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Assessment of Maize (*Zea mays*) Genotypes for Seed Metrics, Agronomic Performance, Yield and Nutritional Content in Southern Savanna Agro-ecological Zone of Nigeria (Wukari as Case Study).

ABSTRACT

Maize as the highest yielding cereal crop in the world is very important for countries like Nigeria, where future food supply would be a great challenge for the rapidly increasing population. Five varieties of maize (Samaz 52, M1217, M1155, Oba 98 and Oba super II) obtained seed companies and commonly cultivated in Wukari environment were evaluated during the 2020/2021 cropping seasons for yield, agronomic performance, seed metrics and nutritional quality at the Research and Teaching Farm of the Federal University Wukari, Taraba State. The experiment was laid out in Randomized complete Block Design with four replications. Data were collected on agronomic, yield traits and nutrient qualities. The result revealed significant differences among the varieties for grain yield, nutritional content, days to tasseling, days to silking, number of seed rows, number of nodes, seed length, hundred seed weight (g) and ear heights (cm) at P>0.05. Height at matirity showed significant difference, with Oba98 having the highest (195.25cm) value. M1217 recorded superiority (24.95g) over the other varieties for 100 seed weight. Laboratory Analysis was conducted to determine the essential amino acid and nutritional content of the five maize varieties. Crude protein concentration in the five varieties varied significantly, with the SAMMAZ52 variety recording the highest value (13.14%).Oba 98 had the highest content of essential amino acid such as Methionine (2.39), Lysine (2.33) and Tryptophan (1.43) over the other varieties assessed.

Keywords: Maize genotypes, seed metrics, nutritional qualities, trait performance and yield.

INTRODUCTION

Maize (*Zea mays* L.) is a cereal crop that belongs to the plant family Gramineae, sub-family *Panicoideae* and the tribe *Andropogoneae* .It was first domesticated by indigenous people in southern Mexico about 10,000 years ago (Benz, 2001). Maize serves as an important staple crop worldwide, serving as staple food for human, livestock feed and industrial raw materials (Troyer, 2006). Maize constitutes the major ingredient of animal feed. Also, ethanol used as bio-fuel and for medical purposes could be produced from maize grains (Monsanto, 2014). In terms of

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production and consumption in the world, maize is ranked third to rice *Oryza sativa* and wheat *Triticum aestivum*. (Ji *et al.*, 2013, Mboya, 2011; IITA, 2009). Maize accounts for 15 to 56% of the total daily calories of people in about 25 developing countries particularly in Latin America and Africa (Adetiminrin *et al*., 2008). When taken into consideration the world cereal acreage, yields and output, maize is ranked the fifth largest in land area cultivated, third largest in yield and fourth largest in output (Surinder, 2011). Globally,maize is grown on an area of about197 million hectares with about 1.13 billion tons production, Africa produces 7.2% of the world production, producing 10 million tons of maize grown on about 40 million hectares and the largest producer in African is Nigeria with production of 6.5 million tons harvested on 10 million hectares (FAOSTAT, 2017).

Maize has a variety of uses as it can be used in the livestock industry to make livestock feeds, for export purposes and also used as human food and for industrial products. Between 90 and 95 percent of the crop is harvested for grain, the remaining 5-10 percent is grown for silage (Jaliya *et al*., 2008). According to IITA (2001) report, maize contains 80 per cent carbohydrates, 10 percent protein, 3.5 percent fibre and 2 percent mineral. Iron and vitamin B are also present in maize. Regardless of its immense importance to animals as well as human, the nutritional value of maize is limited by its low and poor protein concentration. Maize grain protein is low in essential amino acids (lysine and tryptophan). In animal feed, these deficiencies are corrected by addition of supplements that add to the feed cost (Mbuya *et al*., 2010). Quality protein maize cultivars have been developed by various companies in the world, to offer a nutritional solution to people who solely depend on maize as their source of protein (Salami *et al.*, 2007). Furthermore, it yields are limited by both biotic and abiotic factors as pest and disease, drought, mineral deficiency, weed (Oyekunle *et al*., 2013) Identifying genotypes with desirable traits is essential for yield improvement ,however there is inadequate information on the agronomic performance for yield improvement and nutritional content of the commonly cultivated maize varieties in study

Therefore, present research was undertaken to achieve the following objectives;

- To assess the agronomic traits and compare the yield performance of selected maize varieties.
- Evaluation of the nutritional contents of the selected maize varieties cultivated in Wukari

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MATERIALS AND METHOD

Experimental site, Materials and Layout

The Experiment was conducted during the 2016 and 2017 cropping seasons at the Teaching and Research Farm of Federal University Wukari, Taraba State, Nigeria. Wukari falls within the guinea savannah of North-eastern Nigeria, situated at latitude 7.^{0}85'N and longitude 9.^{0}78'E with an average annual rainfall of 1058mm-1300mm and relative humidity dropping to about 15%, alongside annual temperature of 28^{o}C to 30^{o}C . Wukari is characterized by rich agricultural land for the cultivation of many crops such as yam, sorghum, maize, rice and other assorted fruits and vegetables (https//en.m.wikipedia.org/wiki/wukarifederation; Franke *et al.*, 2010). The materials consisted of five varieties of maize; Sammaz 52, M1217, M1155, Oba 98 and Oba II (sourced from the open market), commonly cultivated in Wukari environment. The field was laid out using the Randomized Complete Block Design (RCBD), with an area of 21m × 8m. The whole area was divided into four blocks. Each block contained five treatments made of beds of 3m × 1m per bed, with each bed having twenty four (24) plant stands at 50cm × 25cm planting distance and the distance between each replication was 1m. The experiment was replicated four times. Five plant stands were randomly selected and tagged per plots using alpha-numeric tagging method and attached to the stem with the help of a masking tape, for easy identification in all the replication. Cultural practices such as fertilizer application, thinning, earthen-up, and weed control both mechanical and chemical method were properly carried out.

Data Collection

Data were taken at different stages of growth, such as growth parameters and seed parameters at reproductive stage. Data was collected on the following parameters;

Days to emergence (DTE); that is number of days to the emergence of the sown seeds

Days to tasseling (DTT): Number of days from sowing to emergence of the tassels

Days to silking (DTS): Number of days taken to the visible expression of silk

Height at maturity (HM): Measured in centimeter (cm) using meter rule

Ear height (EH): Measured in centimeter (cm) using meter rule

Width of ear leaf (WEL): Was measured using measuring tape, in centimeter (cm)

Length of ear leaf (LEL): Measured in centimeter (cm) using measuring tape

Ear length (EL): Measured in centimeter (cm) using meter rule

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Length of ear peduncle (LEP): using meter rule measure in cm

Ear diameter (ED): Obtained, by dividing value for ear circumference by 2. The circumference was measured in centimeter, using the tape rule.

Ear weight (EW): measured in gram (g) using sensitive weighing scale

Weight of 100 seeds: measured in gram (g) using sensitive scale

Length of seed (LS): measured in centimeter cm using Vanier caliper

Width of seed (WS): measured in centimeter cm using Vanier caliper

Number of nodes (NN): all the nodes in the stand were counted and recorded

Number of tillers (NT): observation was made on each of the plant stand to determine the tillers population.

Number of tassel branches (NTB): a count of tassel number of branches was done and recorded.

Cob length (CL): Cob length was measure using a ruler

Seed coat colour (SCC): The colour of the seeds

Number of rows: a count of kernel row

Ear Bagging For Control Pollination

As soon as the maize plants started tasseling, proper inspection of the field was carried out and any ear shoot was covered immediately with the ear shoot-bag, firmly, to damage by wind.

Tassel Bagging and Pollen Grains Formation

According to Nielson (2010), the tassel is the male reproductive organ of the maize which helps in fertilizing the ovule for kernel development. In order to obtain pollen grain for pollination, the tassel bag was used in covering the tassel. This is done by inserting the tassel inside the readily provided tassel bag and the base of the tassel bag was fold from each corner and stapled at the base, to hold it in place. This operation was normally done in the morning before the pollen grains are dispersed by breeze. To collect the pollen grain, the bagged tassel was carefully bent and shaken, then the clip and tassel was gently removed from the bag that was used and the anther discarded, leaving only the pollen grain, which has a characteristically pale yellow colour.

Pollination

The pollen grains was collected mechanically by shaking the tassel into an improvise bag thereafter the shaft was isolated remaining the pollen grain dust which was used to pollinate the silk manually after the ear bag was removed to ensure a control pollination.

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The pollination was done very quickly so as to cover it back since the silk is still receptive. This process was carried out three times with a day break in between, to ensure proper fertilization.

Laboratory Analysis

The laboratory analysis (proximate composition estimation) was done using the method of association of analytical chemist

Moisture Content Determination

The moisture content was determined by weighing 2g of feeding stuff with a silica dish which has been previously ignited and weighted. It was dried in the oven (Genlab MINO/30 UK) for 24 hours at 100^0C to constant weight. Cool in desiccators each time just before weighing.

Calculation

$$\% \text{ of moisture} = \frac{100 \times (\text{wt of dish + feedstuff before Drying}) - \text{wt of dish + Feedstuff After Drying}}{\text{wt of feedstuff taken}}$$

Ash Determination

Ash and mineral content was determined according to AOAC number 932.03 and 984.27 (AOAC 2005).

Oil Content Determination

This was estimated using Tecator Soxtec (model 2043 [20430001]; Hilleord, Denmark). A quantity of 1.5g sample mixed with 2.3g anhydrous sulfate was weighed into thimble and covered with absorbent cotton, while 40ml of petroleum ether (40-600C Bpt) was added to a pre weighed cup. Both thimble and cup were attached to the extraction unit. The samples were extracted using ethanol for 30minutes and rinsed for 1 1 /2hour. Thereafter, the solvent was evaporated from the cup to the condensing column. Extracted fat in the cup was then placed in an oven at 1050C for 1 hour and cooled and weighed.

Percent fat was calculated as:

% fat and oil = Initial cup weight – final cup weight × 100 Weight of sample

Crude Protein (CP): Crude protein was determined using the micro Kjeldahl method described by Pearson (1976). A volume 10ml H2SO4 added to 3g of sample was digested with a Kjeldahl digestor (Model Bauchi 430) for 11 /2 hour. A volume of 40ml distilled water was added using a Kjeldahl distillation unit (Model unit B-316) containing 40% concentrated sodium hydroxide and Millipore water. Liberated ammonia was collected in 20ml boric acid with bromocresol green and methyl red indicators and titrated against 0.04 N H2SO4. A blank (without sample) was likewise prepared. Percent protein was calculated as:

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Crude protein (%) = Sample titer – blank titer x 14 x 6.25 × 100 Sample weight

Where; 14 is the molecular weight of nitrogen and 6.25 is the nitrogen factor.

Crude Fiber (Cf): A weighed crucible containing 1g of the defatted sample was attached to the extraction unit (In Kjeldahl, D-40599; Behr labour- technik GmbH, Dusseldorf, Germany) and into this 150ml of hot 1.25% H2SO4 was added and digested for 30minutes, the acid was drained and sample washed with hot distilled water for 1 1 /2h. The crucible was removed and oven dried overnight at 1050C cooled, weighed, and incinerated at 5500C in a muffle furnace (MF-1-02; PCSIR Labs, Lahore, Pakistan) overnight and reweighed after cooling. Percentage extracted fiber was calculated as: % crude fibre = weight of digested sample - weight of ashed sample ×100 Weight of sample Carbohydrate: The carbohydrate content was determined by difference, that is, addition of all the percentage of moisture, fat, crude protein, ash, and crude fiber was subtracted from 100%. This gave the amount of nitrogen-free extract otherwise known carbohydrate. Therefore, it is calculated as: %Carbohydrate =100 - (%Moisture + %Fat + %Ash + % Crude fibre + %Crude protein

Data Analysis

The data collected were subjected to Analysis of Variance (ANOVA), using SPSS software (21^{st} edition and mean was separated using Duncan Multiple Range Test.

RESULT AND DISCUSSION

Agronomic Traits of Maize Varieties

The highly significant genotype effect obtained for the agronomic parameters indicated that enough variability exists to allow identification of local germplasm with reasonable levels of desirable agronomic characteristics. This observation supports the earlier report by Ngwuta *et al.* (2001), that locally available germplasm can serve as sources of hybrid maize development. Morphometric traits such as ear length, ear weight, ear diameter, number of tassel branches per plant and length of ear peduncle of the assessed maize varieties showed no significant difference in their values. According to an earlier work by Parvez (2007), ear weight, ear diameter and ear length are important ear characters that affect yield efficiency while tassel number of branches, length and weight are important tassel characters that affect yield efficiency as a result of abundant pollen grain produced. The result obtained from the research is in harmony with the findings of Gue *et al.* (1996); Ibirinde *et al.* (2019), that tassel traits affect grain yield either

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physiologically, by competing for photosynthesis, or physically by shading effect. Therefore, in breeding program, an ideal male parent is supposed to have large tassels that can produce large amount of pollen grain whereas an ideal female should partition more towards big ear and hence should possess small tassel.

No significant difference was also observed in the day to dusting, number of nodes and days to silking the result disagreement with the finding of Jiban (2013) that the silk emerge from the husk about four to eight days after tasseling, also his finding revealed that period from silking to attainment of physiological maturity is 50-55 days, which is in discordance with the result obtained.

Generally, height at maturity determines the growth attained during the growing phase of plants. Velci *et al.* (2015) posited that, plant height and ear insertion allowed plant center of gravity to stay more balanced, reducing lodging and stem breakage, thereby favouring nutrient transport and plant production. Duncan and Hesketh (1968) observed the variation in height at maturity of different genotypes in maize ranging from 120 cm to 300 cm where highest plant height in OBA98 (195.25cm) and lowest in M1217 (184.67 cm).

Length of seed for the five varieties under investigation showed significant difference in SAMMAZ52 only, while width of seed showed significant difference in all the sample except OBA SUPER 11 which showed significant differences (P = 0.06). The highest weight of 100-grain weight was found in M1217 (24.95g) where the lowest weight was found in OBA SUPER 11 (20.43g). According to Jha *et al.* (1979), variation ranged from 10.8 g to 25.7 g in 100 grain weight which might as much as similar.

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Table 1: Descriptive Statistic of Vegetative Characters

Genotype/traits	DE	DT	DS	DD	NTB	NN	HM(cm)
SAMMAZ52	4.00	52.20^{ab}	57.80^{ab}	60.95^{a}	15.90	12.65	187.35^{ab}
OBA98	4.00	51.65^{b}	55.00^{b}	58.95^{ab}	15.35	13.55	195.25^{a}
MM1155	4.00	53.75^{a}	58.75^{a}	62.25^{a}	15.40	13.70	190.00^{ab}
M1217	4.00	52.43^{ab}	56.38^{ab}	59.52^{ab}	15.05	13.43	184.67^{ab}
OBA SUPER 11	4.00	52.16^{ab}	57.47^{ab}	60.89^{a}	16.58	13.16	187.05^{ab}
Grand Mean	**4.00**	**52.44**	**57.47**	**60.50**	**15.64**	**13.30**	**188.84**
SD	**0.00**	**2.54**	**2.86**	**2.86**	**3.70**	**1.61**	**19.89**

DE= Days to Emergence, DT=Days to Tasseling, DS= Days to Silking, DD=Days to Dusting, NTB=Numbers of Tassel Branches, NN=Numbers of Nodes and HM=Height at Maturity. $P>0.05$.

Table 2: Descriptive Statistic of Reproductive Traits

Genotype/trait	EH(cm)	EL(cm)	ED(cm)	PL(cm)	EW(g)	CL(cm)	CW(g)	AI (.)
SAMMAZ52	99.75^{b}	11.15	3.70^{b}	3.15^{b}	76.95^{b}	10.48	11.53^{b}	34.25^{c}
OBA98	104.15^{a}	11.75	3.88^{ab}	3.45^{b}	93.30^{a}	11.15	14.17^{ab}	35.50^{c}
MM1155	103.70^{a}	12.00	3.88^{ab}	4.05^{a}	95.74^{a}	11.26	15.06^{a}	34.50^{c}
M1217	96.95^{c}	11.45	4.06^{a}	3.95^{ab}	96.30^{a}	10.83	13.67^{ab}	40.95^{a}
OBA SUPER 11	96.53^{c}	11.83	3.93^{a}	3.22^{b}	94.83^{a}	11.08	15.01^{a}	38.95^{a}
Grand Mean	**100.22**	**11.63**	**3.89**	**3.57**	**91.31**	**10.95**	**13.85**	**36.85**
SD	**16.04**	**2.33**	**0.46**	**1.48**	**39.85**	**2.17**	**5.23**	**14.20**

HM=Height at Maturity, EH= Ear Height, EL= Ear length, AI= Angle of Insertion, ED= Ear Diameter, PL= Peduncle Length, EW= Ear Width, CL= Cob length, CW= Cob weight. Superscript a, ab, b and c denote DMRT range, where" a" is the highest and" c" is the least. $P>0.05$.

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Table 3 Descriptive on stastics of seed metrics and yield traits

Genotype/traits	NR	WWH (g)	LS (Cm)	WS (g)	W100 (g)
SAMMAZ52	12.70[ab]	85.00[b]	0.27	0.19	22.95[ab]
OBA98	13.35[a]	104.75[a]	0.33	0.22	22.77[ab]
MM1155	12.73[ab]	106.63[a]	0.28	0.21	23.67[a]
M1217	13.50[a]	108.90[a]	0.30	0.21	24.95[a]
OBA SUPER 11	13.44[a]	107.00[a]	0.31	0.21	20.43[c]
Grand Mean	**13.14**	**102.32**	**0.30**	**0.21**	**23.00**
SD	**1.95**	**43.26**	**0.07**	**0.05**	**1.89**

NR= Number of Rows, WWH= Weight without husk, LS= Length of Seed, WS= Width of Seed, W100 = Weight of 100 Seed. Superscript a, ab, b and c denote DMRT range, where" a" is the highest and" c" is the least. $P>0.05$.

Mean of yield related traits

Table 4 present the traits that are related to yield of maize varieties under investigation. There was a significant difference in the number of nodes per plant. There were no significant difference in the number of cob per plant, and number of seed rows for the five maize varieties. Number of nodes in any plant represents the total leaves produced by it (Ukonze *et al.*, 2016).

Significant difference was observed in seed length, with the OBA98 recording maximum value of 0.33 cm while SAMAZ had 0.27 cm, being the least value. However, the average seed length for the analyzed grains was 0.30cm. Other seed metric traits such as seed width and seed thickness showed no significant difference in their values. The work of Teng *et al.* (1992), observed that a single cultivar; characterized by long, wide and heavy grain produced taller plants, with larger leaf area and heavy seeding. This indicated, that, grain length and width can be used to select vigorous seedling between varieties. Long grain was found to be better indicator of leaf area while grain width can be used for germination percentage, hence improving crop stand and yield.

Values obtained for hundred seed weight (HSW) across the different treatments were significantly difference and ranged from 0.22g to 0.19g. The highest value (0.22g) was recorded by OBA98, least recorded in SAMMAZ52 (0.19g). This suggests that, there is higher concentration of endosperm which contributed to higher seed weight, resulting from frequent

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dusting of pollen grain and the yield potential of OBA98. $P>0.05$.

Table 4. Mean Squares and Coefficient of Variation of Vegetative Characters

Traits	Mean	Mean Square	CV (%)
DE	$4.00 \pm_{0.00}$	0.00	0.00
DT	$52.44 \pm_{2.54}$	6.45	4.84
DS	$57.47 \pm_{2.86}$	8.18	4.98
DD	$60.50 \pm_{2.86}$	8.19	4.73
NTB	$15.64 \pm_{3.70}$	13.70	23.66
NN	$13.30 \pm_{1.61}$	2.59	12.10
HM	$188.84 \pm_{19.89}$	395.73	10.53

DE= Days to Emergence, DT=Days to Tasseling, DS= Days to Silking, DD=Days to Dusting, NTB=Numbers of Tassel Branches, NN=Numbers of Nodes and HM=Height at Maturity, CV= Coefficient of variance. $P>0.05$.

Table 5. Mean Squares and Coefficient of Variation of Reproductive Characters of Maize Genotypes

Traits	Mean (g)	Mean Square	CV (%)
EH	$100.22 \pm_{16.04}$	257.51	16.00
EL	$11.6 \pm_{2.33}$	5.45	20.03
ED	$3.89 \pm_{0.46}$	0.21	11.83
PL	$3.57 \pm_{1.48}$	12.19	41.45
EW	$91.31 \pm_{39.85}$	1587.92	43.64
CL	$10.95 \pm_{2.17}$	4.72	19.82
CW	$13.85 \pm_{5.23}$	27.40	37.76
AI	$36.85 \pm_{14.20}$	201.84	38.53

HM=Height at Maturity, EH= Ear Height, EL= Ear length, AI= Angle of Insertion, ED= Ear Diameter, PL= Peduncle Length, EW= Ear Width, CL= Cob length, CW= Cob weight. $P>0.05$.

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Table 6. Mean Squares and Coefficient of Variation on statistics of seed metrics and yield traits of Maize Genotypes

Traits	Mean (g)	Mean Square	CV (%)
NR	$13.14\pm_{1.95}$	3.81	14.84
WWH (g)	$102.32\pm_{43.26}$	1871.64	42.28
LS (Cm)	$0.30\pm_{0.07}$	0.00	23.33
WS (g)	$0.21\pm_{0.05}$	0.00	23.80
W100 (g)	$23.00\pm_{1.89}$	3.56	8.22

NR= Number of Rows, WWH= Weight without husk, LS= Length of Seed, WS= Width of Seed, W100 = Weight of 100 Seed. $P>0.05$.

Table 7: Proximate Composition of Maize Genotypes

Genotypes/Parameters	Protein	Fat	Ash	Crude fibre	Moisture
SAMMAZ52	13.14^{a}	2.00	1.12	2.55	7.00
MM1155	10.75^{b}	2.55	1.14	2.00	6.98
OBA SUPER 11	10.94^{b}	2.33	1.15	2.00	7.10
OBA98	10.95^{b}	2.35	1.15	2.00	6.86
M1217	10.86^{b}	2.36	1.17	2.00	6.76

CP=Crude protein, CF= Crude fiber, Ash= Ash content M= Moisture content. Superscript a, and b denote DMRT range, where” a” is the highest and” b” is the least. $P>0.05$.

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Amino acids contents

Results in Table (8) for amino acids content showed high variations between the maize genotypes, the total content of amino acids in maize samples ranged from (0.1% in M1217 to 2.48% in OBA98). Methionine also showed high values ranged from 2.39 % (OBA SUPER 11) to 2.39% (OBA98); Valine showed value in maize ranged from 0.62% (M1217) to 1.58 % (OBA98); Arginine showed value in maize ranged from 0.65% (M1217) to 1.81% (OBA98); Typtophan showed value in maize ranged from 0.65% (M1217) to 1.43% (OBA98). These data disagree with those obtained by Lošák *et al.* (2010) who studied the effect of nitrogen fertilization on essential and non-essential amino acids on maize grain.

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Table 8: Values of Amino Acid Profile of Maize Genotypes

Genotype/Parameters	Lys	Met	Typ	Val	Arg
SAMMAZ52	0.88	0.90	0.68	0.69	0.73
MM115	1.86	1.88	0.99	1.12	1.23
OBA SUPER 11	0.39	0.43	0.72	0.78	0.83
OBA98	2.33	2.39	1.43	1.58	1.81
M1217	0.53	0.65	0.55	0.62	0.65

Lys = Lysine, Met = Methionine, Trp = Tryptophan, Val = Valine, Arg = Arginine. P>0.05.

CONCLUSION

The M1217 variety evaluated in the study had superior performance for grain yield, specifically the hundred (100) seed weight. Nutritional qualities of SAMMAZ52 (13.14), as observed in the study showed superiority over OBA98 (10.95), OBA SUPER 11 (10.94), M1217 (10.86) and MM1155 (10.75), particularly in crude protein content. In terms of height at maturity OBA98 has the highest height value (195.25), followed by MM1155 (190.00), SAMMAZ52 (187.35) and the least was observed in M1217 (184.67). OBA98 in terms of essential amino acids such as lysine, methionine and tryptophan recorded the highest value ranged.

It is therefore recommended that the cultivation of M1217 for optimum yield, OBA98 for essential amino acids such as lysine, methionine and tryptophan and SAMMAZ52 for optimum nutritional qualities should be encouraged in Wukari and neighboring communities. Dusting of pollen grain should be made on maize thrice or even more, because it determine the grains filling and yield. Further research should be conducted for further recommendations.

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