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Original Research Article

FIELD EVALUATION OF SEVEN VARIETIES OF COTTON (*GOSSYPIUM HIRSUTUM* L.) IN THE NORTHERN REGION OF CAMEROON

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Abstract: In the North of Cameroon, cotton is an important source of income for thousands of people living in the rural areas. Cotton seeds are a source of food and contribute to food security through production of vegetable oil used for many purposes. However, despite its importance in the food and household economy, cotton yields and production remain low because of the many constraints, such as drought. Drought prohibits the existing local variety from completing its life cycle and the immediate consequence is low yield. It is for this reason that seven new lines of cotton adapted to the northern part of Cameroon were developed by the IRAD through breeding to add to the existing local varieties. This work evaluated the performance of these varieties for the purpose of recommendation to farmers. Out of the seven varieties tested; only the variety Z2416 combined a good performance for both agronomic and technological traits. This variety is far superior in performance compared to the local variety and the six varieties developed with an additional yield of 281 kg / ha. The variety also produced a hint of yellow fine and long fibers (0.4 mm), a higher maturity (1.6 %) while remaining within the accepted standards.

Key words: *Gossypium hirsutum*, varieties, evaluation, yield performance, agronomic and technological traits.

Introduction: Cotton (*Gossypium hirsutum* L.) is the fibrous plant most cultivated in the world (Berti et al., 2006; Adingra, 2011; Bagayoko, 2013). In Northern Cameroon, it represents a significant source of income for thousands of people living in the rural areas. Its seeds are used either as planting material or as a raw material for oil extraction (Estur, 2006; Diaw, 2010; Koulagna, 2015). Cotton seeds contain 20 to 25% of oil in the form of polyunsaturated (acid linoleic and oleic) and saturated (palmitic) fatty acids (MINADER, 2013; Abakar, 2015). They yield vegetable oil, which is used for soap making and other cosmetic products. In addition, its seed has 20 to 30 % protein (Ichiga, 2013). This high protein rate makes it possible to use the cake left after oil extraction towards animal

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feed production and places this oil second to soybean cake (Folefack, 2008; Folefack, 2011).

In spite of its importance, cotton yields are low in Cameroon and in several countries of West and Central Africa (Levrat, 2009; Folefack, 2008; Folefack, 2011). Indeed, the local varieties available are no longer adapted to the current climatic conditions of the region. Confronted with many socio-economic but especially climatic constraints of late return of the first rains combined with some drought in the middle of the season and the early departure of rains in the northern part of the cotton zone of Cameroon, the variety IRMA L484 currently in use finds it difficult to complete its cycle of development and the immediate consequence is poor yield obtained in spite of the good farming practices (Seguy, 2006; Olina, 2008). Studies also showed that the yield obtained using this variety drops because the soil is exhausted of the nutrients and soil moisture (Olina, 2008). In Benin it was recommended that a variety with compact foliage and early and short flowering period is preferable in zones with short rainy season (Sekloka et al., 2008), while the varieties with more vegetative growth and high flowering potential are suited for zones with better climatic and environmental conditions (Rosenheim et al., 1997). The Agricultural Institute of Research for Development (IRAD) Maroua, Cameroon has developed some cotton varieties through backcrossing based for higher yield, fiber length and fiber quality as compared to the existing variety. The principal objective of this study was to evaluate the agronomic and technological traits of seven new lines of cotton developed in the Northern part of the cotton zone of Cameroon

Materials and Methods

Study site: The study was carried out at the Agricultural Institute of Research for Development (IRAD) station of Maroua Kodek (10.67 N latitude and 14.42 E longitude) during the farming year 2012 -2013. The station is located in the plain of Diamaré, some 13 km from the centre town on the axis Maroua - Bogo. This area has an annual average rainfall of 700 mm and the temperature varies from 28 ^{o}C to 40 ^{o}C. During the experiment the precipitation varies from 400 to 700 mm.

Origin of the planting material: The planting material consisted of eight varieties: one local variety (IRMA L484, supplied by the SODECOTON (Cotton Development corporation) used as control in this experiment and seven varieties (IRMA Z2055, IRMA Z2096, IRMA Z2098, IRMA Z2259, IRMA Z2347, IRMA Z2416 and IRMA Z2420) developed by IRAD resulting from F5 lines of the farming year 2011 -2012 (Table 1).

Planting conditions and field design: After tilling the soil with a tractor, the field was sprayed with herbicides and insecticide to remove unwanted biotic intruders. The experimental field design was the Fisher block design with four replicates carrying tags of the eight varieties used. Each block consisted of 6 lines of 10 m each (4 central lines and 2 side lines).The experimental field was composed of two bands of 100 lines of 10 m, separated by an alley of 2 m, that is to say a total surface of 80 m X 22 m = 1 760 m² (including 1 600 m² planted). Sowing was carried out in hills at a spacing of 25 cm within rows and 80 cm between rows. Seeds were hand dibbled at a rate of three seeds per hill and thinning was done with a plant per hill during the first weeding. The density per hectare was 50 000 plants. To protect the young plants against soil worms, carbofuran was used in the hill at planting. Fertilizer application was carried out 45 days after sowing according to the recommendations made by the SODECOTON. The study was conducted on June to October 2013.

Data collection on individual plant variety: Observations were made on the morphology of the survived seedlings at various stages of development of the plants on 10 seedlings of each variety chosen randomly in the central lines. Data were recorded for: number of vegetative branches developed having at least a flower (NVB), number of nodes to the first

fruiting branch (NN1BF), height of the first fruit-bearing branch (H1BF) and the height of the plants (TP) starting from the root collar to the apex after harvest.

The extent of the bacterial attack (Bact) and hairiness (Pilo) of the seeds was also assessed. These parameters were taken on the whole plant according to a visual scale with gradation from 0 to 5. For hairiness, this scale goes from no hair (0) to very hairy (5). Concerning the bacterial attack, this scale goes from healthy (0) to most attacked (5).

Information on the yields, yield components and technological characteristics was collected only from the central rows. Data were recorded on:

- The number of survived plants before the second planting (Stand 1) and at harvest (stand 2) to determine the population density;
- The number of days from planting to the date of appearance of the first flower (D1F) and to the date of opening of the first capsule (D1C);
- estimating cotton seed yields (CSY) by the cotton weight granulates on the four central lines according to the density. The cotton seeds were collected and weighed using a balance and according to the weight of the seeds and the surface area used, one could extrapolate the yield within one hectare;
- Cotton capsule weight (CCW).Thirty capsules are collected at the edges and then their total weight is divided by the number of capsules (30);
- Raw cotton fiber yields (RFY).

The technological characteristics of fibers studied were: length (average length of the longest fibers (UHML), uniformity (UI), strength (Str), lengthening (Elong), index micronaire (IM), maturity (PM), standard smoothness (Hs), brilliance (Rd) and index of yellow (+b).

Analysis of data: Histograms were constructed using excel program. Thereafter, the entire recorded data were subjected to an analysis of variance (ANOVA) using software SAS version 8.0 and the means were compared using the test of Ryan-Einot-Gabriel-Welsch at 5 % significant level.

The following model was used for the analysis of variance for the characters studied:

$$Yil = \mu + S_L + G_I + Eil$$

Where

μ is the intercept (constant value)
S_L is the fixed effect of the block
G_I is the random effect of the variety
Eil is the random residual error not controlled.

Results and Discussion: Effect of variety on the morphological traits of the seven varieties tested, Z2098 was the shortest and Z2259 was the longest (Table 2). The height (TP) of the varieties tested was lower or equal to 124 cm with an average of 112 cm. the other varieties tested have their heights equivalent to that of L484, the control variety. As for the height of the first fruit-bearing branch (H1BF), it was below 25 cm with an average of 22.7 cm. As regards this parameter, only the variety Z2420 appears interesting with a low H1BF. Moreover, for the number of vegetative branches (NBV) by plant, the variety Z2096 had more vegetative branches than the others which had a number of NBV equivalent to that of L484 (control). Hairiness on the seeds is dimensioned, on average to 1. As for the number of vegetative branches and height of the cotton plants, the analysis of variance showed that there are slight differences but nevertheless significant between the cotton plants.

Degree of bacterial attack on the varieties tested: Figure 1 presents the degree of bacterial attack per variety. The results obtained showed that all the varieties tested were infested at varied levels. The variety Z2098 was least attacked, followed by variety Z2416 and the most attacked was variety Z2420 variety. The analysis of variance shows that variety has a highly significant effect ($P < 0.001$) on the evolution of this disease, with a coefficient of variation of 12.2%.

Effect of phenology on the varieties of cotton plant tested: Flowering for all varieties

occurred within 65 days after planting (D1F) with an average of 63.6 (Table 3). The varieties Z2098, Z2259, Z2347 and Z2416 appear earlier in term of opening of the first flower compared to the other varieties which had the same time of opening as the variety L484. The opening of the first capsule occurred within 110 days (D1C)) with an average of 108 days which confirms the behavior of these varieties on the level of the D1FJAL. The number of nodes (NN1BF) to the first fruit-bearing branch was 6.6 with an average of 5.98. The analysis of variance shows that there are not significant differences ($P > 0.05$) between the varieties for the date of flowering and the date of opening of the capsule. The number of nodes to the first fruit-bearing branch, criterion related to the earliness of flowering, was significantly different ($P < 0.05$) among to the varieties tested.

Effect of production on varieties tested: A comparison made on the basis of the average of cotton seed yield (CSY) enables us to classify the varieties in two groups (Table 4). In the first group, we have the following varieties with best output above the average; Z2347, Z2259, Z2420, Z2416 and Z2055 and in the second group we have the varieties with poor output below the average; L484, Z2096 and Z2098.

The capsule weight (CCW) was significantly different ($P < 0.05$) for all the varieties tested. Based on the average, the classification of the varieties is as follows: a group with varieties having a high CCW higher than that of the control, Z2347, Z2259, Z2420 and Z2416 and another group which contains those which have a CCW very low and lower than the control L484: Z2098, Z2055 and Z2096.

All the varieties tested gave a percentage of raw fiber yield (RFY) higher than the control. According to the order of magnitude we have the variety Z2259 followed respectively by varieties Z2416, Z2420, Z2347 and Z2096 which gave a percentage of raw fiber yield higher than 40 %; the varieties Z2098 and Z2055 gave the RFY lower than 40 %.

Evaluation of the population density of the tested varieties: Before the second planting, the number of survived stands was counted for each variety. In general, the density was good with above average for most of the varieties, but L484 and Z2055 had a low density (77/78%) as compared to the other varieties with densities more than 80% (table 5). These results showed us that there is a significant difference ($P < 0.05$) between the varieties. The number of survived stands went from 85% for the L484 variety to 96% for the variety Z2347.

Evaluation of the technological parameters of the varieties tested: In general, the length of the longest fibers (UHML) is acceptable (28.4 mm). Only the varieties Z2055 and Z2259 had shorter length compared to the average of the evaluated varieties with their respective values as 27.6 mm and 27.9 mm (table 6). The L484 control has a good length of fibers and comes just after the varieties which have the longest fibers: Z2347 (29.2 mm) and Z2098 (29 mm). With regard to the uniformity, it was appreciable for all the varieties (83.3 %). The varieties Z2096 and Z2055 had a slight more uniformity (83.9 and 83.8 %). The lowest values were obtained for the varieties Z2347 and Z2259, which were 82.4 % and 82.7 % respectively.

The strength of fibers was also very high (31 g/Tex) (Table 6). The lowest score was recorded on the variety Z2347 with 28 g/tex. The variety Z2055 had the highest strength of the fiber (35.7 g/Tex). However, concerning maturity, all the varieties tested had a good maturity of fibers (> 75 %) except for variety 2420. The standard deviation between the averages of the varieties was considerable 5.11 %. The variety Z2416 had the best score (88.5 %), while the variety Z2420 had the lowest score (71.8 %); the average being 82.1 %.

The brilliance of the fiber was appreciable on the whole (78.9 %) with a considerable standard deviation of 1.95 %. The highest value was recorded on variety Z2055 (81.2 %) and the lowest value is recorded on variety Z2416 (75.8 %). Just like the brilliance, the index of yellow varied from 9.3 (Z2055) to 10.7 (Z2420) with a

standard deviation of 0.64 average of all the varieties tested was 9.9. For the elongation, the standard deviation was low for all the varieties tested (0.17) and so was the case with the index micronaire (0.29).

Conclusion: These studied varieties are likely to be well adapted to the rainfall conditions of the Far North. In the same way, compared to the variety popularized by the SODECOTON (L484), the variety Z2259 had taller plants and the variety Z2076 had shorter plants than the varieties Z2347, Z2420, Z2416, Z2055 and L484, which were at par. With regard to the plant health state, we observed that all the varieties tested had bacterial attack. Nevertheless, one observed differences for the level of the degree of infection of the seedlings. Indeed, the varieties Z2098 and Z2416 were heavily attacked compared to L484. A confrontation of our results made it possible to deduce that the popularized variety (L484) was placed in seventh and fifth ranks respectively for the cotton yield granulates and the average weight of the capsule far behind the variety Z2347 which at the top of classification for these two parameters (cotton yield granulates and average capsule weight). On the basis of all observation (morphology, phenology, bacterial attack) carried out, there exists significant differences between all the varieties for the majority of the measured criteria. The varieties in the course of evaluation showed higher performances (agronomic and morphological) than the control variety.

Ultimately and in comparison with the results obtained (agronomic and technological), we can retain that the varieties Z2416 and Z2420 are those which combine well the two criteria of selection. The variety Z2347 which has a good agronomic behavior presented poor technological results thus confirming the thesis of many authors (Lawson, 2008; Ichiga, 2013) who supported that there is a negative correlation between outputs and qualities of fiber produced. As for the variety Z2096, it was interesting just for the technological level (good length of fiber and average length of the longest fibers. With this intention, the popularization of the new varieties with a better performance (on the agronomic and technological levels) is strategic. It could thus contribute to the compensation of the drop of the world levels of the cotton-fiber whose cotton producer are victims and create one more been worth on the level of the die cotton of the developing countries.

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Table 1. Pedigree of newly developed varieties and L484.

Variety	Pedigrees					
IRMA L484	NTA 88-6	IRMA D160	I307-1364	J281-418	K418-837	L484
IRMA Z2055	IRMA L484	CD 406	U303-16	V411-3	W1011-4	Z2055
IRMA Z2096	IRMA L484	CD 406	U303-32	V423-3	W1020-9	Z2096
IRMA Z2098	IRMA L484	CD 406	U306-32	V423-3	W1020-11	Z2098
IRMA Z2259	IRMA L457	ISA 319	U315-13	V558-4	W1091-1	Z2259
IRMA Z2347	IRMAN229	ISA 319	U333-4	V687-1	W1136-3	Z2347
IRMA Z2416	IRMA J133	CR 184	U342-11	V773-3	W1158-2	Z2416
IRMA Z2420	IRMA J133	CR 184	U342-11	V773-6	W1161-4	Z2420

Table 2. **The effect of variety on the morphology of the plant**

Characteristic	Varieties										
	L484	**Z2055**	**Z2096**	**Z2098**	**Z2259**	**Z2347**	**Z2416**	**Z2420**	**Average**	**P (var)**	**CV %**
NBV	1.1b	1.1b	1.5a	1.2ab	0.7b	0.9b	0.7b	0.9b	1.0	***	25.6
H1BF	22.3abc	22.8abc	24.8ab	23.8abc	25.3a	21c	21.4cb	20.4c	22.7	**	6.7
TP	119ab	118ab	102b	106ab	124a	104ab	118ab	106ab	112	*	8.2
Pilo	0.5ab	0.6ab	0.4b	0.6ab	1.1a	0.5b	0.7ab	0.7ab	0.6	*	38.4

NVB (number of vegetative branches developed having at least a flower); H1BF (height of the first fruit-bearing branch); TP (the height of the plants starting from the root collar to the apex after harvest).

Table 3. Phenological Stages (days after planting) of the cotton plants tested

Phenological Stages	Varieties										
	L484	**Z2055**	**Z2096**	**Z2098**	**Z2259**	**Z2347**	**Z2416**	**Z2420**	**Average**	**P(var)**	**Cv%**
D1F	65	65	65	63	64	61	64	63	64	Ns	2.7
D1C	109	109	108	107	110	109	108	108	108	Ns	4.0
NN1BF	6.0ab	5.8ab	6.7a	5.8b	6.1ab	6.1ab	5.8b	5.7b	6.0	*	6.0

D1F (the number of days from planting to the date of appearance of the first flower) and D1C (to the date of opening of the first capsule), NN1BF (number of nodes to the first fruiting branch).

Table 4. Seed cotton, capsule and raw fiber yield of different varieties tested.

Yield	Varieties										
	L484	Z2055	Z2096	Z2098	Z2259	Z2347	Z2416	Z2420	Average	P(var)	Cv%
CSY	1194cd	1515abc	1052d	1236abc	1518abc	1818a	1476abc	1608ab	1427	***	11.6
CCY	4.8cd	4.6cd	4.3d	4.7cd	5.0cb	5.5a	5.3ab	5.1abc	4.9	***	4.8
RFY	38.6	38.8	40.4	39.6	43.3	41.9	42.4	41.9	40.9		

CSY (cotton seed yield), CCY (cotton capsule yield) and RFY (raw fiber yield).

Table 5. Plant stand of different varieties tested.

	Varieties										
	L484	**Z2055**	**Z2096**	**Z2098**	**Z2259**	**Z2347**	**Z2416**	**Z2420**	**Average**	**p(var)**	**Cv%**
Stand1	79ab	78b	79ab	83ab	80ab	86a	85ab	86a	82	**	4.2
Stand2	85b	90ab	85b	92ab	89ab	96a	95a	94ab	91	**	4.2

Table 6. Fiber quality of the varieties tested.

Varieties	Technological characteristics of fibers								
	UHML	UI	Str	Elong	IM	PM	Hs	Rd	+b
L484	28,8	83,2	30,6	5,2	3,7	79,4	167,0	79,1	9,5
Z2055	27,6	83,8	35,7	5,7	3,9	86,0	150,0	81,2	9,3
Z2096	28,1	83,9	30,3	5,5	4,0	85,1	158,0	80,2	9,4
Z2098	29,0	83,5	29,6	5,4	3,9	83,1	162,0	80,8	9,4
Z2259	27,9	82,7	32,5	5,5	4,2	85,1	169,0	78,4	10,5
Z2347	29,2	82,4	28,0	5,6	3,7	77,6	174,0	79,9	9,7
Z2416	28,3	83,3	30,5	5,2	4,5	88,5	168,0	75,8	11,0
Z2420	28,7	83,1	30,9	5,3	3,5	71,8	189,0	75,9	10,7
Mean	28,4	83,3	31,0	5,4	3,9	82,1	167,1	78,9	9,9
SD	0,39	0,82	1,53	0,085	0,22	4,25	9,24	1,41	0,41

UHML (average length of the longest fibers), UI (uniformity); Str (strength), Elong (lengthening), IM (index micronaire); PM (maturity); Hs (standard smoothness), Rd (brilliance); and +b (index of yellow).

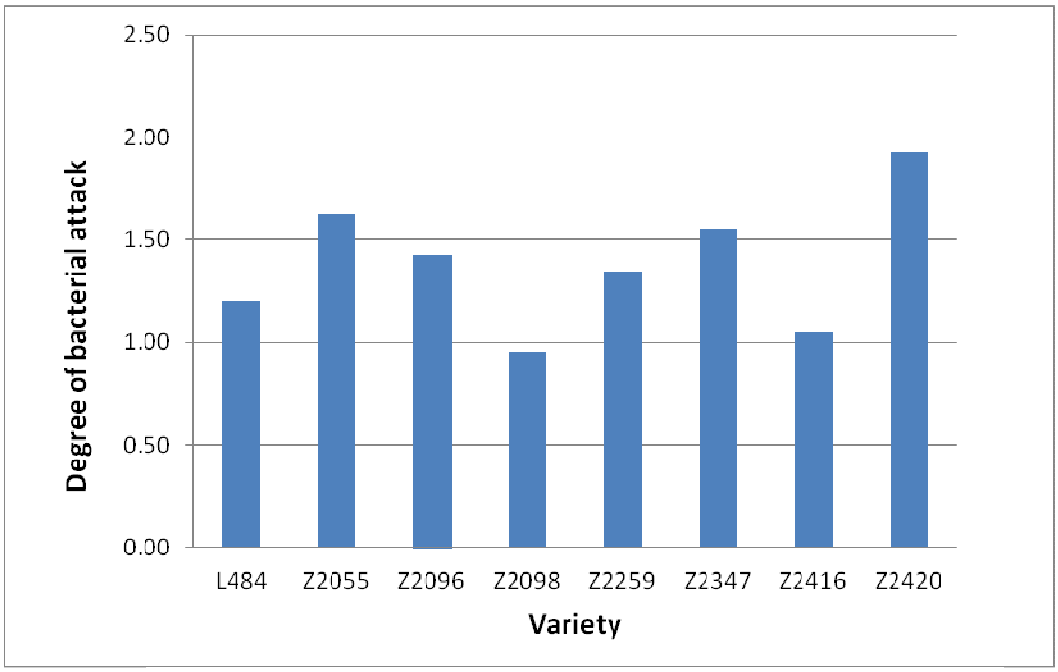

Figure 1. Degree of bacterial attack in different cotton varieties.