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Research article

Agro-morphological and physiochemical studies of upland rice (Oryza sativa L.) varieties for variability with yield and quality related parameters in south Gondar district, Ethiopia

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ABSTRACT

Study was conducted during the main cropping season of 2016 in Fogera and Libo Kemkem District, South Gondar, Ethiopia to evaluate agro-morphological and physiochemical studies of upland rice (Oryza sativa L.) varieties for variability and their association with yield and their quality. A total of ten up land rice varieties namely NERICA13, NERICA12, NERICA4, SUPERICA1, HIDASE, ADET, ANDASA, TANA, KOKIT and GETACHEW laid down in a randomized complete block design with three replications were used. The study revealed significance ($P < 0.05$) difference in ago-morphological parameters like plant height, number of spike lets, biomass yield, straw yield, grain yield and harvest index in Fogera district, and productive tillers, number of spike lets, grain yield and harvest index in Libo Kemkem District. At Fogera district the highest yield were recorded in NERICA13 (4738 kg/ha), GETACHEW (4614 kg/ha), NERICA4 (4092 kg/ha), NERICA12 (4020 kg/ha) and Adet (3557.4 kg/ha) varieties, and NERICA12 (4583 kg/ha), NERICA13 (4013 kg/ha) NERICA4 (4002 kg/ha) and Adet (3380 kg/ha) varieties at Libo Kemkem districts. Five varieties (NERICA (4, 12 and 13), GETACHEW and ADET) at both locations had been tested for physicochemical analysis. The result showed that such rice varieties grain have a cooking grain length of 7.39 mm (ADET), 7.68 mm (NERICA4), 7.65 mm (NERICA12), 7.88 mm (NERICA13) and 6.76 mm (GETACHEW); cooking grain width of 2.61 mm (ADET), 2.64 mm (NERICA4), 2.70 mm (NERICA12), 2.79 mm (NERICA13) and 2.91 mm (GETACHEW); Grain thickness of 1.91 mm (ADET), 2.73 mm (NERICA4), 2.69 mm (NERICA12), 2.72 mm (NERICA13) and 2.23 mm (GETACHEW. and grain length/width (L/w) ratio 2.67 mm (ADET), 1.85 (NERICA4) 1.80 (NERICA12), 1.92 (NERICA13) and 2.09 (GETACHEW) were revealed and determination of grain shapes. Broken density was obtained 85.74mg/cm3 (ADET), 83.47mg/mm3 (NERICA4), 84.38mg/mm3 (NERICA12), 87.5mg/mm3 (NERICA13) and 73mg/mm3 (GETACHEW). Also investigations showed that upland rice grains contained 11.63–14.27% moisture; 1–1.24%, ash; 2.90–3.62% fiber and 8.07–10.35% protein. Gelatinization Temperatures ranged from 58.33 to 72.67% and grain contents of carbohydrates 73.57–75.65% were shown and significantly affected among their five upland rice grains varieties. Among the treatments of upland rice varieties were gained 35.79% of grain yield advantageous over all treatments at both locations. The results revealed in relatively morphologically and physicochemical properties of

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the three types of upland rice varieties NERICA (4, 12 and 13) were recommended to maximizing grain yielding for rice producing farmers.

Abbreviations

G	Gram
Kg ha^{-1}	Kilo gram per hectare
Km	Kilo meter
T ha^{-1}	Ton per hectare
SSA	Sub Saharn Africa

1. Introduction

Rice (*Oryza sativa* L.*)* is a major food crop, ranking second to wheat among the most cultivated cereals in the world. It is a staple food for more than half of the world's population [1]. In recent years, the relative growth in demand for rice is faster in SSA than anywhere else in the world [2] (see Fig. 1).

The cultivation of rice in Ethiopia is of a recent history. Currently, however, its use as food and cash crop is well recognized. Rice in Ethiopia is one of strategic food security commodities and its expansion is also linearly increasing in different parts of the country [3]**.** Ethiopia is endowed with a range of geographic and climatic conditions that suit to rice production with an estimated potential of more than 30 million hectares. The suitable rice production areas in Ethiopia are Gambella, Pawe, Fogera, Metema and Oromia Zone [4]. The total national rice production recorded in 2008 of 40% is shared largely to produce in the Amhara region at Fogera plain. Rice can be produced as high as 10–18 t ha^{-1} in countries have advanced in its cultivation [5].

However, in Africa as much as below its world average 4.35 t ha^{-1} of paddy rice. Whereas, in Ethiopia particularly 2.31 t ha^{-1} of paddy rice is produced, due to lack of high yielding varieties and improper agronomic management practices. Ethiopia adopted NERICA varieties such as NERICA-1, 2, 3, 4 and Suparica-1 varieties in addition to the local varieties such as X-Jigna and others. There have been twelve upland/lowland NERICAs and Sativa-type, and three irrigated rice varieties released in Ethiopia from 1999 up to 2007. Due to the introduction of upland and irrigated rice varieties in the country, rice farming has increased from 53,302 farmers in

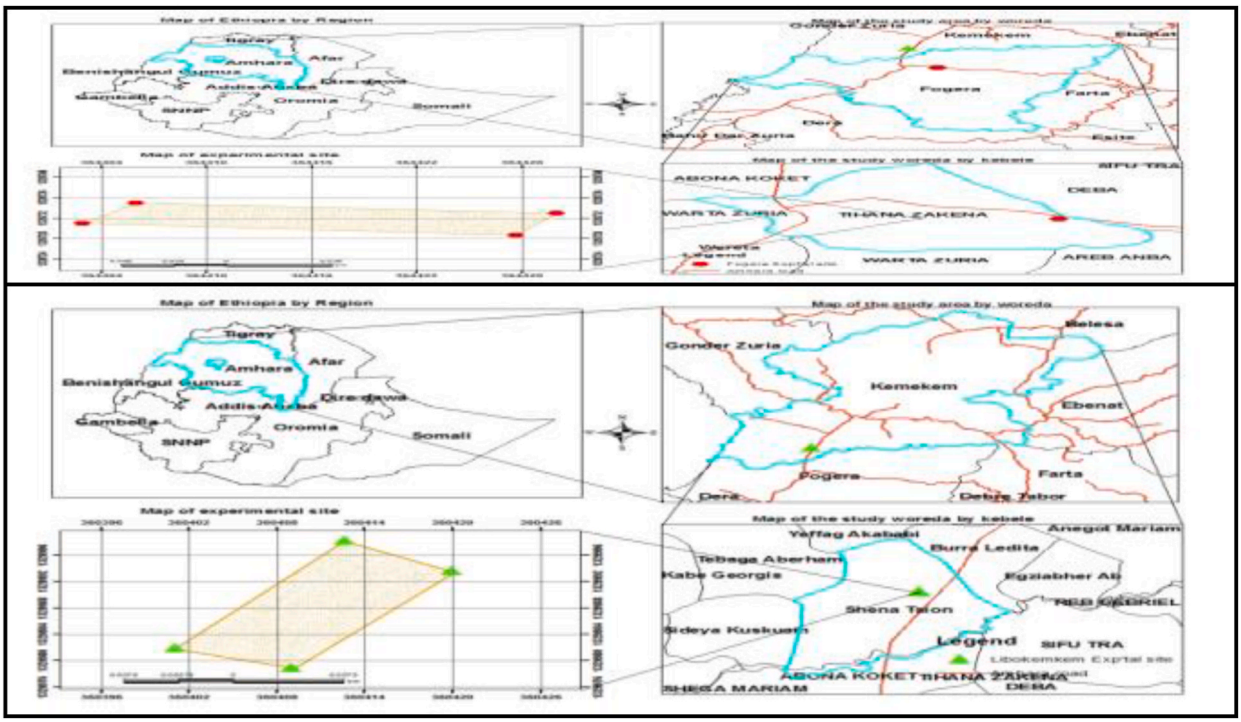

Fig. 1. Map of Fogera and Libo Kemkem, respectively.

2006 to over 284,268 in 2009. Low productivity in Ethiopia resulted due to lack of high yielding varieties, terminal moisture deficit and low soil fertility [3].

The National Rice Improvement Program has been conducting multi-environment variety trials since two decades to identify high yielding varieties which are wider adaptability, early maturing and resistant to major diseases. Though released, the nature of such improved upland rice variety has not been tested especially in potential producing areas of Ethiopia [6]. Only a few studies have been done on upland rice variety. However, agro-morphological and physiochemical studies of upland rice varieties for variability and their association with yield and quality related parameters are not yet studied. Therefore this study was developed with the objective of studying such variability of upland rice varieties with yield and quality in south Gondar district.

2. Materials and methods

2.1. Description of the study area

The two districts are among the 106 Woredas of the Amhara Regional State and found in South Gondar. The study areas are found in Amhara region, South Gondar, Fogera and Libo Kemkem Districts, study areas Fogera and Libo Kemkem are found 625 km and 645 km away from Addis Ababa, respectively and 55 km and 75 km, respectively from the Regional capital city of Bahir Dar. The Geographical location of Fogera and Libo Kemkem varies from 364,430 to 364403 *m* Easting and 1,320,735 to 1320728 *m* Northing and altitude of 1820–1823 *m*. a.s.l and 1,330,000 to 1329979 *m* Northing and 370,627 to 360401 *m* Easting and altitude of 1799–1804 *m*. a.s.l. Respectively. The most dominant crop of farm land are allocated for annual crops where cereals covered 51,472 ha; pulses cover 9819.98 ha; oil seeds 6137 ha; root crops 1034.29 ha; and vegetables 882.08 ha [7]. The major crops include tef, maize, finger millet and rice, in order of area coverage. The productive potential of the experimental location could be judged from its cropping history. The detail account of the cropping history of experimental site prior to the present experiment had been growing as relay cropping of legume like grass pea, chickpea, safe flower and fenugreek. Soil types of the study areas are Vertisols. Its slope ranges from 0 to 2%. The area has *weina dega* agro-ecology with rainfall of 1200–1500 mm per annum. The mean annual temperature is about 17.5–20$^{0}_{C.}$

2.2. Experimental details

The experiment was conducted under rain fed condition during the main cropping season of 2016/2017 in Fogera and Libo Kemkem districts. A total of ten up land rice varieties from national rice research training center (NRRTCs) namely NERICA13, NERICA12, NERICA4, SUPERICA1, HIDASE, ADET, ANDASA, TANA, KOKIT and GETACHEW laid out in randomized complete block design (RCBD) with three replications. Treatments were allocated in each experimental plot randomly. Gross plot size was 1.40 m × 2.0 *m*, Net plot size 1.0 m × 1.80 *m*. All recommended agronomic practices were done.

2.3. Data collected and statistical analyses

Phonological parameters, number of total tillers per plant, productive tillers per plant, plant height, panicle length, number of spike lets per panicle, 1000-grain weight, aboveground biomass yield, straw yield (tha^{-1}), grain yield (kg ha^{-1}).

2.3.1. Harvest index

The harvested index was calculated by using the following formula and expressed in ratio of grain yield and biological yield per plot.

$$\text{Harvest Index(H.I.)} = \frac{\text{Granin yield}}{\text{Biological yield}}$$

2.3.2. Quality parameters

Varieties which were relatively high yielder (NERICA 4, NERICA 12 NERICA13, GETACHEW and ADET) were selected, seeds polished, milled and tested for quality at Bahir Dar University, department of food science and technology with 500 g of grain seed. These varieties were tested for physical properties, cooking quality and their chemical properties.

Determination of Physical Properties: Length, Width and Length/Width (L/W) Ratio with [8] method. 20 whole grain samples was collected at random from each variety and dimension was measured using a venial caliper calibrated in millimeters (mm) to obtained the average length and width ratio.

L/W = Average length of rice (mm)/Average width of rice (mm).

Gelatinization time and gelatinization temperature at 90^{0}c with the method of [9]: Two grams (2 g) of the different samples of grain seeds were weighed and poured into 5 different test tubes, and 10 mls of distilled water was added into each of the test tube containing the samples, and shaken vigorously to obtain uniform solution, which was heated in a water bath placed on a hot plate and the components was continuously and gently stirred with the aid of glass rod stirrer until gelatinization was achieved.

Determination of Chemical properties was done with the method of [10]. 0.1 g of starch was weighed into a test tube, 1 ml of 95% ethanol and 9 ml 1 N NaOH was added. The mouth of the tube covered with paraffin to mix content very well. 0.5 ml of aliquot was used in the analysis. 0.1 *m* of acetic acid solution and 0.2 ml of standard solution was added to make up 10 ml of solution of distilled water and allowed for 20 min for standard color development.

Table 1
Agro-morphological studies on upland rice varieties at Fogera District.

Up land Rice Variety	Parameters											
	DTH	DTM	Tt	Pt	PH	Pl	NSL	BMY	SY	Thsw	GY	HI
Nerica 13	83	131	8.2	7.2	86.4^{ab}	17.4^{a}	80^{ab}	18056^{ab}	13317^{ab}	29.5	4738.9^{a}	0.26^{ab}
Nerica 12	83.67	132	8.27	5.93	88.93^{ab}	16.8^{ab}	99.67^{a}	16204^{ab}	12183^{ab}	29.93	4020.4^{ab}	0.25^{ab}
superica1	85.67	130.33	8.2	6.6	77.4^{ab}	14.2^{ab}	78.8^{ab}	12500^{b}	9769^{b}	28.67	2731.5^{bc}	0.22^{ab}
Nerica 4	81.67	132.33	8.27	6.53	80.67^{ab}	15.07^{ab}	97.87^{ab}	14352^{b}	10259^{b}	28.23	4092.6^{ab}	0.29^{a}
Hidasie	82	129.33	7.93	6.73	89.13^{ab}	15.6^{ab}	81.6^{ab}	12963^{b}	9546^{b}	27.47	3416.7^{ab}	0.27^{ab}
Adet	79	137	8.67	6.87	84.27^{ab}	16^{ab}	98^{ab}	13426^{b}	9869^{b}	29.37	3557.4^{ab}	0.27^{ab}
Andasa	79	88.33	5.73	4.87	53.4^{b}	9.87^{ab}	45.27^{b}	10185^{b}	8489^{b}	19.73	1696.3^{c}	0.12^{b}
Tana	69	141.67	8	8	102.47^{a}	16.67^{ab}	98.2^{ab}	14815^{ab}	10520^{b}	27.5	4294.4^{a}	0.32^{a}
Kokit	85	136.33	8	6.93	84.93^{ab}	15.33^{ab}	68.8^{ab}	11574^{b}	7859^{b}	27.67	3714.8^{ab}	0.33^{a}
Getachew	61.67	141.33	9.2	8.27	103.33^{a}	15.8^{b}	99.33^{ab}	23148^{a}	18533^{a}	25.8	4614.8^{a}	0.2^{ab}
MEAN	72.07	129.93	8.17	6.74	84.65	15.24	84.35	14,444	10,855	27.29	3589.44	0.24
MSE+	29.66	25.99	2.04	1.68	17.12	3.34	18.87	4118.27	3746.3	5.67	678.01	0.67
LSD at 0.05	ns	ns	ns	ns	*	*	*	*	*	ns	*	*
CV (%)	41.16	20	25.09	24.94	20.22	21.91	22.37	28.51	34.53	20.78	18.88	27.52

Table 2
Agro-morphological studies on upland rice varieties at Libo Kemkem District.

Upland Rice Variety	Parameters'											
	DTH	DTM	Tt	Pt	PH	Pl	NSL	BMY	SY	Thsw	GY	HI
Nerica 13	106.67	137.67	14.20	12.53^{ab}	87.47	17.00	133.40^{ab}	13,426	9344	28.23	4081^{a}	0.30^{a}
Nerica 12	100.33	134.33	16.67	15.33^{a}	88.80	17.33	140.87^{a}	15,278	10,694	28.23	4583^{a}	.0.30^{a}
superica1	70	90.33	11.73	8.73^{ab}	52.20	9.83	64.40^{b}	10,648	9322	24.53	1326^{b}	0.08^{b}
Nerica 4	105.33	136	15.93	13.60^{ab}	75.93	16.88	137.13^{a}	13,889	9887	29.80	4002^{a}	0.29^{a}
Hidasie	97	131.67	17.53	13.60^{ab}	77.24	15.75	137.4^{a}	10,185	7080	28.03	3106^{ab}	0.30^{a}
Adet	96.67	132	16.93	14.76^{a}	85.00	16.08	139.73^{a}	12,037	8657	27.17	3380^{ab}	0.28^{a}
Andasa	96.33	130	17.03	13.30^{ab}	83.20	14.67	92.07^{ab}	11,574	8719	26.63	2856^{ab}	0.29^{a}
Tana	111	140	12.60	9.40^{ab}	83.87	16.58	118.53^{ab}	11,574	13,528	22.30	3231^{ab}	0.19^{ab}
Kokit	70	90.33	10.93	7.60^{b}	48.27	7.85	107.47^{ab}	7407	5206	17.73	2208^{ab}	0.20^{ab}
Getachew	111	140.33	14.67	11.80^{ab}	89.78	16.333	127a	16,759	13,909	21.98	3683^{ab}	0.21^{ab}
MEAN	96.43	126.30	14.82	12.06	77.16	14.75	119.80	12,879	9634	24.98	3245.00	0.25
MSE+	28.02	35.87	4.74	3.50	21.39	3.91	29.94	5617.43	4693.55	7.82	1267.79	0.08
LSD at 0.05	ns	ns	ns	*	ns	ns	*	ns	ns	ns	*	*
CV (%)	29.06	28.40	32.00	29.08	27.72	26.52	24.99	43.61	48.72	31.30	39.67	35.28

Means with the same letter are not significantly different.
Key: '*' significance difference, DTH = Days to heading, DTM = Days to maturity, Tt = Total tillers, Pt = productive tillers, PH = plant height, NSL = number of spikelets, BMY = biomass yield, SY = straw yield, THSW = thousand seed weight, GY = grain yield and HI = harvest index.

All data collected was checked for ANOVA assumptions and subjected to analysis of variance using SAS Version 9.2 statistical software [11]. Treatment means were compared using LSD value at 5% significant level [12].

3. Results and discussions

3.1. Growth parameters

Plant Height: plant height was significantly ($p < 0.05$) affected by upland rice varieties at Fogera Districts. However, it was not significantly ($p < 0.05$) affected by the study of upland rice varieties at Libo Kemkem District. The highest plant height was recorded in variety Getachew (103.33 cm) and the lowest in Andasa (53.8 cm) variety at Fogera Districts (Table-1). Plant height is a major trait affecting yield potential in rice. Plant height is controlled by genetic character and least by environmental factors [13].

Panicle length: panicle length was significantly ($p < 0.05$) affected by upland rice varieties at Fogera Districts. However, it was not significantly ($p < 0.05$) affected by the study of upland rice varieties at Libo Kemkem District. The highest panicle length was recorded in variety NERICA3 (17.4 cm) and the lowest in Getachew (15.8 cm) variety at Fogera Districts (Table-1 and 2). Significant panicle length observed between genotypes. Panicle length is a significant trait for improving grain yield in rice. Panicle length is influenced by germplasm characters and soil moisture contents through the heading stages. The higher panicle length means high yield due to increasing number of spike lets depending on the varieties [14].

Total number of tillers: Total number of tillers were not significantly affected at both locations but the number of productive tillers were very significantly ($P < 0.01$) influenced among varieties at Libo Kemkem Districts (Table 2). The highest number of productive tillers (15.33 cm) and the lowest number of productive tillers (14.76 cm) were recorded at NERICA12 and ADET varieties, respectively. Productive tillers at Libo Kemkem Districts were shown better than Fogera Districts due to the suitability of soil characters

Table 3
Physicochemical results on promising u land rice varieties at both Fogera and Libo Kemkem Districts.

Upland Rice Varieties	Grain Length (mm)	Grain Width (mm)	Grain Thickness (mm)	Ratio of L/w
ADET	6.82[b]	2.56[c]	1.91[c]	2.67[a]
NERICA4	6.67[d]	2.45[e]	1.85[e]	2.73[a]
NERICA12	6.79[c]	2.52[d]	1.86[d]	2.69[a]
NERICA13	7.09[a]	2.61[b]	1.92[b]	2.72[a]
GETACHEW	6.32[e]	2.84[a]	2.09[a]	2.23[b]
Mean	6.74	2.60	1.92	2.6
MSE+	0.0038	0.0024	0.0042	0.0922
LSD at 0.05	0.0072	0.0045	0.0079	0.1738
Level of significance	*	*	*	*
CV	0.055	0.093	0.219	3.54

Means with the same letter are not significantly different.
Key: '*' = significance difference.

for upland rice varieties. Number of productive tillers a crucial factor that causes variation of increasing grain yield [15].

Number of spike lets per panicle: Number of spike lets per panicle were significantly ($p < 0.05$) differed among the varieties at Fogera and Libo Kemkem districts (Table-1 & 2). Relatively the treatments showed that the highest numbers of spike lets per plant (140) and the lowest number of spike lets of NERICA12 (64.4) and ANDASA varieties (45) were recorded at Fogera and Libo Kemkem Districts respectively. Increasing numbers of spikelets per panicle can induce productivity. The same as the result found low temperature prevailed at high altitude might have influenced the varieties to great extent by affecting the reproductive and grain filling stages. Rice is a cold sensitive plant [16] and the prevalence of cooler air temperature below 15^{O}c at flowering growth stages increase sterility [17] thereby reduce the number of spikes per panicle [1]. Confirmation the results found according to Ref. [18and19]. [20] reported to be influenced by panicles per plant, grains per panicle and grain weight **It** is one of the yield attributes of rice that contributes to the grain yields and genotypes/cultivars having higher panicles per plant could have higher grain yield.

Cultivars having higher number of grains per hectare may not necessarily have higher number of panicles per plant. In conformity with the findings of the present study [21], noted that panicle number of rice crop is the most important factor that causes variation in the grain yield of rice.

3.1.1. Above ground biomass and straw yield

Biomass and Straw yields were not significantly ($p < 0.05$) affected among varieties at Libo Kemkem Districts. However these parameters were significantly ($p < 0.05$) affected among varieties at Fogera Districts (Table-2 and 1). The highest and the lowest biomass and straw yield yields were recorded in GETACHEW and KOKIT varieties (23,148 kg $ha^{-1}$and 18533 kg/ha, respectively) and (11574 kg/ha and 7859 kg/ha, respectively). Getachew rice varieties were produced at elevated quantity of biomass until sufficient water is being available other than its largely affected by moisture stress. Similarly the results reported that rice straw is an important resource for livestock feed and construction of houses in Ethiopia [22].

Grain yield (kg/ha): *Grain yields were highly significantly ($P < 0.01$) different among the varieties at Fogera and Libo Kemkem Districts. The highest grain yield was recorded in NERICA13 (4738.*9 kg/ha*), NERICA12 (4020.*4 kg ha^{-1}*), NERICA4 (4092.*6 kg ha^{-1}*) at Fogera Districts and GETACHEW (*3683 kg ha^{-1}*), NEIRICA12 (*4583 kg ha^{-1}*), NERICA13 (*4081 kg ha^{-1}*) and NRICA4 (*4002 kg ha^{-1}*) at Libo Kemkem Districts.* The highest NERICA13 (4738 kg ha-1) and lowest ANDASA (1696.3 kg ha-1) yields were obtained 35.79% yield advantage over the treatments. The average grain yield was 3589.4 kg/ha at Fogera and 2834.8 kg/ha at Libo Kemkem *(Table-1 and 2)*. Likewise to the results found yield level of NERICA genotypes were reported in Ethiopia and elsewhere in Africa [17,23,24 and 25]]. *Harvest index; Harvest indexes was significantly ($p < 0.05$) differed at both Fogera and Libo Kemkem districts. The highest and lowest harvest indexes was recorded in KOKIT (0.033) and GETACGEW (0.2) rice varieties in Fogera District, NERIKA 12 and 13 and Hidasie (0.30) and Tana (0.19) rice varieties at Libo Kemkem District (Table-1 & 2). Getachew rice variety was superior in ratio of grain yield and biomass yield as a result is had high harvest index. HI is a valuable index in assessing treatment effects in partitioning* assimilates into grain [26,27].

3.2. Physicochemical quality parameters

3.2.1. Physical properties

The lengths, width, thickness, L/W ratio were significantly different ($P < 0.05$) among the varieties. Accordingly, NERICA4 (6.67 mm), NERICA12 (6.79 mm), NERICA13 (7.09 mm), GETACHEW (6.32 mm) and ADET (6.82 mm),. Webb (1980) found the average length of long type in the range from 6.7 to 7.0 and short type from 5.2 to 5.4 mm. Rice grain width was shown NERICA4 (2.45 mm), NERICA12 (2.52 mm), NERICA13 (2.61 mm), GETACHEW (2.84 mm) and ADET (2.56 mm) significantly affected by the five promising up land rice varieties. The long and short types were significantly different (Table-3). These value was located within the range of 1.9–2.0 [28] and 2.0–2. l mm (Mutter, 1998) reported for the long type rice. The results are similar to those obtained who reported a range of 2.7–3.1 mm for the short type rice [29].

Length/width ratio (L/W) values were significant among varieties and with values of NERICA4 (1.85), NERICA12 (1.80), NERICA13 (1.92), GETACHEW (2.09) and ADET (2.67). ADET rice grain seed was with longest grain length ratio (Table-3).

[30] reported that grain shape (based on length/width ratio) was classified as slender (>3.00) or bold (1.01–2.00). Grain thickness

Table 4
Physicochemical results on promising upland rice varieties at both Fogera and Libo Kemkem Districts.

Uland Rice Varieties	Protein (%)	Fiber (%)	Ash (%)	Moisture Content (%)	Carbohydrate Content (%)	Gelatinization Temperatures (90^{oc})
ADET	10.07^{b}	3.18^{c}	1.13^{b}	12.67^{d}	**73.57^{c}**	70.83^{ab}
NERICA4	8.58^{d}	3.62^{a}	1.07^{c}	13.83^{b}	74.65^{b}	68.50^{c}
NERICA12	10.35^{a}	2.90^{e}	1.00^{e}	1163^{e}	75.65^{a}	58.33^{d}
NEICA13	9.33^{c}	3.00^{e}	1.02^{d}	13.57^{c}	74.64^{b}	69.33^{bc}
GETACHEW	8.07^{e}	3.38^{b}	1.24^{a}	14.27^{a}	74.34^{b}	72.67^{a}
Mean	9.28	3.22	1.09	13.19	74.56	67.93
MSE+	0.0465	0.019	0.0066	0.09	0.2528	1.1583
LSD at 0.05	0.0876	0.0357	0.0124	0.1696	0.4761	2.1809
sign. Difference	*	*	*	*	*	*
CV	0.5011	0.59	0.6064	0.982	0.339	1.7.50

Means with the same letter are not significantly different..
Key: * = significance difference.

was significantly ($P < 0.05$) changed among the varieties. Accordingly seeds had a grain thickness of NERICA4 (2.73 mm), NERICA12 (2.69 mm), NERICA13 (2.72 mm), GETACHEW (2.23 mm) and ADET (1.91 mm) (Table-3). These results were in conformity with the range of 1.5–1.7 mm for long type [28]. [31] reported a range of 1.9–2.0 mm for the short type rice.

3.2.1.1. Chemical composition. In all chemical compositions taken a significant ($P < 0.05$) difference observed among the varieties. Accordingly the moisture content (Mc') of NERICA4, NERICA12, NERICA13, GETACHEW and ADET varieties were $13.83^{\%}$, $11.63^{\%}$, $13.57^{\%}$, $14.27^{\circ\%}$ and $12.67^{\%}$ of the five grain samples respectively (Table 4). The result was in accordance with [32] in which values fall within the range of 9–13%. The lower MC of the Sudanese sample could be attributed to differences in the temperature used in the drying process.

Ash values of NERICA4, NERICA12, NERICA13, GETACHEW and ADET varieties were 1.07%, 1%, 1.02%,% and 1.24% and 1.23% respectively (Table 4). These values were in line with the results found [33] who reported 0.3–0.8% ash.

Rough fiber values of NERICA4, NERICA12, NERICA13, GETACHEW and ADET varieties were 3.62%, 2.92%, 3%, 3.38% and 3.18% respectively. 0.2–0.5% rough fiber result was reported by [33].

Protein values of NERICA4, NERICA12, NERICA13, GETACHEW and ADET varieties were 8.58%, 10.35%, 9.33%, 8.07% and 10.07% respectively (Table 4). These results were in conformity with the range of 5.7–9.9% [34] and the range of 5–9% reported by Ref. [31].

Carbohydrate contents before cooking were found to be 74.69% (NERICA4), 75.65% (NERICA12), 74.64% (NERICA13), 74.34% (GETACHEW) and 73.57% (ADET) (Table 4). All selected rice grain samples were significant differences within the five grain samples of rice varieties. These values were lower than that obtained by Ref. [35] who reported 77.6% for milled rice and this could be due to the relatively high protein content of the samples under investigation. Seeds with high protein content have a relatively low starch accordingly [36].

Gelatinization Temperature were found to be 68.50 (NERICA4), 58.33 (NERICA12), 69.33 (NERICA13), 72.67 (GETACHEW) and 70.83 (ADET) (Table 4). While the importance of gelatinization temperature is for determining, the time required for cooking milled rice. The differences in GT could be due to the environmental conditions such as temperature during ripening [37].

4. Conclusion and recommendation

The present study was conducted in Libo Kemkem and Fogera Districts, in South Gondar zone, Ethiopia during main cropping seasons of 2016/17. Many parameters taken were significant among varieties. Plant height, number of spike lets, biomass yield, straw yield, grain yield and harvest index at Fogera District, and number of tillers, number of spike lets, grain yield and harvest index in Libo Kemkem District. The highest yields were observed in NERICA13, GETACHEW, NERICA4 and NERICA12 varieties in Fogera District, and NERICA12, NERICA13, and NERICA4 in Libo Kemkem District. These varieties had 35.79% of yield advantage over the others and earning 3 tons of yields advantageous.

The five superior genotypes grain physicochemical properties revealed that significance difference exists among genotypes. Grain moisture contained 11.63–14.27%; 1–1.24% ash; 2.90–3.62% fiber and 8.07–10.35% proteins, grain contents of carbohydrates 73.57%–75.65% and gelatinization temperatures ranges from 58.33 to 72.67%. These varieties NERICA (4, 12 and 13) can be recommended to maximizing grain yielding for South Gondar and for areas with similar agrological areas. Further studies are important to determine morphological adoption, physicochemical, and economic feasibility of newly released rice varieties.

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