. The results revealed that application manure in large areas where barley is produced will increase the organic matter content of soils. In addition, organic liquid nitrogen can be applied easily and cheaply using a pulverizer at the end of booting period, and this practice will increase yield and quality of barley.

Author Contributions

All field study from sowing to harvest was carried out by AM. After the harvest, Parameters such as 1000 grain weight, hectoliter weight and protein ratio were analysed in grain laboratory by TT. In addition, TT have analysed statistically the data obtained. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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References

Anonymous. 1990. Official methods of analysis of the AOAC. Association official analytical chemists, Fifteenth edition, Arlington.

Akkaya. A. 1994. Wheat growing. Kahramanmaras Sutcu Imam University, Faculty of Agriculture, publication no: 1, textbooks publication no: 1, Kahramanmaras, Turkey, pp. 225.

Alinezhad S, Sinaki JM, Zarei M, Baradan M, Abadi F. 2013. Effects of organic fertilizers and drought stress on physiological traits in barley. Inter J Agro Plant Prod, 4 (2): 300-306.

Abera T, Tufa T, Midega T, Kumbi H, Tola B. 2018. Effect of integrated inorganic and organic fertilizers on yield and yield components of barley in liben jawi district. Inter J Agron, 2(**7**): 1-11.

Ahmadi G, Jaafarinia M. 2018. Evaluating the effects of biofertilizers on growth and emergence of Barley (Hordeum *vulgare L.*). Asian J Agri Biol, 3(3): 110-116.

Anonymous 2020. Agri products development markets. Barley Januray, No: BU-01, https:// arastirma.tarimorman.gov.tr/tepge/Belgeler (accessed date: December 12, 2019).

Barzegar AR, Yousefi A, Daryashenas A. 2002. The effect of addition of different amounts and types of organic materials on soil physical properties and yield of wheat. J Plant Soil, 247 (3): 295–301.

Butler TJ, Muir JP. 2006. Dairy manure compost improves soil and increases tall wheatgrass yield. J Agron, 98(4):1090-1096.

Danısman F, Belliturk K. 2006. Foliar fertilizer. Harran Univ J Faculty Agri**,** 11(2):7-12 [In Turkey].

Dogan Y, Kendal E, Karahan T, Ciftci V. 2014. Determination of yield and some quality characteristics of some barley (Hordeum *vulgare L.*) genotypes in Diyarbakir conditions. JAFAG, 31(2), 31-40.

Edmeades DC. 2003. The long-term effects of manures and fertilizers on soil productivity and quality: A review. Nutrition Cycl Agroecosys, 66(3): 165-180.

Jianren G, Jianhai Y, Zaicheng Z, Yunfang G, Hubao G. 2000. Preliminary report on application of tianyuan maturation accelerating organic liquid fertilizer to barley and wheat. J Acta Agri Shanghai, 16(2): 86-88.

Korkut KZ, Saglam N, Baser I. 1993. Research on some traits affecting the yield of bread and durum wheat. Trakya Univ J Agri Fac, 2(2): 111-118.

Kettlewell PSI, Griffiths MWI, Hocking TJ, Wallington DJ. 1998. Dependence of wheat dough extensibility on flour sulphur and nitrogen concentrations and the influence of oliar applid sulphur and nitrogen fertilisers. J Cereal, 28(6): 15-23.

Koksel H, Sivri D, Ozboy O, Basman A, Karacan HD. 2000. Grain Laboratory Handbook. Hacettepe University, Engineering Faculty Publications, Ankara, Turkey, pp.47.

Kutlu I, Balkan A, Bilgin O. 2015. Analysis of heredity and population differences of some spike traits in bread wheat. Kahramanmaras Sutcu Imam University, J Natural Sci, 18(4): 40-47, [In Turkey].

Ozcan S, Brohi AR. 2000. The effect of various leaf fertilizers on growth and dry matter and N-P-K content of Bread Wheat (Triticum *aestivum L.)*. Gaziosmanpasa Univ J Agri Fac, 17(1): 133-136.

Ofosu-Anim J, Leitch M. 2009. Relative efficacy of organic manures in spring barley (Hordeum *vulgare L.*) production. Australian J Crop Sci, 3(1): 13-19.

Poehlmen JM. 1987. Breeding field crops. Van Nostrand Reinhold Conmpany Inc. 115, Fifth editions, Avenue, New York.

Smith GP, Googing MJ. 1999. Models of wheat grain quality considering climate, cultivar and nitrogen effects. Agri Forest Meteorol, 94(1): 86-93.

Tan M, Serin Y. 1995. Effects of rhizobium inoculation and various nitrogen fertilizer rates on hay, seed, straw and crude protein yields, crude protein percentage and nodule number of irrigated common vetch in Erzurum. Turk J Agric For, 19(3), 137- 144.

Unal. S. 2002. Importance of quality in wheat and methods used in its determination. In: Proceedings of the Cereal Products Technology Congress and Exhibition, 3-4 October, Turkey, pp. 25-37.

Yıldırım M, Akıcı C, Koc M. 2009. Barutcular C. Applıcability of canopy temperature depression and chlorophyl content in durum wheat breeding. Anatolian J Agri Sci, 24(3): 158-166.

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GENETIC GAIN IN YIELD AND YIELD ATTRIBUTING TRAITS OF RICE UNDER UPLAND ECOSYSTEM OF FOGERA, NORTHWEST ETHIOPIA

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Abstract: Evaluation of varieties from different years in a common environment is one of the most direct methods used to estimate breeding progress. Twenty upland rice varieties released in Ethiopia from 1998 to 2016 were evaluated at Fogera National Rice Research and Training Center in 2017 cropping season to estimate the amount of genetic gain over the years. The varieties were laid out in a randomized complete block design with three replications. Analysis of variance revealed significant differences among varieties for all traits. Grain yield was increased from 2.76 t ha^{-1} to 4.86 t ha^{-1} over the past 18 years. The average rate of increase in grain yield of upland rice per year, estimated from the linear regression on year of variety release, was 0.044 t ha^{-1} with a relative genetic gain of 1.59% year^{-1}, although non-significant. The study showed significant improvements in grain-filling period, panicles length and number of filled-grains panicle^{-1}. Significant reduction was also observed in days to heading and thousand-seed weight. No marked changes were observed in grain yield per plant and biological yield, number of fertile tillers, plant height and days to maturity over the 18-year period.

Keywords: Genetic gain, Grain yield, Regression, Rice, Yield attributes

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1. Introduction

The global production area and yield of rice has been estimated to be 167 million hectares and 769.6 million tons, respectively. About 692 million tons of paddies are produced from 145 million hectares of land in Asian continent. Asia produces about 90% of the world's rice production (FAOSTAT, 2017) which shows its importance in food security for Asians. Africa harvested 36.5 million tons of rice from 14.9 million ha of cultivated land, with productivity of 2.4 t ha^{-1}. In Ethiopia, 48484 ha of land was covered, and 140335 tons of paddy rice was produced in 2017 resulting with a national average productivity of 2.89 ton ha^{-1} (FAOSTAT, 2017). Nonetheless, a yield as high as 6 ton ha^{-1} has been recorded on research fields under upland ecosystem (Dessie et al., 2018).

Rice introduced to Ethiopia in 1970s but formal research was started in 1985/6 with the establishment of Pawe and Abobo agricultural research centers during the resettlement program. Since then, a number of rice germplasm have been introduced from different international institutions for different agro-ecosystems and objectives, and evaluated on multi-locations and years. Consequently, the first rice variety was released in 1998 by Pawe agricultural research center. Up to now, 35 varieties have been released and registered for different agro-ecosystems (MoANR, 2016).

Evaluation of breeding progress allows quantification of genetic change that has been achieved over time. Different traits influencing yield should be analyzed periodically to evaluate breeding progress and to determine traits with greatest contribution to yield (Green et al., 2012). Assessment of the contribution of plant breeding on yield improvement of a certain crop and appraisal of the past gains are useful for identifying potential areas for future breeding endeavors (Waddington et al., 1986). As stated by Evans (1993) knowledge of changes resulted by crop breeding on grain yield and its components is important to evaluate the efficiency of previous works. In measuring progress in genetic yield potential, complications can arise as a result of interactions between cultivar and growing condition (Evans and Fischer, 1999). Nonetheless, evaluation of improved varieties released in different years in a common environment has been a direct method used to estimate the progress in yield improvement made in a given crop (Perry and D'Antuono, 1989). Breseghello et al. (1998) proposed the method used to calculate grain

yield growth rate for a region, a state, or the entire area of interest in a breeding program. The gain for sub regions within the same program may show whether the new lines are adapted to specific environmental conditions.

In Ethiopia, works pertaining to genetic gain have been documented on bread wheat (Tarekegn et al., 1995), tef (Teklu and Tefera, 2005; Dargo et al., 2016), barley (Fekadu et al., 2011), maize (Worku and Zelleke, 2007), lowland sorghum (Woldesemayat et al., 2015), haricot bean (Bezaweletaw et al., 2006), groundnut (Hagos et al. 2012), lentil (Bogale et al., 2015), faba bean (Tolessa et al., 2015) and chick pea (Belete et al., 2017). However, no work has been reported on rice in Ethiopia. The objectives of the present investigation are to know the level of genetic gain on yield and yield related characters of released upland rice varieties based on their time of release and to determine changes produced by genetic improvement on yield and yield related traits.

2. Material and Methods

2.1. Description of the Study Area

The study was undertaken at Fogera national rice research and training center, Ethiopia. Average altitude of Fogera ranges from 1,750 to 2,500 meters above sea level (m.a.s.l.) with an average rain fall of 1284 millimeter and temperature ranging from 11.5°C to 27.9°C. The experimental site is located at 11°58' N latitude, 37° 41'E longitude and at an elevation of 1810 m.a.s.l. Based on ten years' average meteorological data, the annual rainfall is 1300 mm and mean annual minimum and maximum temperatures are, 11.5° C and 27.9°C, respectively. The soil type is Vertisol with pH of 5.90.

2.2. Experimental Materials

Experimental materials were 20 upland rice varieties released by different research centers in different years. Eight of the varieties were NERICA (New Rice for Africa) types initially developed for upland ecosystem by Africa Rice. NERICA varieties were developed by interspecific hybridization of *Oryza glaberrima* and *Oryza sativa* (Samado et al., 2008). The description of the varieties is as shown in Table 1.

2.3. Experimental Design and Management

A field experiment was conducted using 20 released upland rice varieties at Fogera national rice research and training center during 2017 main cropping season. Randomized complete block design with three replications in 14m x 39.5m total area was used. Each experimental plot had a total area of 6m^2 (1.5m x 4m) and six rows at 0.25m interval while the distance between plots and between blocks were 0.5m and 1m, respectively. Seeds have been sown in rows with manual drilling at a rate of 60kg ha^{-1}. Fertilizer application was at a rate of 60.5 kg NPS and 125 kg urea per hectare. All NPS have been applied during planting while urea application was in three splits at planting, tillering and at panicle initiation stages.

Table 1. List of upland rice varieties used for the study

No	Variety	Pedigree	Year of release
1	Pawe-1	M-55	1998
2	Kokit	IRAT-209	2000
3	Suprica-1	WAB 450	2006
4	NERICA3	WAB 450-IB-P-2B-HB	2006
5	NERICA4	WAB 450-IB-P-9/1	2006
6	NERICA2	WAB 450-1-1-P31-1-HB	2007
7	Getachew	AD-01	2007
8	Andassa	AD-012	2007
9	Tana	AD-048	2007
10	NERICA14	WAB 880-1-32-1-2-P1-HB	2010
11	Kallafo-1	FOFIFA-3737	2010
12	NERICA6	WAB 450-IBP-160-HB	2011
13	NERICA15	WAB 881-10-37-18-3-P1-HB	2011
14	Hidasse	WAB 515-B-16A1-2	2012
15	Chewaqa	YIN lu 20	2013
16	NERICA10	WAB 450-11-1-1-P41-HB	2013
17	NERICA12	WAB 880-1-38-20-17-P1-HB	2013
18	Adet	WAB 450-1-B-P-462-HB	2014
19	NERICA13	WAB 880-1-38-20-28-P1-HB	2014
20	Fogera-1	ART15-7-16-30-2-B-B	2016

Source: MoANR (2016)

2.4. Data Collection

Observation and data recording for the traits under study were based on the standard evaluation system for rice (IRRI, 2013). The data were collected from ten randomly selected plants of each plot for traits treated on plant-basis like plant height (cm), panicle length (cm), number of panicles per plant, number of total grains per panicle, number of filled-grains per panicle, number of fertile tillers per plant, yield per plant (gm). However, days to heading, days to maturity, grain-filling period, thousand-seed weight (gm), biological yield (t ha^{-1}) and grain yield (t ha^{-1}) were taken on plot-basis; the four central rows were considered. Grain yield was adjusted at 14% moisture level.

2.5. Statistical Analysis

2.5.1. Analysis of variance

Analysis of variance (ANOVA) was done using Statistical Analysis System (SAS) version 9.4 Computer software program following SAS statement for randomized complete block design (SAS, 2012). Mean separation was done by comparing every pair of means by Least Significance Difference (LSD) test.

2.5.2. Genetic gain

Linear regression analysis was used to calculate the genetic gain for each trait considered in the study. The breeding effect was estimated as a genetic gain for grain yield and associated traits in upland rice by regressing mean of each character for each variety against the year of release of that variety using PROC REG procedure of SAS. The coefficient of linear regression gives the

estimate of genetic gain in ton ha^{-1} year^{-1} or in % per year (Evans and Fisher, 1999). The relative annual gain achieved over the years was determined as a ratio of genetic gain to the corresponding mean value of oldest variety and expressed as percentage.

Annual rate of gain (b) $= \frac{\text{covxy}}{v(x)}$

where X= the year of variety release, Y= the mean value of each character for each variety, Cov= Covariance, and V= Variance

The functional form of linear relationship between a dependent variable Y and independent variable X is represented by the equation:

$Y = \alpha + \beta x$

where Y= the value of the dependent variable, X= the independent variable, α= the intercept of the line and β= the regression coefficient (slope of the line), or the changes in Y per unit change in X.

3. Results and Discussion

3.1. Analysis of Variance and Performance of Varieties

The result of the analysis of variance for the different morphological and agronomic traits is presented in Table 2. There were significant differences (P<0.01) among varieties for all characters studied, indicating the existence of genetic variability within the varieties. The present investigation is in confirmation with early findings (Veasey et al., 2008; Worede et al., 2014; Fentie et al., 2014).

Mean of days to heading of all varieties in the trial was 94.71 days. The variety NERICA10 was significantly (P≤0.05) earliest in heading than the other varieties whereas Pawe-1 was very late in heading than the other varieties. Likewise, mean days to maturity of all varieties were 142.87. The variety NERICA14 had significantly (P≤0.01) earliest maturity. However, Pawe-1 had highly significant (P≤0.01) late days to maturity from all the other varieties. The mean of grain-filling period of varieties was 48.15 days. The variety Kokit had the shortest (33.3) grain-filling period, although it was not significantly (P≤0.01) different from variety NERICA14. The variety NERICA10 had significantly longest grain-filling period than the other varieties (Table 3).

The mean plant height was 85.38cm which ranged from 70.7cm (NERICA10) to 107.6cm (Getachew). Getachew was the tallest (107.6cm) followed by Andassa (104cm), Tana (101.8cm) and Chewaqa (101.4cm); however, Pawe-1 was the shortest (71.4cm). Panicle length of the varieties ranged from 12.1 cm to 20.9 cm with a mean of 18.39cm. The variety NERICA2 showed the longest panicle length (20.9 cm) which was significantly (P≤0.01) different from all the other varieties in the study except NERICA13, NERICA12 and Getachew. In contrast, the variety Pawe-1 had the smallest panicle (12.1 cm) of all the varieties (Table 3).

Number of fertile-tillers ranged from 6 to 9.7. The variety NERICA4 scored the highest number of fertile-tillers per plant followed by Andassa (9.4) and Tana (8.8). While that of variety NERICA15 was significantly lower than the rest of the varieties. The mean number of panicles per plant was 10.02 and it ranged from 8.4 (Kokit) to 13.5 (Hidasse). Hidasse, followed by NERICA6 (11.7) and NERICA12 (11.1) had higher number of panicles per plant. The oldest improved variety, Pawe-1, had 9.7 panicles.

The total number of grains per panicle ranged from 57.5 (NERICA14) to 105.8 (NERICA4). NERICA4 followed by Fogera-1 (105.1), NERICA6 (104) and Superica-1 (102.7) were varieties with higher total number of grains per panicle. Likewise, number of filled-grains panicle^{-1} of varieties ranged from 53.5 to 98.5 with the mean of 75.09 filled-grains panicle^{-1}. The variety NERICA4 produced highest number of filled-grains panicle^{-1} than the others. The varieties such as NERICA15, NERICA14, Kokit, Pawe-1 and NERICA10 produced lower number of filled-grains panicle^{-1} than the other varieties in the study (Table 3).

Table 2. Analysis of variance for 13 traits of 20 upland rice varieties at Fogera in 2017

Traits	Variety (df=19)	Error (df=38)	R^2 (%)
Days to heading	303.413**	2.439	0.984
Days to maturity	259.137**	4.997	0.963
Grain-filling period	256.894**	5.578	0.958
Plant height (cm)	382.638**	11.694	0.943
Panicle length (cm)	10.882**	0.689	0.89
Number of panicles per plant	3.911**	0.744	0.78
Number of total grains per panicle	753.097**	3.256	0.991
Number of filled-grains per panicle	650.801**	3.386	0.989
Number of fertile tillers per plant	3.070**	0.354	0.815
Thousand-seed weight (gm)	26.124**	0.950	0.932
Yield per plant (gm)	47.803**	0.621	0.975
Biological yield (t ha^{-1})	10.465**	0.379	0.933
Grain yield (t ha^{-1})	1.874**	0.113	0.893

*,**= Significant at P ≤ 0.05 and 0.01, respectively, df= degree of freedom R^2= coefficient of determination.

Mean yield per plant of upland rice varieties was 13.02 g, and it ranged from 5.2 g for NERICA15 to 20.7 g for NERICA12. Besides NERICA12, NERICA4, NERICA3, Suprica-1 and Tana also had higher yield per plant. However, varieties such as NERICA15, Kokit, Chewaqa and NERICA14 had relatively lower yield per plant than the other varieties in the study (Table 3).

Table 3. Mean of yield and yield related traits of the 20 upland rice varieties

Varieties	DH	DM	GFP	PH	PL	NPP	NTGP	NFGP	NFTP	TSW	YP	BY	GY
Adet	89.3^{hi}	144.3^{cdef}	55.0^{cd}	79.1^{f}	18.0^{ef}	9.5^{defgh}	86.4^{e}	82.1^{g}	7.0^{ghi}	28.6^{cde}	13.7^{fgh}	8.8^{defg}	4.5^{bcd}
Andassa	103.3^{d}	146.0^{bcde}	42.7^{g}	104.0^{ab}	19.1^{cde}	9.7^{cdefgh}	83.6^{ef}	73.8^{j}	9.4^{ab}	27.9^{def}	14.7^{defg}	9.8^{cd}	5.1^{a}
Chewaqa	107.3^{b}	148.0^{bc}	40.7^{gh}	101.4^{b}	19.1^{cde}	9.7^{cdefgh}	74.4^{g}	62.1^{l}	6.7^{hij}	25.3^{ij}	8.4^{j}	7.7^{hi}	3.8^{fghi}
Kallafo-1	85.0k	142.0^{f}	57.0^{bc}	83.2^{ef}	16.9^{fg}	9.7^{cdefgh}	75.6^{g}	69.2^{k}	7.7^{defg}	29.8^{c}	13.4^{ghi}	8.1^{ghi}	4.2^{def}
Fogera-1	92.3^{fg}	142.3^{ef}	50.0^{ef}	80.9^{ef}	17.7^{fg}	10.7^{bcd}	105.1^{ab}	95.3^{b}	8.5^{bcd}	25.1^{ij}	14.2^{efg}	9.3^{cde}	4.9^{abc}
Getachew	106.3^{bc}	146.0^{bcde}	39.7^{gh}	107.6^{a}	20.3^{abc}	10.5^{bcde}	85.7^{e}	76.0^{ij}	6.2^{ij}	28.3^{cde}	12.6^{hi}	12.4^{a}	4.4^{cde}
Hidasse	90.7^{gh}	142.7^{def}	52.0^{de}	81.3^{ef}	19.2^{bcde}	13.5^{a}	96.1^{c}	87.5^{de}	7.5^{defgh}	26.5^{fghi}	14.9^{def}	7.8^{ghi}	4.1^{defg}
Kokit	90.3^{gh}	123.7^{gh}	33.3^{j}	73.4^{gh}	17.6^{fg}	8.4^{h}	59.0^{i}	54.0^{no}	7.1^{fghi}	27.6^{defg}	8.0^{j}	5.8^{kl}	3.5^{hi}
NERICA10	79.7^{l}	146.0^{bcde}	66.3^{a}	70.7^{h}	18.2^{def}	9.1^{efgh}	80.8^{f}	58.1^{m}	8.1^{cde}	26.0^{hij}	9.0^{j}	6.6^{jk}	3.3^{ij}
NERICA12	97.7^{e}	149.3^{b}	51.7^{de}	93.9^{c}	19.5^{abcd}	11.1^{bc}	96.6^{c}	90.5^{cd}	8.2^{cde}	32.6^{b}	20.7^{a}	9.1^{cdef}	4.9^{ab}
NERICA13	90.7^{gh}	145.7^{bcdef}	55.0^{cd}	85.1^{de}	20.5^{ab}	9.8^{cdefgh}	75.3^{g}	70.3^{k}	6.9^{ghij}	32.6^{b}	12.4^{i}	8.7^{efgh}	4.7^{abcd}
NERICA14	86.3^{jk}	120.7^{h}	34.3^{ij}	72.4^{h}	19.2^{bcde}	8.6^{gh}	57.5^{i}	53.7^{o}	6.7^{hij}	26.3^{ghi}	8.7^{j}	5.4^{l}	3.7^{fghi}
NERICA15	87.7^{ij}	125.0^{g}	37.3^{hi}	85.2^{de}	18.2^{def}	10.1^{cdef}	57.7^{i}	53.5^{o}	6.0^{j}	27.1^{efgh}	5.2^{k}	6.1^{kl}	2.3^{k}
NERICA2	85.3^{jk}	145.7^{bcdef}	60.3^{b}	78.8^{fg}	20.9^{a}	9.9^{cdefg}	92.0^{d}	80.5^{gh}	8.4^{bcd}	25.6^{hij}	12.2^{i}	**7.2^{ij}**	3.6^{ghi}
NERICA3	91.0^{gh}	146.0^{bcde}	55.0^{cd}	78.2^{fg}	17.2^{fg}	9.9^{cdefg}	85.0^{e}	79.0^{hi}	8.1^{cdef}	27.6^{defg}	16.8^{c}	8.3^{fgh}	4.8^{abc}
NERICA4	90.7^{gh}	145.0^{cdef}	54.3^{cd}	79.1^{ef}	18.0^{ef}	10.3^{cdef}	105.8^{a}	98.5^{a}	9.7^{a}	27.0^{efgh}	19.2^{b}	9.4^{cde}	5.0^{ab}
NERICA6	99.0^{e}	146.3^{bcd}	47.3^{f}	90.6^{cd}	19.9^{abc}	11.7^{b}	104.0^{ab}	85.5^{ef}	6.7^{hij}	24.4^{j}	15.5^{cd}	5.8^{kl}	3.9^{efgh}
Pawe-1	122.7^{a}	160.0^{a}	37.3^{hi}	71.4^{h}	12.1^{h}	9.7^{cdefgh}	62.7^{h}	57.0^{mn}	7.4^{efgh}	35.8^{a}	9.0^{j}	10.0^{c}	2.8^{jk}
Superica-1	94.3^{f}	146.3^{bcd}	52.0^{de}	89.7^{cd}	16.6^{g}	9.3^{defgh}	102.7^{b}	92.4^{bc}	8.2^{cde}	31.5^{b}	16.5^{c}	6.7^{jk}	3.7^{fghi}
Tana	104.7^{cd}	146.3^{bcd}	41.7^{g}	101.8^{b}	19.5^{bcd}	8.9^{fgh}	86.3^{e}	82.7^{fg}	8.8^{abc}	28.8^{cd}	15.2^{de}	11.1^{b}	5.0^{ab}
Mean	94.71	142.87	48.15	85.39	18.39	10.02	83.61	75.1	7.656	28.23	13.015	8.19	4.12
LSD (5%)	2.582	3.695	3.904	5.652	1.372	1.425	2.983	3.042	0.983	1.611	1.303	1.018	0.555
C.V (%)	1.649	1.565	4.905	4.005	4.516	8.609	2.158	2.451	7.771	3.453	6.055	7.521	8.155

Means with in a column followed by the same letter are not significantly different at P≤0.05. DH= Days to heading, DM= Days to maturity, GFP= Grain-filling period, PH= Plant height, PL= Panicle length, NFTP= Number of fertile tillers per plant, NPP= Number of panicles per plant, NTGP= Number of total grains per panicle, NFGP= Number of filled-grain per panicle, TSW= Thousand-seed weight, YP= Yield per plant, BY= Biological yield and GY= Grain yield.

Thousand-seed weight ranged from 24.4gm (NERICA6) to 35.8gm (Pawe-1) with a mean of 28.23gm. Pawe-1 followed by NERICA12 and NERICA13 (both 32.6gm) and Superica-1 (31.5gm) were large seeded varieties.

The mean biological yield of the upland rice varieties was 8.19 t ha^{-1}, and it ranged from 5.4 t ha^{-1} for NERICA14 released in 2010 to 12.4 t ha^{-1} for Getachew released in 2007 (Table 3). Varieties such as Tana (11.1 t ha^{-1}) and Pawe-1 (10 t ha^{-1}) also had higher biological yield. The varieties released in 1998, 2007 and 2016 had relatively higher biological yield than the others (Table 4).

Table 4. Trend of genetic progress for grain-yield and biological-yield in upland rice varieties released from 1998-2016 over the oldest variety (Pawe-1)

Varieties	Year of release	Mean grain yield (t ha^{-1})	Increment over the oldest variety		Mean biological yield (t ha^{-1})	Increment over the oldest variety	
			t ha^{-1}	%		t ha^{-1}	%
Pawe-1	1998	2.760	-	-	10.00	-	-
Kokit	2000	3.490	0.730	26.449	5.78	-4.22	-42.20
NERICA3	2006						
NERICA4	2006	4.522	1.762	63.849	8.10	-1.90	-18.98
Superica-1	2006						
Andassa	2007						
Getachew	2007	4.523	1.763	63.889	10.11	0.11	1.11
NERICA2	2007						
Tana	2007						
Kallafo-1	2010	3.980	1.220	44.203	6.73	-2.27	-32.73
NERICA14	2010						
NERICA15	2011	3.122	0.362	13.104	5.91	-4.10	-40.92
NERICA6	2011						
Hidasse	2012	4.130	1.370	49.638	7.83	-2.17	-21.70
NERICA10	2013						
Chewaqa	2013	4.001	1.241	44.968	7.81	-2.19	-21.91
NERICA12	2013						
Adet	2014	4.598	1.838	66.606	8.74	-1.26	-12.62
NERICA13	2014						
Fogera-1	2016	4.860	2.100	76.087	9.28	-0.72	-7.20

The mean grain yield of upland rice varieties was 4.12 t ha^{-1}, which ranged from 2.31 t ha^{-1} for the variety NERICA15 to 5.13 t ha^{-1} for the variety Andassa. Andassa had significantly (P≤0.05) highest yield than the others (Table 3). The highest yielder variety, Andassa represents 63.8 % increment over the older variety (Pawe-1). More or less, similar trends of genetic progress were reported in wheat in Ethiopia (Tarekegn et al., 1995). The recently released upland rice variety, Fogera-1, showed significantly (P≤0.05) higher grain yield than most of the varieties tested in the study except Andassa, NERICA4, Tana and NERICA12. It exceeded the oldest variety (Pawe-1) by 76.08%. In the same way, Tarekegn et al. (1995) reported 89% and 71% grain yield improvement of the recent bread wheat variety at Holetta and Kulumsa, respectively. In winter wheat, 27.6% greater seed yield of newly released cultivar than the older cultivars was reported in UK (Shearman et al., 2005). Mean grain yields of varieties released in 2006, 2007, 2014 and 2016 exceeded that of the older variety released in 1998 by 1.76 (63.85%), 1.76 (63.89%), 1.84 (66.61%) and 2.10 (76.10%) t ha^{-1}, respectively (Table 4).

3.2. Genetic Improvement of Yield and Yield Attributing Traits

The linear regression analysis of days to heading and days to maturity on year of variety release showed negative regression coefficient, which was significantly different from zero for days to heading (Table 5). In agreement with this study, Donmez et al. (2001) in winter wheat reported that modern cultivars were significantly earlier than the oldest ones for days to flowering. Breseghello et al. (2011) also reported reduction of 0.25 days yr^{-1} in days to flowering in upland rice.

As evidenced from the regression of variety means against year of release, plant height showed 0.353 cm year^{-1} increment although it was not significant (Table 6). In agreement to this finding, Teklu and Tefera (2005) reported low (0.4285 cm year^{-1}) and non-significant

genetic gain of plant height over 35 years of tef improvement. Contrary to this, Ortiz et al. (2002) reported that yield improvement was achieved by reducing plant height in two row barley (0.2 cm year^{-1}) and six row barley (0.16 cm, year^{-1}) varieties. Breseghello et al. (2011) also reported reduction of 0.52 cm yr^{-1} in plant height in upland rice.

The analysis showed that the regression coefficient for panicle length for the period studied was 0.216, which is significantly (P≤0.05) different from zero (Table 6). This result indicated panicle length was steadily modified with the year of release of a variety.

Number of fertile tillers per plant of upland rice varieties showed a slight but not significant (P≤0.05) decreasing trend over the 18 years period (Table 5). The annual relative genetic gain of number of fertile tiller per plant for the periods 1998-2016 was -0.45% (Table 6). This implies that there was a decreasing trend in number of fertile tiller per plant across the years of release.

Number of filled-grains per panicle revealed significant (P≤0.05) trend of increase over the period studied (Table 5). Accordingly, it increased by 0.76 grains year^{-1}, indicating that rice improvement program has significantly enhanced number of filled-grain panicle^{-1}. This implies that improved grain yield in the modern varieties appears to be associated more with the production of a higher number of filled-grain panicle^{-1}. The annual relative genetic gain for number of filled grain panicle^{-1} was estimated to be 1.33 % for the period 1998-2016 (Table 6).

Table 5. Mean values, regression coefficient (b), intercept and coefficient of determination (R^2) for various traits of 20 upland rice varieties released from 1998-2016

Traits	Mean	b	Intercept	R^2
Days to heading	94.72	-0.931*	1965.74	0.185
Days to maturity	142.87	-0.104	352.46	0.003
Grain-filling period	48.15	0.827*	-1613.34	0.173
Plant height (cm)	85.39	0.353	-624.26	0.0212
Panicle length (cm)	18.39	0.216*	-414.69	0.277
Number of panicles per plant	10.02	0.082	-154.98	0.112
Number of total grain per panicle	83.61	1.013	-1951.34	0.088
Number of filled-grains per panicle	75.09	0.76*	-1450.87	0.058
Number of fertile tillers per plant	7.66	-0.033	73.15	0.022
Thousand-seed weight (gm)	28.23	-0.232*	493.44	0.133
Yield per plant (gm)	13.02	0.094	-175.67	0.012
Biological yield (t ha^{-1})	8.19	-0.044	93.13	0.011
Grain yield (t ha^{-1})	4.12	0.044	-84.10	0.067

*= Significant at P≤0.05.

Table 6. Mean annual relative genetic gain (RGG) of different traits over the18 years of upland rice improvement in Ethiopia

Traits	Mean of the oldest variety	Increment/decrement	RGG (% year^{-1})
Days to heading	122.7	-0.931	-0.76
Days to maturity	160.0	-0.104	-0.07
Grain-filling period	37.30	0.827	2.22
Plant height (cm)	71.43	0.353	0.50
Panicle length (cm)	12.13	0.216	1.78
Number of panicles per plant	9.77	0.082	0.84
Number of total grain per panicle	62.70	1.013	1.62
Number of filled-grains per panicle	57.00	0.760	1.33
Number of fertile tillers per plant	7.40	-0.033	-0.45
Thousand-seed weight (gm)	35.83	-0.232	-0.65
Yield per plant (gm)	9.02	0.094	1.04
Biological yield (t ha^{-1})	10.00	-0.044	-0.44
Grain yield (t ha^{-1})	2.76	0.044	1.59

The linear regression analysis for thousand-seed weight depicted significant (P≤0.05) negative linear relationship with cultivar age (Table 5). The relative annual genetic gain of thousand-seed weight of varieties mean over year of variety release was -0.65% (Table 6).

The average rate of increase in grain yield of upland rice varieties was 0.044 t ha^{-1} year^{-1}, although non-significant (Table 5 and Figure 1). Notwithstanding yield potential increment with the deployment of dwarfing genes in wheat and rice, it is generally considered that yield is under multi genic control and the yield potential progress is mostly gradual (Evans and Fischer, 1999). Similar trends have been reported by dos Reis et al. (2015) who reported 13.99 kg ha^{-1} improvement in irrigated rice per year. Under irrigation, Peng et al. (2000) reported 75 and 81 kg ha^{-1} grain yield increment per year in rice in 1996 and 1998, respectively. Tabien et al. (2008) found 42.2 and 26.3 kg ha^{-1} yield improvement per year for irrigated rice under high and low N conditions, respectively. Breseghello et al. (2011) also found 19.1 kg ha^{-1}, corresponding to 0.67% per year, gain for yield in upland rice. Zhu et al. (2016) reported 61.9 and 75.3 kg ha^{-1} annual gains of rice grain yield in 2013 and 2014, respectively. Teklu and Tefera (2005) also reported genetic gains of 27.16 kg ha^{-1} per year of release in tef.

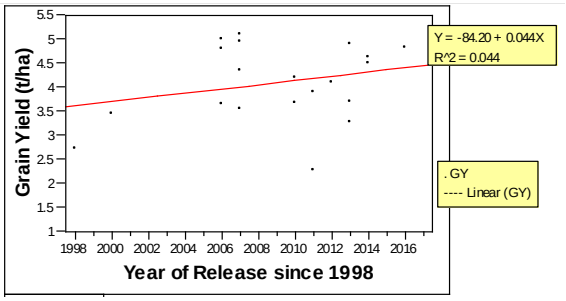

Figure 1. Relationship between mean grain yield of 20 upland rice varieties and the year of release.

Grain yield showed a general increase from old to new varieties during the last two decades of upland rice breeding in Ethiopia (Figure 1). This is in agreement with the findings of Teklu and Tefera (2005) in tef, Tarekegn et al. (1995) in wheat, Wych and Stuthman (1983) in oat.

The relative annual genetic yield gain in the 20 varieties of upland rice released between 1998 and 2016 was 1.59% year^{-1} (Table 6). Similar to the present study, an annual increase of 0.8% in oats (Wych and Stuthman, 1983), 0.9% in malt barley (Wych and Rasmusson, 1983), 1% in irrigated rice (Peng et al., 2000), 0.79% in tef (Teklu and Tefera, 2005) and 0.86% in wheat (Miri, 2009) were reported. This indicates that grain yield of rice has not yet attained a ceiling in Ethiopia, signifying the opportunity to further improve upland rice yield. In line with the present findings, Teklu and Tefera (2005) in tef in Ethiopia, and Khodarahmi et al. (2010) in wheat in Iran found no indication of yield potential plateau.

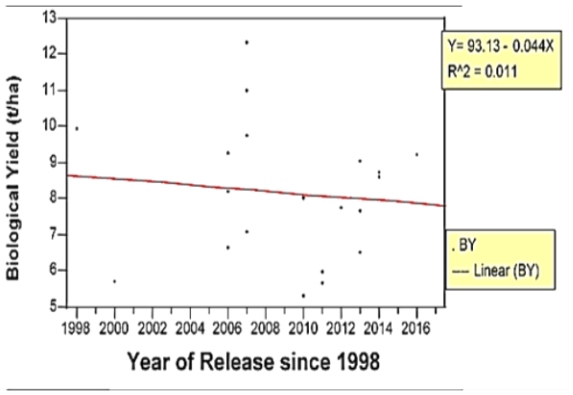

Figure 2. Relationship between mean biological yield of 20 upland rice varieties and the year of release.

The average rate of increase in biological yield of upland rice varieties was -0.044 t ha^{-1} per annum, though not-significant (Table 5 and Figure 1). The annual relative genetic gain for biological yield of the upland rice varieties was estimated to be -0.44% for the period 1998-2016 (Table 6). In contrast, Zhu et al. (2016) reported 0.097 and 0.11 t ha^{-1} annual gains of biological yield for rice in 2013 and 2014, respectively. Teklu and Tefera (2005) also reported a significant biological yield improvement in tef. Similarly, Donmez et al. (2001) pointed out that the gain in grain yield in wheat genotypes was accompanied by an increase in total biomass yield (0.16%). The study revealed that upland rice improvement program has not significantly enhanced the biological yield of the modern varieties.

3.3. Phenotypic Correlations of Grain Yield and Other Traits

The result of the phenotypic correlation analysis is depicted in Table 7. Days to maturity showed significant positive association with grain yield (r_p=0.30*). The result is in agreement with Fentie et al. (2014). The correlation between plant height and grain yield was positive and significant (r_p=0.39**) which indicates that an increase in plant height leads to an increase grain yield. Similar results have been reported by Fentie et al. (2014) and Ratna et al. (2015).

The correlation between number of productive tillers per plant and grain yield was positive and significant (r_p=0.50**) which is in agreement with the report of Madhavilatha et al. (2005) and Ratna et al. (2015). Number of filled-grains per panicle had positive and highly significant association with grain yield (r_p=0.64**). The result is substantiated with those of Elsadig and Abdalla (2013), Ratna et al. (2015) and Somchit et al. (2017).

Yield per plant had highly significant positive correlation (r_p=0.77**) with grain yield. Biological yield was in positive and significant relationship with grain yield (r_p=0.57**). This result is supported by the findings of Rangare et al. (2012), Fentie et al. (2014) and Rathor et al. (2014).

Table 7. Phenotypic correlation coefficient (r_p) of 13 traits of 20 released upland rice varieties

Variable	DM	GFP	PH	PL	NPP	NTGP	NFGP	NFTP	TSW	YP	BY	GY
DH	0.54**	-0.53**	0.47**	-0.32*	0.07	-0.05	-0.02	-0.05	0.42**	0.03	0.54**	0.01
DM		0.43**	0.27*	-0.2	0.2	0.49**	0.42**	0.33*	0.40**	0.47**	0.57**	0.30*
GFP			-0.23	0.14	0.13	0.54**	0.44**	0.38**	-0.05	0.44**	-0.01	0.28*
PH				0.43**	0.18	0.26*	0.26*	0.01	0	0.28*	0.50**	0.39**
PL					0.23	0.24	0.2	-0.06	-0.41**	0.16	0.02	0.37**
NPP						0.45**	0.43**	0	-0.08	0.34**	0.15	0.17
NTGP							0.95**	0.48**	-0.18	0.81**	0.25*	0.55**
NFGP								0.49**	-0.05	0.88**	0.34**	0.64**
NFTP									0.05	0.56**	0.29*	0.50**
TSW										0.16	0.39**	0.04
YP											0.39**	0.77**
BY												0.57**

*, ** at 5 % and 1% probability level respectively, DH= Days to heading, DM= Days to maturity, GFP= Grain-filling period, PH= Plant height, PL= Panicle length, NFTP= Number of fertile tillers per plant, NPP= Number of panicles per plant, NTGP= Number of total grains per panicle, NFGP= Number of filled grains per panicle, TSW= Thousand-seed weight, YP= Yield per plant, BY= Biological yield and GY= Grain yield.

The study of correlation revealed that plant height, number of productive tillers per plant, yield per plant and biological yield were characters which possessed significant positive association with grain yield. The positive and significant correlation of these traits with grain yield suggests that yield have increased with increase of those characters.

4. Conclusion and Recommendation

Information on the genetic progress achieved over time from a breeding program is useful to develop effective and efficient breeding strategies for further improvement. The present study showed increment in grain yield of upland rice varieties with 0.044 t ha^{-1} (1.59% $year^{-1}$) average rate of increase per year and decrement in biological yield with -0.044 t ha^{-1} (-0.44% $year^{-1}$), although non-significant. The result demonstrated significant reduction in days to heading and thousand-seed weight, and significant increment in panicle length, grain-filling period and number of filled-grains $panicle^{-1}$. On the looming climate change, there might have been occurrences of new biotic and abiotic stress factors, and the latest varieties may be better adapted to these factors in addition to the significant changes.

The positive and significant correlation of plant height, number of productive tillers per plant, yield per plant and biological yield with grain yield suggests that yield have increased with the increase of those characters. However, this study needs subsequent testing of varieties at different locations to come up with sound recommendation.

Author Contributions

BZ; initiated the research idea, developed, organized, analyzed and interpreted the data and wrote the manuscript. TD: suggested the research methods, structured the paper and organized the manuscript FW; supervised the research, suggested the research methods, structured the paper and edited the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Belete T, Mekbib F, Eshete M. 2017. Assessment of genetic improvement in grain yield potential and related traits of Kabuli type chickpea (Cicer arietinum L.) varieties in Ethiopia (1974-2009). Adv. Crop Sci Tech, 5: 284.

Bezaweletaw K, Belete K, Sripichitt P. 2006. Genetic gain in grain yield potential and associated agronomic traits in haricot bean (Phaseolus vulgaris L.). Kasetsart J (Natural Sci), 40: 835-847.

Bogale DA, Mekbib F, Fikre A. 2015. Genetic improvement of lentil [Lens culinaris Medikus] between 1980 and 2010 in Ethiopia. Malays J Med Biol Res, 2(3): 284-292.

Breseghello F, de Morais OP, Rangel PHN. 1998. A new method to estimate genetic gain in annual crops. Genetics and Mol Biol, 21(4). DOI: 10.1590/S1415-47571998000400024.

Breseghello F, de Morais OP, Pinheiro PV, Silva ACS, da Maia de Castro E, Guimarães ÉP, de Castro AP, Pereira JA, de Matos Lopes A, Utumi MM, de Oliveira JP. 2011. Results of 25 years of upland rice breeding in Brazil. Crop Sci, 51: 914-923.

Dargo F, Mekbib F, Assefa K. 2016. Genetic gain in grain yield potential and associated traits of tef [Eragrostis tef (Zucc.) Trotter] in Ethiopia. Global J Sci Frontier Res, D16(6): 1-17.

Dessie A, Zewdu Z, Worede F, Bitew M. 2018. Yield stability and agronomic performance of rain fed upland rice genotypes by using GGE bi-plot and AMMI in North West Ethiopia. Int J Res Rev, 5(9): 123-129.

Donmez E, Sears RG, Shroyer JP, Paulsen GM. 2001. Genetic gain in yield attributes of winter wheat in the Great Plains. Crop Sci, 41: 1412-1419.

dos Reis GG, Fritsche-Neto R, Soares PC, de Oliveira Cornélio

VM, de Sousa Reis M, de Morais OP, da Silva Marques T. 2015. Accuracy and genetic progress of agronomic traits in irrigated rice program in Brazil. Afr J Agric Res, 10(43): 4032-4038.

Elsadig AI, Abdalla KM. 2013. Estimation of genetic variability and correlation for grain yield components in rice (Oryza sativa L.). Glob J Plant Ecophysiol, 3: 1-6.

Evans LT. 1993. Crop evolution, adaptation and yield. Cambridge University Press, New York, USA.

Evans LT, Fischer RA. 1999. Yield potential: Its definition, measurement and significance. Crop Sci, 39: 1544-1551.

FAOSTAT. 2017. URL: http://www.fao.org/faostat/en/#data/QC. (access date: 10.09.2019).

Fekadu W, Zeleke H, Ayana A. 2011. Genetic improvement in grain yield potential and associated traits of food barley (Hordeum vulgare L.) in Ethiopia. Ethiop J Appl Sci Technol, 2(2): 43-60.

Fentie D, Alemayehu G, Siddalingaiah M, Tadesse T. 2014. Genetic variability, heritability and correlation coefficient analysis for yield and yield component traits in upland rice (Oryza sativa L.). East African J Sci, 8(2): 147-154.

Green AJ, Berger G, Griffey CA, Pitman R, Thomason W, Balota M, Ahmed A. 2012. Genetic yield improvement in soft red winter wheat in the Eastern United States from 1919 to 2009. Crop Sci, 52: 2097–2108.

Hagos F, Zeleke H, Woyessa B. 2012. Genetic gain in yield and yield related traits of groundnut (Arachis hypogea L.) in central rift valley of Ethiopia. East African J Sci, 6(2): 125-136.

IRRI. 2013. Standard evaluation system for rice. 5th (ed.). International Rice Research Institute, 55p, Manila. Philippines.

Khodarahmi M, Nabipour A, Zargari K. 2010. Genetic improvement of agronomic and quality traits of wheat cultivars introduced to temperate regions of Iran during 1942-2007. Afr J Agric Res, 5(9): 947-954.

Madhavilatha L, Sekhar MR, Suneetha Y, Srinivas T. 2005. Genetic variability, correlation and path analysis for yield and quality traits in rice (Oryza sativa L.). Res on Crops, 6(3): 527-534.

Miri H. 2009. Grain yield and morpho-physiological changes from 60 years of genetic improvement of wheat in Iran. Experimental Agri, 45: 149-163.

MoANR. 2016. Crop variety register. Issue No. 19. Plant variety release, protection and seed quality control directorate. Addis Ababa, Ethiopia.

Ortiz R, Nurminiemi M, Madsen S, Rognli OA, Bjørnstad Å. 2002. Genetic gains in Nordic spring barley breeding over sixty years. Euphytica, 126(2): 283-289.

Peng S, Laza RC, Visperas RM, Sanico AL, Cassman KG, Khush GS. 2000. Grain yield of rice cultivars and lines developed in the Philippines since 1966. Crop Sci, 40: 307-314.

Perry MW, D'Antuono MF. 1989. Yield improvement and associated characteristics of some Australian spring wheat cultivars introduced between 1960 and 1982. Aust J Agr Res, 50: 457-472.

Rangare NR, Krupakar A, Ravichandra K, Shukla AK, Mishra AK. 2012. Estimation of characters' association and direct and indirect effects of yield contributing traits on grain yield in exotic and Indian rice (Oryza sativa L.) germplasm. Intl J Agric Sci, 2(1): 54-61.

Rathor AP, Singh A, Suresh BG, Lavanya GR, Yadav Y. 2014. Diversity analysis of local land races and improved germplasm of rice (Oryza sativa L.) under Allahabad agro-climatic conditions. Indian J Applied Res, 4(8): 38-42.

Ratna M, Begum S, Husna A, Dey SR, Hossain MS. 2015. Correlation and path coefficients analyses in basmati rice. Bangladesh J Agri Res, 40: 153-161.

Samado EA, Guei RG, Nguyen N. 2008. NERICA: Origin, nomenclature and identification characteristics, pp. 10-19. In E.A. Somado, R.G. Guei and S.O. Keya, (eds.). NERICA®: The New Rice for Africa – a Compendium. Africa Rice Center, Cotonou, Benin.

SAS. 2008. Statistical Analysis System. Version 9.2, SAS Institute Inc., Cary, NC., USA.

Shearman VJ, Sylvester-Bradley R, Scott RK, Foulkes MJ. 2005. Physiological processes associated with wheat yield progress in the UK. Crop Sci, 45: 175-185.

Somchit P, Sreewongchai T, Sripichitt P, Matthayatthaworn W, Uckarach S, Keawsaard Y, Worede F. 2017. Genetic relationships of rice yield and yield components in RILs population derived from a cross between KDML105 and CH1 rice varieties. Walailak J Sci Tech, 14(12): 997-1004.

Tabien RE, Samonte SOPB, McClung AM. 2008. Forty-eight years of rice improvement in Texas since the release of cultivar Bluebonnet in 1944. Crop Sci, 48: 2097-2106.

Tarekegn A, Tanner DG, Gebeyehu G. 1995. Improvement in yield of bread wheat cultivars released in Ethiopia from 1949 to 1987. African Crop Sci J, 3(1): 41-49.

Teklu Y., Tefera H. 2005. Genetic improvement in grain yield potential and associated agronomic traits of tef (Eragrostis tef). Euphytica, 141: 247-254.

Tolessa T, Keneni G, Mohammad H. 2015. Genetic progresses from over three decades of faba bean (Vicia faba L.) breeding in Ethiopia. Australian J Crop Sci, 9: 41-48.

Veasey EA, da Silva EF, Schammass EA, Oliveira GCX, Ando A. 2008. Morphoagronomic genetic diversity in American wild rice species. Braz Arch Biol Tech, 51: 95-104.

Waddington S, Ransom S, Osamanzi M, Sounders D. 1986. Improvement in the yield potential of bread wheat adapted to North West Mexico. Crop Sci, 26: 699-703.

Woldesemayat MY, Mekbib F, Gebeyehu S. 2015. Genetic gain in lowland sorghum [Sorghum Bicolor (L.) Moench] varieties in Ethiopia. Int J Hortic Plant Breed Sci, 2(1): 1 -13.

Worede F, Sreewongchai T, Phumichai C, Sripichitt P. 2014. Multivariate analysis of genetic diversity among some rice genotypes using morpho-agronomic traits. J Plant Sci, 9: 14-24.

Worku M, Zelleke H. 2007. Advances in improving harvest index and grain yield of maize in Ethiopia. East African J Sci, 1: 112-119.

Wych RD, Rasmusson DC. 1983. Genetic improvement in malting barley cultivars since 1920. Crop Sci, 23: 1037-1040.

Wych RD, Stuthman DD. 1983. Genetic improvement in Minnesota-adapted oat cultivars released since 1923. Crop Sci, 23: 879-881.

Zhu G, Peng S, Huang J, Cui K, Nie L, Wang F. 2016. Genetic improvements in rice yield and concomitant increases in radiation- and nitrogen-use efficiency in middle reaches of Yangtze River. Sci Rep, 6, 21049. DOI: 10.1038/srep21049.