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RESEARCH ARTICLE

EVALUATION OF AGRONOMIC CHARACTERISTICS AND LEAVES SPOT DISEASES RESISTANCE OF NEW GROUNDNUT (ARACHIS HYPOGEA L.) VARIETIES IN BURKINA FASO

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Abstract

Groundnut is one of the most widely grown oilseeds in Burkina Faso. It plays an important role both in population feeding and in the rural economy. However, its production faces a number of constraints that impact on performance of varieties developed. Among these constraints, leaf spot diseases such as early and late leaves spot diseases and rosette disease are the main diseases affecting groundnut production.This study was undertaken with the aim of providing farmers with agronomically efficient groundnut varieties resistant to the main diseases through the evaluation of new groundnut varieties. The plant material consisted of 11 new groundnut varieties and 02 control varieties. The experiment was carried out using a Fisher block design with 03 replications. Data collected concerned the severity of early and late leaves spot and rosette diseases as well as agro-morphological parameters. Variety ICGV176351 and the resistant control NAMA were resistant to early leaf spot disease with scores of 2 and 3 respectively. The control TS32-1 was more susceptible to late leaf spot disease with a severity rating of 6.33, while the control variety NAMA and the new variety ICGV176351 were resistant with severity ratings of 3. Variety ICGV176358 performed better with a pod yield of 1542.77 kg/ha and a haulm yield of 1678.33 kg/ha. On the basis of the ascending hierarchical classification, varieties in group 1 composed of ICGV176350, ICGV176352, ICGV176353 and ICGV176358, were the best with good agronomic performance and good resistance to leaves spot diseases. The varieties tested in this study can be disseminated to increase groundnut production in Burkina Faso.

Introduction:-

Groundnuts are grown in more than 100 countries worldwide, on more than 26.4 million hectares, with an average productivity of 1.4 tons per hectare. Developing countries account for 97% of the area and 94% of global production

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(Ntareet al., 2008). The main producers are China and India, which supply more than 60% of global production (Nobaet al. 2014). Africa accounts for around 25% of production, with Nigeria, Senegal and Sudan being the main producers.

In Burkina Faso, groundnut remain a major oilseed sector, with production rising steadily from 244,922 tons in 2007 to 515,672 tons in 2016 and around 530,190 tons in 2019. Its cultivation in Burkina Faso is a good source of income for rural populations. Women traditionally play an important role in groundnut growing using the product for their own consumption and as a source of additional cash income. In addition, more than 300,000 people live directly or indirectly from groundnut revenues (Tiendrebeogo, 2012).

Despite this importance of groundnuts, the average yield remains low, at around 865 kg/ha (MAAH, 2017). This low yield is partly linked to biotic constraints that have a significant impact on the yield of varieties. Among these biotic constraints, diseases such as rosette and early and late leaves spot diseases are responsible for yield losses of up to 70%, depending on the susceptibility of the varieties, with adverse effects on seed quality (Ntareet al., 2001). Given the economic importance of the losses caused by these diseases, it is becoming important to develop control methods to minimize production losses. The use of improved resistant varieties appears to be a sustainable solution to these diseases. Hence the interest of our study, the general objective of which is to provide producers with high-performance groundnut varieties that are resistant to the main leaf diseases of groundnut.

Materials and Methods:-

Experimental site

The study was conducted at Souri, on the experimental site of the University of Dédougou. The Souri site is located 12^{o} 25 North, 3^{o} 31 West. The climate is Sudano-Sahelian, with rainfall ranging from 600 to 900mm per year. The rainy season begins in May and ends in September. In addition, there are five (05) types of tropical ferruginous soil

Plant material

The plant material consists of 13 groundnut varieties including two (02) controls and 11 new varieties were selected at ICRISAT Bamako. The controls are varieties popularised in Burkina Faso whose behaviour to leaves spot diseases is already known (Table 1).

Table 1:- List of varieties studied.

Varieties	Cycle (days)	Performance	Behaviour in relation to leaves spot diseases	Origin
ICGV 176348	Nd	Nd	Nd	ICRISAT
ICGV 176349	Nd	Nd	Nd	ICRISAT
ICGV 176350	Nd	Nd	Nd	ICRISAT
ICGV 176351	Nd	Nd	Nd	ICRISAT
ICGV 176352	Nd	Nd	Nd	ICRISAT
ICGV 176353	Nd	Nd	Nd	ICRISAT
ICGV 176354	Nd	Nd	Nd	ICRISAT
ICGV 176355	Nd	Nd	Nd	ICRISAT
ICGV 176356	Nd	Nd	Nd	ICRISAT
ICGV 176357	Nd	Nd	Nd	ICRISAT
ICGV 176358	Nd	Nd	Nd	ICRISAT
NAMA (control)	110	-	Resistant	INERA
TS32-1(control)	90	-	Sensitive	INERA

Methods:-

Experimental design

The experiment was conducted using a completely randomised Fisher Block design with three (03) replications. Each variety was sown in four (04) rows of three (03) metres with a spacing of 20cm between bunches and 0.5 metre between rows. Plots were spaced 1m apart and replicates 1.5m apart.

Soil preparation and sowing
Ploughing was carried out using a tractor, followed by crushing, harrowing and levelling. The sowing lines were marked out using a wedge at 20 cm spacing. One seed was sown per plot. Each elementary plot comprised 4 lines 3 m long.

Plot management and harvesting
The trial was set up in June 2023. The first weeding was carried out two weeks after sowing. The second weeding was carried out 30^{eme} days after sowing, followed by ridging 45^{eme} days after sowing. Fertilisation consisted of applying 100 kg/ha of NPK fertiliser formulated 14-23-14 after the first weeding. No phytosanitary treatments were used during vegetation. Harvesting was carried out according to the cycle of the varieties.

Assessment of the severity of early and late leaves spot and rosette diseases
Epidemiological parameters were assessed in terms of the severity of early and late leaves spot and rosette diseases**.**

1. Early leaf spot disease (ELS70): this is the severity of the disease at 70 days after sowing, using the ICRISAT 9-point rating scale (Subrahmanyam et al., 1995);
2. Late leaf spot disease (LLS80): this is the disease severity rating at 80 days after sowing, using the ICRISAT 9-point rating scale (Subrahmanyam et al., 1995);
3. Groundnut rosette disease (GRD): the severity of the disease at 70 days after sowing on a 5-point scale.

Assessment of agro-morphologicaltraits
The agro-morphological parameters were assessed according to ICRISAT descriptor. It concerned nine (09) characteristics. These are:

1. Date of first flowering (DFF): this is the number of days after sowing that the first flower appears in each plot;
2. Date of 50% flowering (D50%F): this is the number of days between the sowing date and the date when 50% of the plants in each plot have flowered;
3. Plant height (PH): this is the average height of the main stem of 5 plants per plot at maturity;
4. Pod yield (YieldP): this consists of evaluating the pod yield of each variety per hectare;
5. haulm yield (YieldH): this consists of evaluating the haulm yield of each variety per hectare;
6. Number of pods per plant (NPP): this is the average number of ripe pods per plant from five (5) randomly selected plants;
7. Shelling percentage (%S): this is the ratio of the weight of seeds to the weight of pods in a sample of 200 grams of pods reduced to 100;
8. 100 kernel weight (100KW): this is the weight of 100 good seeds selected at random.

Data analysis
The data collected was entered into an Excel spreadsheet. Normality tests were performed to observe variables following the normal distribution. Analysis of variance was performed using R software version 3.1. Means were separated using the Turkey test. The same logic was used for Person's correlation analysis was also carried out to observe the relationships between pathological and agronomic parameters. Poorly correlated and discriminating characteristics were used to group varieties according to agronomic and epidemiological performance.

Results and Discussion:-

Results:-

Behaviour of varieties to leaves spot and rosette diseases
Results of analysis of variance and the average severity scores for early and late leaves spot and rosette diseases are given in Table 2 below.

Severity of early leaf spot disease (ELS70):
The results of the analysis of variance showed that the severity of early leaf spot disease discriminated between varieties at the 5% probability threshold (Table 2). The behaviour of the varieties to early leaf spot disease was very diverse. Varieties ICGV176350, ICGV176358, ICGV176353 and ICGV176348 were moderately resistant with severity scores of at least 4. The disease was most severe in the susceptible control TS32-1 with a severity rating of more than 5. However, it was less severe in the variety ICGV176351 (severity rating of 2) and the resistant control NAMA (severity rating of 3), followed by the varieties ICGV176349, ICGV176355, ICGV176354 and ICGV176357, which were resistant to early leaf spot disease with a severity rating of 3.

Severity of late leaf spot disease (LLS80):
At 80 days after sowing, symptoms of late leaf spot disease were more advanced on the varieties evaluated. Analysis of variance showed a significant difference between varieties. The control TS32-1 was more susceptible with a severity rating of 6.33, while the symptoms of the disease did not progress in the control variety NAMA and the new variety ICGV176351 with severity ratings of 3. However, the varieties ICGV176350 and ICGV176349 were moderately resistant with a severity rating of 5 (Table 2).

Groundnut rosette disease (GRD):
Rosette disease was not very severe in view of the severity scores observed. Analysis of variance showed no significant difference between varieties at the 5% probability level. The new varieties and the controls did not differ when it came to rosette attacks. Although the susceptible control (TS32-1) had the highest rating, the varieties were all tolerant to rosette (Table 2).

Table 2:- Reaction of varieties to early, late leaves spot and groundnut rosette diseases.

Varieties	ELS70	LLS80	GRD
ICGV176350	4.333 bc	5.333 ab	1.33
TS32-1	5.667 c	6.333 b	2.33
ICGV176358	4.333 bc	4.667 ab	1.00
ICGV176353	4.333 bc	4.667 ab	1.00
ICGV176352	4.667 bc	4.667 ab	1.33
ICGV176356	3.333 ab	3.333 a	1.66
ICGV176348	4.333 bc	4.000 ab	1.33
NAMA	3.000 ab	3.000 a	1.00
ICGV176349	3.333 ab	5.000 ab	1.33
ICGV176355	3.333 ab	4.333 ab	1.66
ICGV176354	3.000 ab	4.667 ab	1.00
ICGV176357	3.333 ab	4.000 ab	1.33
ICGV176351	2.333 a	3.333 a	1.33
Pr> F	0.000	0.003	0.103
Significant	***	**	Ns

Legend: **ELS70**: early leaf spot disease; **LLS80**: late leaf spot disease; **GRD**: groundnut rosette disease.

Agronomical performance of varieties tested
Results of the analysis of variance and the mean values of the agro-morphological traits are shown in Table 3 below.

Date of first flowering (DFF):
The analysis of variance showed no significant difference between varieties at the 5% probability threshold according to the Turkey test (Pr=0.1) for the date of first flowering. The coefficient of variation was also low at just 3%. On average, the varieties had their first flowers at 25 days. The minimum and maximum dates were 23 and 27 days respectively (Table 3).

Date of 50% flowering (D50%F):
The number of days between the sowing date and the date when 50% of the plants had flowered is summarised in Table 3. It varied from 28 to 33 days. On average, the varieties flowered after 29 days. Analysis of variance showed a significant difference between varieties (Pr=0.001). The coefficient of variation was low at 5%. The TS32-1 control had a long flowering period of 32 days. Varieties ICGV176358, ICGV176353 and ICGV176352 were early (28 days). The NAMA control had a sowing-flowering cycle of 29 days.

Plant height (PH):
Analysis of variance showed that plant height did not discriminate between varieties at the 5% probability level**.** However, the coefficient of variation was low at 13%. The average height of the varieties was 31 cm.

Pod and haulm yields (YieldP and YieldH):
Analyses of variance of pod and haulm yields were significant between varieties (Pr=0.0001). In addition, the coefficients of variation were high, at 36% and 33% respectively for pod and haulm yields. The respective ranges of

variation were 388.33 to 1891.66 kg/ha and 396.66 to 1991.66 kg/ha for pod and vane yields respectively. The average performance of the varieties was 1024.14 kg/ha for pod yield and 1165.17 kg/ha for stalk yield (Table 3). ICGV176358 was the best performing variety with a pod yield of 1542.77 kg/ha and a vane yield of 1678.33 kg/ha, while ICGV176351 had the lowest performance with 456.11 kg/ha and 476.66kg/ha respectively. The control varieties TS32-1 and NAMA had pod yields of 610 and 1063 kg/ha respectively and haulm yields of 802.22 kg/ha and 1527.77kg/ha.

Number of pods per plant (NPP):
The number of pods per plant does not discriminate between varieties. However, the coefficient of variation was high at 25%. The minimum and maximum values were 9 and 33 pods per plant. The average performance for the number of pods was 18 per plant (Table 3).

Shelling percentage (%S):
The shelling percentage of the varieties varied from 67 to 78% with an average of 73.05%. The coefficient of variation was low at 3%. The analysis of variance was significant between varieties at the 5% probability threshold (Pr=0.009) (Table 3). It was low for ICGV176356 (68.66%), but high for NAMA and ICGV176358 (75%). The TS32-1 control can be shelled at 71.33%.

100 kernel weight (100KW):
The 100-kernel weight discriminates (Pr=0.02) evenly between varieties at the 5% probability threshold. The minimum value was 34g and the maximum 45g. The average performance of the varieties was 39.87 g. The coefficient of variation was low at 6% (Table 3). ICGV176351 had the highest 100-kernel weight at 43.33g. The control varieties TS32-1 and NAMA had 100-seed weights of 42 g and 39.33 g respectively.

Table 3:- Agronomical traits of varieties.

Varieties	DFF	D50%F	PH	YieldP	YieldH	NPP	%S	100KW
ICGV176350	26	29^{abc}	34	1302.77^{bcd}	1607.22^{c}	20	74.66^{b}	39^{ab}
TS32-1	25	32^{c}	31	610^{ab}	802.22^{ab}	23	71.33^{ab}	42^{ab}
ICGV176358	24	28^{a}	35	1542.77^{d}	1678.33^{c}	20	75.33^{b}	40.66^{ab}
ICGV176353	26	28^{a}	31	1340^{bcd}	1310b^{c}	17	74^{ab}	41^{ab}
ICGV176352	24	28^{a}	32	1412.77^{cd}	1220^{abc}	17	74.66^{b}	39^{ab}
ICGV176356	26	31^{bc}	31	925^{abcd}	1446.11^{bc}	19	68.66^{a}	39.66^{ab}
ICGV176348	25	28^{ab}	31	1003.88^{abcd}	926.66^{abc}	20	72.66^{ab}	42.33^{ab}
NAMA	25	29^{abc}	30	1063.33^{abcd}	1527.77^{bc}	17	75^{b}	39.33^{ab}
ICGV176349	24	28^{ab}	28	1005.5a^{bcd}	979.44 c^{ab}	17	74.33^{b}	39.66^{ab}
ICGV176355	26	30^{abc}	30	695.55 c^{ab}	1073.33^{abc}	15	71.66^{ab}	36.33 ^{a}
ICGV176354	26	30^{abc}	29	947.77^{abcd}	1093.88^{abc}	14	73^{ab}	38.33^{ab}
ICGV176357	25	29^{abc}	29	1008.33^{abcd}	1005.55^{abc}	13	71.66^{ab}	37.66^{ab}
ICGV176351	25	29^{abc}	28	456.11^{a}	476.66^{a}	18	72.66^{ab}	43.33^{b}
Min	23	28	20	388.33	396.66	9	67	34
Max	27	33	40	1891.66	1991.66	33	78	45
Avg	25	29	31	1024.14	1165.17	18	73.05	39.87
CV	3	5	13	36	33	25	3	6
Pr> F	0.142	0.001	0.723	0.0001	0.0001	0.527	0.009	0.023
Significant	Ns	**	Ns	***	***	Ns	**	*

Legend: DFF: Date of first flowering; **D50%F**: Date of 50% flowering; **PH**: Plant height; **YieldP**: Pod yield; **YieldH**: Hull yield; **NPP**: Number of pods per plant; **%S**: Shellingpercentage; **100KW**: 100-kernel weight.

Relationship between agronomic and epidemiological parameters
Analysis of Pearson's bivariate correlations between agronomic and epidemiological parameters revealed the existence of significant correlations between traits (Table 4). Positive and significant correlations existed between:date of 50% flowering date (D50%F) and rosette disease (GRD) with a correlation coefficient r = 0.741 ; early leaf spot disease severity (ELS70) and plant height (PH) with a correlation coefficient r = 0.674 ; the severity of early leaf spot disease (ELS70) and the number of pods per plant (NPP) (r = 0.641); plant height (PH) and pod yields (YieldP) (r = 0.636) and haulm yields (YieldH) (r = 0.677). Significant negative correlations were also

observed between date of 50% flowering (D50%F) and pod yield (YieldP) with r = -0.662 and between date of 50% flowering (D50%F) and shelling percentage (%S) with r = -0.766 ; between rosette disease (GRD) and pod yield (YieldP) (r = -0.579), as well as with shelling percentage (%S) with r = -0.633).

Table 4:- Correlation between quantitative characteristics and leaves spot diseases parameters

Variables	DFF	D50%F	ELS70	LLS80	GRD	PH	YieldP	YieldH	NPP	%S	100KW
DFF	**1**										
D50%F	0.553	**1**									
ELS70	-0.136	0.028	**1**								
LLS80	-0.110	0.170	**0.751**	**1**							
GRD	0.189	**0.741**	0.433	0.434	**1**						
PH	-0.192	-0.178	**0.674**	0.314	0.045	**1**					
YieldP	-0.359	**-0.662**	0.357	0.129	**-0.579**	**0.636**	**1**				
YieldH	0.022	-0.224	0.183	-0.037	-0.400	**0.677**	**0.781**	**1**			
NPP	-0.216	0.139	**0.641**	0.377	0.457	**0.644**	0.039	0.106	**1**		
%S	-0.511	**-0.766**	0.116	0.165	**-0.633**	0.297	**0.617**	0.342	0.028	**1**	
100KW	-0.279	-0.107	0.215	0.022	0.107	0.108	-0.186	-0.374	**0.658**	0.039	**1**

Values in bold are different from 0 at significance level alpha=0.05

Legend: DFF: Date of first flowering; **D50%F**: Date of 50% flowering; **PH**: Plant height; **YieldP**: Pod yield; **YieldH**: Hull yield; **NPP**: Number of pods per plant; **%S**: Shellingpercentage; **100KW**: 100-kernel weight.

Classification of varieties according to their agronomical performance and behaviour to leaves spot diseases

Discriminating traits with low correlation through analysis of variance and correlation matrix were used to group varieties according to their agronomic performance and disease behaviour through hierarchical ascending classification analysis. These traits are**:**date of first flowering appearance (DPF); severity of early leaf spot disease(ELS70); plant height (PH); pod yield (YieldP); 100-kernel weight (100KW). Three (03) groups were obtained (Figure 1). The average performance of these groups is shown in Table 5. There are 3 groups in total:

Group 1:

Group 1 is characterised by varieties with a first flowering date of 25 days and a late leaf spot disease severity of 4.833. The varieties in this group have a height of 32.708 cm, a pod yield of 1399.58 kg/ha and a 100-grain weight of 39.917g. It includes four (04) varieties: ICGV 176350, ICGV 176352, ICGV 176353 and ICGV 176358.

Group 2:

The three varieties in the second group (ICGV 176351, ICGV 176355 and the TS32-1 control) were characterised by a date of appearance of the first flower of 25 days; a late leaf spot disease severity rating of 4.667. The average height of the varieties in this group was 29.66 cm; pod yield was the lowest at 587.22 kg/ha and the weight of 100 grains was 40.556 g.

Group 3:

The third group contains six (06) varieties (ICGV 176348, ICGV 176349, ICGV 176354, ICGV 176356, ICGV 176357, NAMA) their date of appearance of the first flower is 25 days; the late leaf spot disease severity score was 4; these varieties were 29.55 cm tall; pod yield was moderately high at 992.315 kg/ha and 100-grain weight was the lowest at 39.500 g.

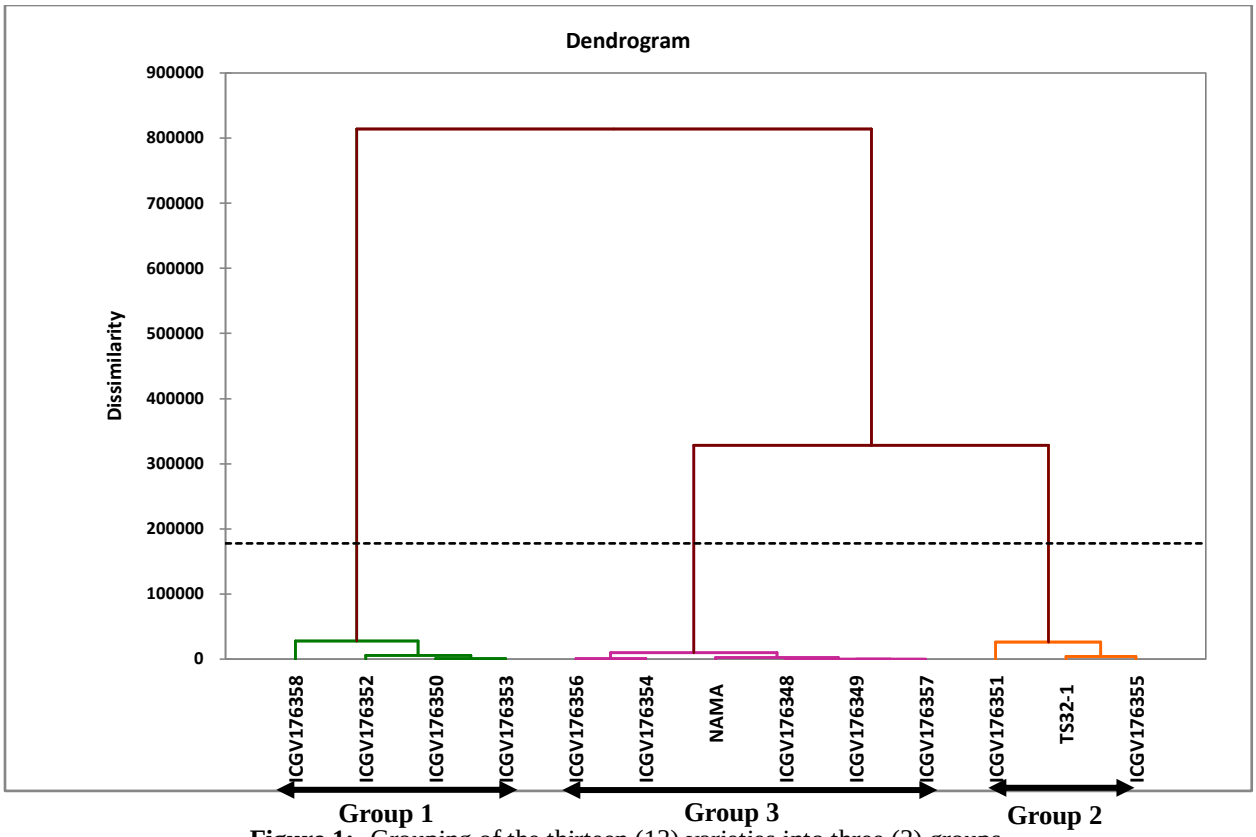

Figure 1:- Grouping of the thirteen (13) varieties into three (3) groups.

Table5:- Performance of the CAH groups.

Groups	DFF	LLS80	PH	YieldP	100KW
G1(4 varieties)	25.000	4.833	32.708	1399.583	39.917
G2(3varieties)	25.444	4.667	29.667	587.222	40.556
G3(6varieties)	25.278	4.000	29.556	992.315	39.500

Legend: **DFF**: Date of first flowering; **LLS70**: late leaf spot disease; **HP**: Plant height; **YieldP**: Pod yield; **100KW**: Weight of 100 kernel;

Discussion:-

Generally speaking, evaluation of the behaviour of varieties in the face of disease has revealed differential reactions. Indeed, we could distinguish varieties resistant or tolerant to early and late leaf spot disease. The ratings of 2 and 3 observed for ICGV176351 and the NAMA control would mean that these varieties are resistant to early and late leaf spot disease. In addition, the variant notes 1 and 2 in the rosette would mean that all the varieties are resistant and have behaved similarly in the face of this disease. This is because each variety contains genes that enable it to respond differently to disease attacks. These results are in line with those of Lepoivre and Semal (1989), who showed that the behaviour of a population of host plants towards a pathogen is determined by their genotype.

The results of the analysis of variance showed significant differences for most of the agronomical traits. This means that there is variability between the varieties evaluated. So, for these discriminating characteristers, the varieties would be different from one another. However, for non-discriminating traits, the new varieties and the controls would have similar performances. In fact, the date of 50% flowering of 28 days recorded by the varieties ICGV176358, ICGV176353 and ICGV176352 would mean that there is early genetic material within the varieties. This is an advantage when choosing varieties. These varieties would therefore be a response to climate change. ICGV176358 was the best performing variety with a pod yield of 1542.77 kg/ha and a haulm yield of 1678.33 kg/ha, while ICGV176351 had the lowest performance with 456.11 kg/ha and 476.66kg/ha respectively. The diversity of genes within the varieties could explain the diversity in yield performance, given that the varieties were evaluated under the same conditions. Varietal performance could also be influenced by other factors such as soil

type. To this end, Sankara (1997) and Bazile et al (2016) have shown that tropical ferruginous soils are low in the phosphorus responsible for pod filling in groundnuts. This lack of mineral elements is thought to be the cause of poor fixation of certain ions such as aluminium, calcium and manganese. The immediate consequence could be poor pod filling, leading to low yields. The hierarchical ascending classification made it possible to group the varieties into three (03) groups. Varieties in group 1 performed well, with pod yields of over 1399 kg/ha and tolerance to late blight (score of 4). The tolerant varieties in this group could be included in the catalogue and made available to growers.

Conclusion:-

This study was undertaken with the aim of providing growers with agronomically efficient groundnut varieties that are resistant to the main diseases. The variety ICGV176351 and the resistant control NAMA were resistant to early leaf spot disease, with scores of 2 and 3 respectively. The control TS32-1 was more susceptible to late leaf spot disease with a severity rating of 6.33, while the symptoms of the disease did not develop in the control variety NAMA and the new variety ICGV176351 with severity ratings of 3. The ICGV176358 variety performed best with a pod yield of 1542.77 kg/ha and a haulm yield of 1678.33 kg/ha, while the ICGV176351 variety performed worst with 456.11 kg/ha and 476.66kg/ha respectively. On the basis of the hierarchical ascending classification, the varieties in group 1, made up of ICGV176350, ICGV176352, ICGV176353 and ICGV176358, were the best, with good agronomic performance and resistance to leaf diseases. This study provided satisfactory results for the Souri experimental perimeter. However, it does not give an idea of the behaviour of these varieties in other agro-ecological zones of Burkina Faso. For this reason, the study should be continued by evaluating the varieties on other sites.

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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