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*RESEARCH ARTICLE*

# VARIABILITY OF AGRO-MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF HYBRID SORGHUM VARIETIES IN BURKINA FASO

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## *Abstract*

Sorghum is the first cereal grown in Burkina Faso. It is produced in all regions of the country, however yields in the field are very low. In view of this low productivity, new hybrid varieties have been introduced from Brazil and Mali. Our study aims to evaluate their agro morphological and nutritional characteristics in order to disseminate the most efficient genotypes. A completely randomized block device with three (03) repetitions has been set up at the Farako-Bâ research station. Observations focused on five (05) agro morphological traits such as the semi-flowering cycle, plant height, panicle length, weight of a thousand grains and yield and six (06) biochemical traits including total water, total sugar, protein, fat and mineral content. Analysis of variance and heritability in the broad sense were performed. Our results showed both agro morphological and biochemical variability between the varieties evaluated. Heritability in the broad sense has also shown that all traits studied are under the influence of genetic rather than environmental factors. In general, hybrids obtained semi-dwarf sizes and yields above 4000 kg/ha. The control variety KAPELGA recorded the highest values of protein and mineral content. The highest sugar content is obtained in the hybrid XBS60015 with 17.82 µg Glu/100mgMS. Correlation analyses have shown that there is a negative and very highly significant correlation (-0.86) between yield and protein content. The most efficient hybrids will be able to be disseminated following participatory selection tests on different sites nationwide.

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## Introduction:-

Sorghum [Sorghum bicolor(L) Moench] is one of the main cereal crops in Burkina Faso. In 2017-2018, national sorghum production was estimated at 1,365,989 tones on 1,667,193 hectares, or 44% of the cereal area and 39% of cereal production (DGESS, 2018). As a result, it takes the first place among cereal crops in terms of production and area. As a result, it takes the first place among cereal crops in terms of production and area. Also, in terms of food, it

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is considered the staple food of rural populations and serves through the realization of several local dishes such as dough, couscous, local donuts, cakes, local beer. Despite these potentialities, sorghum productivity remains low with an average yield of about one (01) ton per hectare, despite the varietal breeding programs put in place. This low productivity is explained by a high use of local Guinea breed seeds of large sizes (more than 3.50 m) which is not very productive (Zongo, 1991). It is therefore necessary to meet the needs of producers by providing them with more productive equipment that is well adapted to the requirements of the various agro-ecological zones of Burkina Faso. Nutritional characteristics therefore become important factors to be evaluated in selection. The definition of these characteristics will make it possible to identify and promote in breeding programmes new varieties that meet the needs of consumers. It is in this context that INERA has introduced sorghum hybrids from Brazil and Mali. Therefore, before their diffusion to scale, our study aims to characterize the agronomic and biochemical properties of hybrids in comparison with improved local varieties in order to retain the best performers.

## Materials And Methods:-

### Study sites

The study was carried out in the 2019-2020 wet campaign at the Farako-Bâ research station, a locality located 10 km southwest of Bobo-Dioulasso on the Bobo-Banfora axis, national road number 7. The geographical coordinates of the station are 04°20' west longitude; 11°06' north latitude and 405 m above sea level.

The climate of the area is south Sudanese (Fontes and Guinko, 1995). Rainfall is highly variable and the annual average is 950 mm (Tankoano, 2016). During the experiment, the Farako-Bâ weather station recorded 1117.6 mm of water in 60 rainy days. The soils of Farako-Bâ are of the tropical ferruginous type with little leaching. These are very sandy soils with a sandy-silty texture. They are low in clay and organic matter, which explains their low cation exchange capacity (CEC). These soils are also acidic and deficient in nitrogen, phosphorus and available potassium (Bado, 2002).

### Plant material

The plant material studied consists of 16 hybrids including 15 from Brazil and one (01) from Mali and 3 local checks (table 1). The three witnesses come from INERA's gene bank.

**Table 1:-** sorghum hybrids using for this study.

| Hybrids | Origin |
|---|---|
| BRG71088 | Brazil |
| BRG71098 | Brazil |
| BRG71108 | Brazil |
| BRG70688 | Brazil |
| XBG05193 | Brazil |
| BRG98564 | Brazil |
| MSP332 | Brazil |
| XBS60015 | Brazil |
| MSP326 | Brazil |
| MSP320 | Brazil |
| ISQ332 | Brazil |
| BRG08858 | Brazil |
| BRG37555 | Brazil |
| BRG01896 | Brazil |
| BRG09068 | Brazil |
| BRG21463 | Brazil |
| ICSV1049 | Burkina Faso |
| SARIASO14 | Burkina Faso |
| KAPELGA | Burkina Faso |
| PABLO | Mali |

## Methods:-

### Experimental design

The trial was conducted using a completely randomized Fisher block device with three (03) repetitions. The seedling spacing was 0.80 m between the lines and 0.40 m between the plants. The experiment was performed in Farako-Bâ site (N: 04°20 and W: 11°60) located in West of Burkina Faso using randomized complete block design with 3 replications. The distance between rows and plants was 80 cm. Each line was grown in 5 rows with 24 plants per row. Experiment was managed following high input system with 300 kg of fertilizers (NPK + urea). The biochemical analyses of the varieties were carried out at the Biochemistry Laboratory of the Nazi Boni University in Bobo-Dioulasso. A sample of 100 g of sorghum was taken from each variety. The grains were then crushed and then processed in a triplicata device with an encoding of their identifier for the reliability of the data.

### Data collection

The various observations concerned: The Height of the Plant (HP), date of 50% flowering (CSF), length of the panicle (LonP), weight of a thousand Grains (PMG) and Grain Yield (RendG). Five biochemical characteristics were measured includingdry matter or water (TE) content, total protein content (TP), fat content (MGr), mineral or ash content.

### Data analysis

The data collected during agronomic observations and biochemical analyses were first entered on the Excel 2016 spreadsheet. The R software was used to perform the analysis of variance (ANOVA), finally to observe the agronomic and biochemical characteristics that discriminate between varieties. The same software was used to calculate heritability ($H^2$). XLSTAT 2018 was used to establish character relationship studies, including the Pearson correlation matrix and Principal Component Analysis (PCA).

## Results:-

### Agronomic characteristics

Table 2 presents the values of the various agronomic parameters obtained. For 50DH, the average cycles of hybrids and controls varied from 59 to 68 days. The earliest hybrids are: BRG08858 (60 JAS) and BRG710 (60 JAS). The hybrid MSP326, MSP332 and the Sariasso14 control are the latest with a cycle of 67 days. The hybrid MSP326, MSP332 and the Sariasso14 control are the latest with a cycle of 67 days. Analysis of variance showed a very highly significant difference between hybrids and controls (Pr=<0.0001). The coefficient of variation (CV) and the heritability value ($H^2$) are 4% and 81% respectively.

For plant heights, the analysis of variance also showed a very highly significant difference for the height character of the plants. Heritability and coefficient of variation were very high with 99% and 45% respectively (Table II). In addition, the values ranged from 90 to 353 cm. The shortest hybrid is BRG09068 with 90 cm. PABLO recorded the largest size with 337cm.

Regarding the weights, a thousand grains, they varied from 21.92 to 28.61g with an average of 25.13g. Hybrids BRG71108, BRG70688 and BRG98564 recorded the smallest weight of a thousand grains with 23g compared to 28g for BRG37555. The coefficient of variation recorded is 18% and heritability is 95%. The analysis of variance also showed a very highly significant difference at the probability threshold of 5% according to the Turkey test.

Grain yield also discriminated against the varieties evaluated. It varied from 2844 to 5631 kg/ha with an average of 4778 kg/ha. The BRG98564 hybrid recorded the highest yield at 5595 kg/ha. The control variety KAPELGA obtained the lowest yield with 2887 kg/ha. The analysis of variance showed a very highly significant difference at the probability threshold of 5% according to the Turkey test. The heritability in the broad sense obtained is 99% and the coefficient of variation is 14%.

**Table 2:-** means values of agro-morphological traits.

| Varieties | 50DH | HP (cm) | LonP (cm) | PMG (g) | Yiels (kg/ha) |
|---|---|---|---|---|---|
| BRG71088 | 64 | 139 | 33,1 | 25,56 | 5438 |
| BRG71098 | 60 | 119 | 31,8 | 24,65 | 5239 |
| BRG71108 | 62 | 106 | 34,1 | 23,17 | 5203 |
| BRG70688 | 63 | 103 | 32,8 | 23,03 | 5395 |

| | | | | | |
|---|---|---|---|---|---|
| XBG05193 | 66 | 101 | 33,3 | 24,21 | 5508 |
| BRG98564 | 63 | 113 | 33,8 | 22,84 | 5595 |
| MSP332 | 67 | 107 | 33,2 | 23,7 | 4881 |
| XBS60015 | 62 | 128 | 34 | 26,84 | 4346 |
| MSP326 | 67 | 125 | 29,5 | 26,57 | 4593 |
| MSP320 | 66 | 134 | 35,1 | 25,93 | 5170 |
| ISQ332 | 62 | 129 | 31,8 | 25,9 | 5417 |
| BRG08858 | 60 | 97 | 33,7 | 25,51 | 4634 |
| PABLO | 66 | 337 | 46,3 | 24,63 | 4591 |
| BRG09068 | 63 | 89 | 33,5 | 23,64 | 4465 |
| BRG21463 | 66 | 92 | 31,7 | 23,87 | 5338 |
| ICSV1049 | 65 | 160 | 28,3 | 26,59 | 3543 |
| SARIASO 14 | 67 | 163 | 26,3 | 26,47 | 4355 |
| KAPELGA | 63 | 275 | 39,3 | 26,8 | 2887 |
| BRG37555 | 63 | 101 | 31,8 | 27,87 | 4221 |
| BRG01896 | 62 | 100 | 38 | 24,83 | 4725 |
| Min | 59 | 85,6 | 25,45 | 21,92 | 2844 |
| Max | 68 | 352,4 | 48 | 28,61 | 5631 |
| Moy | 63,85 | 13 | 33,57 | 25,13 | 4778 |
| E-T | 2,57 | 5,8 | 4,35 | 1,5 | 684 |
| CV(%) | 4 | 45 | 13 | 18 | 14 |
| $H^2$(%) | 81 | 99 | 94 | 95 | 99 |
| Pr | <0,0001 | <0,0001 | <0,0001 | <0,0001 | <0,0001 |
| Signification | *** | *** | *** | *** | *** |

50DH: Semi-50% flowering cycle; HP: plant height; LongP: length of the panicle; ; PMG: weight of a thousand grains; Yield: grain yield; Min: Minimum value; Max: Maximum value; E-T: Deviation-Type; CV: Coefficient of Variation; $H^2$: Heritability; Pr: Probability; = very highly significant difference

**Biochemical characteristics**

Results of the measured biochemical traits are recorded in Table 3. Water content ranged from 8.12 to 10.97% with an overall average of 9.82%. The highest water content is obtained with the MSP332 hybrid (10.42%) and the smallest with the PABLO hybrid (8.51%). Controls KAPELGA, SARIASSO14 and ICSV1049 recorded 9.35% respectively; 9.43% and 10.02%. The analysis of variance showed a very highly significant difference at the 5% threshold according to the DeTurkey test (P<0.0001). The coefficient of variance and heritability recorded 5% and 82% respectively.

Water content ranged from 8.12 to 10.97% with an overall average of 9.82%. The highest water content is obtained with the MSP332 hybrid (10.42%) and the smallest with the PABLO hybrid (8.51%). Controls KAPELGA, SARIASSO14 and ICSV1049 recorded 9.35% respectively; 9.43% and 10.02%. Heritability in the broad sense recorded is 99%. The coefficient of variation is 36%. (Table II). Controls KAPELGA, SARIASSO14 and ICSV1049 obtained 8.23 respectively; 10.90 and 5.05 µg Glu/100mgMS.

For total protein content, the contents ranged from 9.84 to 13.70% with an overall average of 11.54%. The local check KAPELGA is the richest in protein with 13.45% and the hybrid BRG98564 recorded the lowest rate 10.04%. Controls SARIASSO 14 and ICSV1049 recorded 11.69% and 12.84% respectively.

The analysis of variance also showed a very highly significant difference at the 5% threshold (Pr=<0.0001) according to the Turkey test. The heritability obtained is 99% and the coefficient of variation is 7%.

The fat content ranged from 0.037 to 0.11%. Local checks ICSV1049, PABLO, SARIASSO14 and the hybrid BRG37555 recorded the highest lipid contents (0.11%). The HYBRID BRG71108 achieved the lowest fat content e (0.03%). The analysis of variance showed a very high difference at the 5% threshold according to the Fisher test (Pr=<0.0001).

Regarding the mineral content, the highest content is obtained with the CONTROL KAPELGA (1.95%) and the hybrid MSP320 (1.01%) recorded the lowest mineral content. The mineral content ranged from 0.96 to 2.21% with an average of 1.52%. Local checks ICSV1049 and SARIASSO14 scored 1.42% and 1.74% respectively. The analysis of variance did not show a significant difference between the varieties studied. The heritability in the broad sense recorded is 90% and the coefficient of variation is 16%. The analysis of variance showed a very highly significant difference at the 5% threshold according to the Fisher test (Pr=<0.0001).

**Table 3:-** Biochemical characteristics of sorghum hybrids.

| Varieties | TE (%) | ST (µg Glu/100mgMS) | PT (%) | MGr (%) | MM (%) |
|---|---|---|---|---|---|
| XBS60015 | 10.2 | 17.82 | 11.91 | 0.07 | 1.3 |
| MSP332 | 10.42 | 10.12 | 10.96 | 0.09 | 1.28 |
| BRG08858 | 10.27 | 8.31 | 12.04 | 0.09 | 1.37 |
| ICSV1049 | 10.02 | 5.05 | 12.84 | 0.11 | 1.42 |
| BRG37555 | 9.49 | 11.91 | 12.16 | 0.11 | 1.64 |
| BRG09068 | 9.78 | 14.95 | 12.82 | 0.09 | 1.8 |
| ISQ332 | 10.05 | 14.22 | 11.05 | 0.07 | 1.22 |
| MSP326 | 9.99 | 17.22 | 11.79 | 0.06 | 1.4 |
| PABLO | 8.51 | 19.25 | 11.91 | 0.11 | 1.67 |
| BRG71088 | 10.33 | 7.2 | 11.4 | 0.09 | 1.66 |
| BRG21463 | 9.63 | 9.92 | 10.87 | 0.1 | 1.3 |
| XBG05193 | 10.31 | 13.14 | 11.62 | 0.08 | 1.78 |
| SARIASSO14 | 9.43 | 10.9 | 11.69 | 0.11 | 1.74 |
| MSP320 | 9.51 | 12.02 | 11.06 | 0.07 | 1.01 |
| BRG01896 | 9.76 | 8.82 | 11.41 | 0.09 | 1.5 |
| KAPELGA | 9.35 | 8.23 | 13.45 | 0.1 | 1.95 |
| BRG71098 | 10.32 | 8.65 | 10.37 | 0.08 | 1.46 |
| BRG98564 | 9.85 | 16.41 | 10.04 | 0.07 | 1.76 |
| BRG70698 | 9.46 | 4.35 | 10.62 | 0.07 | 1.54 |
| BRG71108 | 9.74 | 8.15 | 10.75 | 0.03 | 1.72 |
| Min | 8.12 | 4.3 | 9.84 | 0.037 | 0.96 |
| Max | 10.97 | 19.33 | 13.7 | 0.114 | 2.21 |
| Moy. | 9.82 | 11.33 | 11.54 | 0.089 | 1.52 |
| E-T | 0.53 | 4.17 | 0.86 | 0.019 | 0.26 |
| CV(%) | 5 | 36 | 7 | 21 | 16 |
| $H^2$(%) | 82 | 99 | 99 | 97 | 90 |
| Pr | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Signification | *** | *** | *** | *** | *** |

TE: water content; TS: total sugar content; PT: total protein content; MGr: fat content; MM: mineral content; Min: Minimum value; Max: Maximum value; E-T: Deviation-Type; CV: Coefficient of Variation; $H^2$: Heritability; Pr: Probability; = very highly significant difference

**correlations between agronomic and biochemical traits**

**Correlation matrix between traits:** Analysis of Pearson's bi-varied correlations between traits revealed the existence of relationships between agro morphological and biochemical traits (table 4). Indeed, it appears from these analyses that there are negative and very significant correlations on the one hand between the water content and the height of the plants (r=-0.65) and on the other hand between the water content and the length of the panicle (r=-0.53). The protein content is positively and significantly correlated with the fat content (r=0.4) and the weight of a thousand grains (r=0.58). On the other hand, it is negatively correlated with yield (r= -0.86). In addition, the fat content, the height of the plants and the weight of a thousand grains are negatively and significantly correlated with the grain yield, respectively with correlation coefficients of -0.44; -0.49 and -0.62. Height is negatively positively correlated with panicle length (r= -0.63) (Figure 1).

**Table 4:-** Correlation between characters.

| **Traits** | **TE** | **ST** | **PT** | **MGr** | **MM** | **50DH** | **HP** | **LonP** | **PMG** | **Yield** |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TE** | **1** | | | | | | | | | |
| **ST** | -0.208 | **1** | | | | | | | | |
| **PT** | -0.196 | 0.021 | **1** | | | | | | | |
| **MGr** | -0.289 | -0.121 | **0.460** | **1** | | | | | | |
| **MM** | -0.298 | 0.012 | 0.266 | 0.230 | **1** | | | | | |
| **50 DH** | -0.248 | 0.224 | 0.074 | 0.220 | -0.142 | **1** | | | | |
| **HP** | **-0.659** | 0.229 | 0.414 | 0.345 | 0.310 | 0.228 | **1** | | | |
| **LonP** | **-0.532** | 0.285 | 0.128 | 0.054 | 0.207 | -0.113 | **0.631** | **1** | | |
| **PMG** | -0.037 | 0.083 | **0.587** | 0.277 | -0.184 | 0.050 | 0.259 | -0.186 | **1** | |
| **Yield** | 0.276 | 0.082 | **-0.867** | **-0.449** | -0.273 | -0.029 | **-0.495** | -0.096 | **-0.622** | **1** |

Legend: CSF: Semi-flowering cycle; HP: plant height; LongP: length of the panicle; ; PMG: weight of a thousand grains Yield: grain yield; TE: water content; TS: total sugar content ;P T: total protein content; MGr: fat content; MM: mineral content

**Character Association:**

The results of the Principal Component Analysis (PCA) are grouped in Figure 2 and Table III. They give an estimate of the variability represented by each axis. The first three axes (F1 and F2) express 54.14% of the level of variability. Traits such as the semi-flowering cycle 50% (50DH); plant height (HP); mineral content (MM) and yield; fat content (TE); the water content is correlated to the F1 axis. The level of variability expressed on this axis is 34.41%. The F1 axis is described as the axis of nutritional productivity and quality. Panicle length (LongP), weight of thousand grains (PMG) and total sugar content (ST) are correlated to the F2 axis with 19.72% of the level of variability.

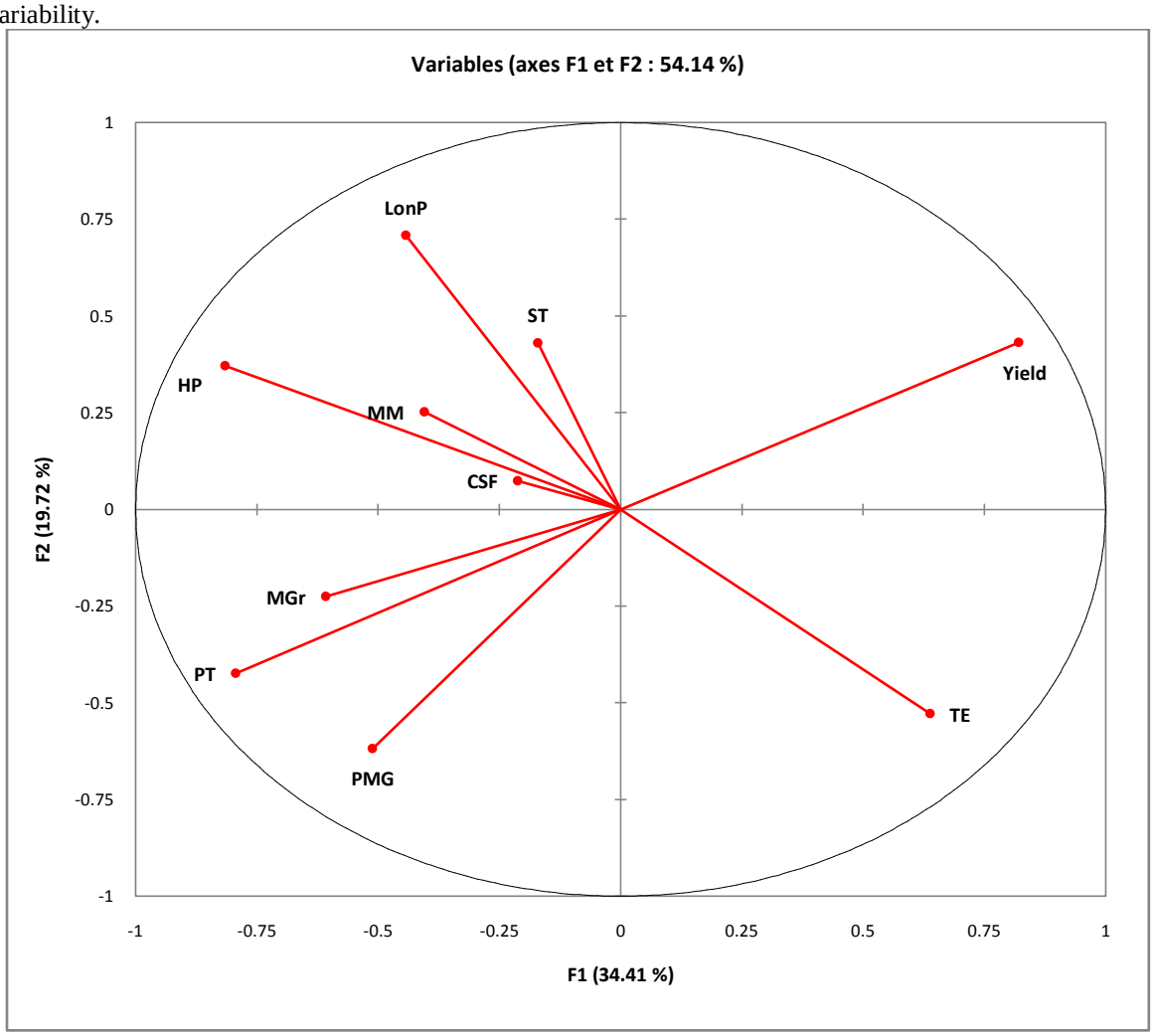


**Figure 1:-** Character Association.

Legend: CSF: Semi-flowering cycle; HP: plant height; LongP: length of the panicle; PMG: weight of a thousand grains Yield: grain yield; TE: water content; TS: total sugar content; P T: total protein content; MGr: fat content; MM: mineral content

## Discussion:-

The very highly significant differences recorded with the different traits evaluated would mean that these traits discriminate between the varieties being evaluated. Moreover, those results also indicate that all hybrids under evaluation were distinct in both agromorphological and biochemical aspects. There is therefore genetic variability between the varieties evaluated. High heritability values in the broad sense would mean that all evaluated traits are under the influence of environmental factors. Indeed, the majority of hybrids were smaller than the controls. This would be related to the fact that these hybrids could be semi-dwarf and/or non-photosensitive cultivars. These results are similar to those of Naoura et al (2014) who had obtained similar sorghum plant heights. The short size of these hybrids would be an asset for breeding as it would allow plants to resist the shed better than large varieties and therefore have a good harvest index. In the same vein, Vaksmann et al (2005) reported that small sorghum varieties better value nutrients by reducing straw production in favor of grain production. The results of the semi-flowering cycle obtained inform us of the existence of early material among the hybrids studied. These results are close to those Nebié et al (2012) who evaluated sweet grain sorghum varieties in North-Central Burkina Faso. In addition, the period of the semi-flowering cycle would be a very important variable for the adaptability of a variety to a given agro-ecological zone. All hybrids had a grain yield above 4000 kg/ha. This high yield potential of hybrids would be due to their great vigour in development. ICRISAT (2011), confirms that the use of hybrid sorghum seeds is very superior to local controls and improved varieties in station trials. The nutrient results also showed that there would be genetic variability between the hybrids and the controls evaluated. The MSP332 hybrid recorded the highest water content. Standards in Burkina Faso would recommend that the water content in cereal grains should not exceed 13% because this would promote the development of microorganisms. All the varieties studied have a content lower than this standard and could therefore be suitable for good preservation. Diabetes is a disease that results in high blood sugar levels, we talk about hyperglycemia. The hybrid variety BRG706088 recorded the lowest total sugar content with 4.35 µg Glu/100mgMS. This variety could be recommended for people with diabetes. In addition, the authors Serna-Saldivar and Rooney (1995); Nandini et al., (2001) and Pontieri et al., (2010) state that the predominant carbohydrate in ripe sorghum grain is starch. The carbohydrate content and composition is a function of the variety and climatic conditions of cultivation. For Kulamarvaetal.,(2009), the starch and slow sugars in sorghum grain are more suitable for diabetics than other cereals. The total protein content would also depend on the variety, the values obtained are similar to those of Pontieri et al., (2010) and UdachanIranna et al., (2012). These authors would have obtained values between 8.9 and 13.1%. In addition, nutritionists agree that proteins play an essential role in the body. They have a structural role and also participate in the renewal of tissues. The consumption of varieties such as BRG09068 could contribute to improving the health of populations. The grains of sorghum hybrids contained relatively low lipid levels. Our results are in line with those of Serna-Saldivar and Rooney (1995) and khatir et al., (2013). The recorded mineral content would also vary from one variety to another. According to Dicko et al., (2016), this mineral material is unevenly distributed and is more concentrated in the germ and pericarp. Correlation analyses have shown the relationships between certain biochemical and agromorphological traits. The negative and very highly significant correlation that exists on the one hand between yield and total protein content would mean that 86% of the variation in yield would explain that of protein content. In addition, protein-rich varieties have a low grain yield. The principal component analysis also showed the F1 axis as the axis of productivity and nutritional composition. This axis would be the axis of selection.

## Conclusion:-

The objective of the study, which was to contribute to a better understanding of the productivity and nutritional quality of the new hybrid varieties of sorghum before the releases, is achieved. Analysis of variance showed significant differences for all agro-morphological and biochemical traits. Heritability values in the broad sense have also shown that these traits are under the influence of genetic factors rather than the environment. In general, hybrids obtained semi-dwarf sizes and yields above 4000kg/ha. Control KAPELGA recorded the highest values of protein and mineral content. The highest sugar content is obtained with hybrid XBS60015. However, the study should finally continue to evaluate other biochemical compositions of hybrids in vitamin and mineral elements and antinutritional factors.

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