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ORIGINAL ARTICLE

WEEDING TECHNIQUE AND DISEASES IN DIFFERENT MAIZE PLOTS (*Zea mays* L.)

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ABSTRACT

Background: Maize is one of the graminaceae that are more cultivated in the world. It is a basic food culture most largely practiced in sub-Saharan Africa. In Cameroon, maize is the principal source of income for more than three million producers and it is highly strategic culture, from the point of view security and sovereignty food. **Objectives**: The objective of this study is to identify a more productive variety, less susceptible to phytotoxicity of weedkiller treatment and less attacked by diseases under experimental conditions. **Methods**: Three weeding techniques and three varieties were used in Split-plot design with four repetitions to destroy weeds. Visual diagnosis thanks to precise observations of symptoms, was done in fields to identification of diseases, thereafter incidence and severity were evaluated. **Results**: Four pathological diseases and five physiological diseases were recorded. The results showed that treatments had not significant effect on growth of maize cultivars, particularly plant height, stem collar diameter and leaves number. The incidence of helminthosporiosis and foliar spots of varieties V2 (variety CMS 8501) and V3 (variety CMS 8704) was significantly higher in plots control (WT0: unweeded) compared in plots weeding with hand and chemical weeding. These results showed that the local variety had the highest severity in all the treatments compared to improve varieties. **Conclusions:** The local variety was more diseases sensitive than improved varieties. High yields were recorded for improved varieties and low yield for local variety. For hand weeding treatment (WT1) and chemical weeding (WT2) yields were high compared to unweeded treatment (WT0).

Keywords*: Zea mays L., diseases, incidence, severity, weeding techniques*

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the cereals that are more cultivated in the world. It is a basic food culture most largely practiced in sub-Saharan Africa. It occupies more than 33 million ha each year [1]. Maize was introduced in Cameroon by the Portuguese [2] and constitutes one of the main food crops [3]. It is cultivated in the five agro-ecological zones of North and South Regions of the country and constitutes the third foodstuff produced after cassava and plantain [4]. Maize plays an essential role in human, animal consumption and constitutes a source of raw material for industries [5-6]. Diseases and insects cause significant damage during the production of maize. Loss varies from 15 to 50 % compared to total annual production [7]. The diseases are mostly caused by fungi, viruses and bacteria [8]. Some of these pathogenic agents multiply abundantly in the presence of weeds. It is estimated that weeds which infest maize plots during the first four weeks after plantlets emergence reduce grain yield of 40 to 97 % [9-10-11-12]. This reduction is due to competition for the resources such as water, light and nutriments [13-14]. Weeding plays major role in maize-grain production. Successful harvest depends on the success of war against weeds [15]. The principal methods of weeds control being offered to producers are hand, mechanical and chemical weeding [16]. Thus, maize culture holds prior place in the studies to undertake [3], this one was directed towards the research of improved varieties highly productive, resistant to certain diseases and the control of weeds [17, 18]. The objective of this study is to identify a more productive variety, less susceptible to phytotoxicity of weedkiller treatment and less attacked by diseases.

2. MATERIALS AND METHODS

2.1 Study site: An open field experiment was carried out in Akonolinga; located at 110 km from Yaoundé (3°46′ of Northern latitude and 12°15' of longitude east, altitude 669 ± 3 m). It belongs to the agro-ecological zone V of Cameroon characterized by a Congo-Guinean climate type, with two dry seasons alternating with two rainy seasons. Average rainfall varies between 1500 and 2000 mm over 10 months. Annual average temperature is relatively constant ranging from 23 to 27 °C and average humidity is above 80 % [19].

2.2 Plant and weedkiller material: Three different varieties of maize, sensitive to diseases: CMS 8701, CMS 8501 (improved and tolerant) and local variety (sensitive) were used. A chemical pesticide named "Herbimaïs", a mixture of Atrazine 750 g/kg and Nicosulfuron 40 g/kg was used for weeding in maize plots after plantlet emergence. Weedkiller solution of 15 liters made of 46 g of "Herbimaïs" and water was used to spray a surface of 86.4 m² representing 12 experimental units.

2.3 METHODS

2.3.1 Experimental design: The experimentation was carried out in a factorial design "Split-plot" [20] with nine treatments combinations per block, three varieties and three weeding techniques. Each combination used 56 plants with a total of 168 plants per plot for a total of 504 plants per block. A total of 36 experimental units measuring 2.4 m x 3 m each, spacing between them by 1 m and 1.5 m gaps between blocks. In each sub-plot sowing density was 80 cm x 50 cm [21], with two seeds per seed hole, in four lines with seven plants per line.

2.3.2 Weeding methods: Hand weeding thanks to rudimentary tool was carried out the same day as the chemical weeding. Weed killer solution was applied at stages from six to eight leaves for maize [22]. As for the unweeded, no action of weeding was undertaken until the end of the experimentation.

2.3.3 Data collection: Plants were taken randomly in basic experimental units and used for data determination.

2.3.3.1 Emergence rate: The plantlet emergence was observed the 6th day after sowing. Moubitang's (2010) formula bellow was used for calculation [23].

$$ER\ (\%) = (n/N) \times 100 \qquad (1)$$

Where: ER = emergence rate, N = number of raised plantlets and N = total number of sown seeds.

2.3.3.2 Evaluation of plant growth: Height of plants were measured from the third week after sowing and repeated weekly with a tailor's ruler from collar to the end of the last deployed leaf. The stem diameter was measured at collar level using a caliper each weekend and total number of leaves per plant was counted and recorded. The counting of leaves was done weekly.

2.3.3.3 Study of diseases: The main focus for diseases study was incidence and severity of attack of most representative diseases. The identification of diseases was done in field thanks to precise observations of symptoms, their evolution over time and space [24]. Incidence is proportion of infected plants on an experimental plot, independently of gravity of disease attack on each plant. It is determined by the following formula:

$$I(\%) = \frac{Npm}{Npt} X100 \qquad (2)$$

With: I (%) = disease incidence on studying plot**,** Npm = number of infected plants on the plot and Npt = total number of plants on the plot (healthy and infected plants).
Disease severity shows the gravity of a disease on an organ or whole plants in an experimental plot. It is calculated with Tchoumakov and Zaharova's (1990) formula [25]:

$$S = \frac{\sum_{n}^{i}(ab)}{N} \qquad (3)$$

With: S = severity of attack, a = number of diseased plants, b=corresponding degree of infection in % and N = total number of diseased plants studied on the plot.

2.3.3.4 Yield: The harvest of maize was made 3 months 16 days after sowing. Dry grain yield of 6 plants randomly collected in each experimental unit of a block, expressed in kg per hectare was calculated with the formula below according to [26-27]:

$$Y(\text{kg.ha}^{-1}) = \frac{DGWp\ x\ 28}{7.2\ \text{m}^2} X10\,000\ m^2 \qquad (4)$$

With: Y = yield; DGWp = dry grains weight per plant, 28 = number of plants per treated elementary plot**,** 7.2 m² = surface of each treated elementary plot.

2.4 Statistics analyses: Results were subjected to analysis of variance (ANOVA), to determine significant differences among treatments, varieties and interaction variety*treatment using the software analysis system. Duncan test was performed to ascertain any significant differences between treatments means. The results were considered significant at $P < 0.05$.

3. RESULTS

3.1. Emergence rate

The emergence rate was different for the three maize varieties used in this work. On the 8th day after sowing emergence rate was: 79.91, 86.31 and 83.33 % for local variety, CMS 8501 and CMS 8704 respectively.

3.2. Effect of treatment on plant growth: Effect of treatment on plant growth at different weeks after sowing is presented in table I. The analysis of variance for the plant growth did not reveal significant differences $(p > 0.05)$ between treatment at 4, 7 and 10 WAS. The WT0, WT1, and WT2 treatments had average diameters of: 1.84 ± 0.4, 1.88 ± 0.99 and 1.83 ± 0.36 cm respectively ten weeks after sowing. The best plant height during these periods (7 and 10 WAS) was recorded under WT0 (0.92 ± 0.32 m) and WT2 (2.01 ± 0.17 m) treatments respectively. For the number of leaves produced by plants, in the tenth week after sowing, the lowest (12.25 ± 1.51) was obtained at WT0 treatment and the highest number of leaves (12.50 ± 1.80) was found in the treatment WT2.

Table 1: Table presents the collar diameter, height and leaves number per plant in the various treatments.

Parameters	Treatments	Time (WAS) 4 (WAS)	7 (WAS)	10 (WAS)
Diameter (cm)	**WT0**	1.17 ± 0.26a	1.83 ± 0.29a	1.84 ± 0.40a
	WT1	1.19 ± 0.24a	1.75 ± 0.23a	1.88 ± 0.39a
	WT2	1.22 ± 0.28a	1.71 ± 0.33a	1.83 ± 0.36a
LSD (0.05)		1.42	1.33	0.17
F_{cal}		0.24	1.67	0.33
Height (m)	**WT0**	0.29 ± 0.09a	0.92 ± 0.32a	1.94 ± 0.33a
	WT1	0.29 ± 0.07a	0.88 ± 0.20a	1.86 ± 0.45a
	WT2	0.29 ± 0.09a	0.86 ± 0.28a	2.01 ± 0.17a
LSD (0.05)		0.32	0.21	0.16
F_{cal}		0.57	0.24	0.17
Leafs number	**WT0**	9.44 ± 1.16a	13.61 ± 1.41a	12.25 ± 1.51a
	WT1	9.13 ± 1.50a	14.38 ± 1.09a	12.28 ± 1.32a
	WT2	9.47 ± 1.46a	13.42 ± 1.58a	12.50 ± 1.80a
LSD (0.05)		0.61	0.75	1.05
F_{cal}		0.80	0.44	0.15

Values in the columns followed by the same letter are not significantly different at p > 5 %. **WT0**: unweeded; **WT1**: hand weeding; **WT2**: chemical weeding

3.3. Varietal effect on plant growth: The analysis of variance reveals significant $(p < 0.05)$ differences between varieties with respect to stem diameter (7 and 10 WAS). V1 had an average diameter of (1.98 ± 0.34 and 2.06 ± 0.53 cm) which is significantly different from that of V2 (1.63 ± 0.25 and 1.72 ± 0.33 cm) and V3 (1.68 ± 0.25 and 1.78 ± 0.30 cm) which is not significantly different (Tab 2). For the plant height, V2 had the highest height (0.98 ± 0.31 m) on average followed by V3 (0.95 ± 0.24 m) and the lowest height (0.73 ± 0.25 m) was recorded at local variety at with (V1: 0.73 ± 0.15 m). The analysis of variance for the plant height reveal significant differences between varieties 7 WAS. In the same way, numbers of leaves reveal significant differences between varieties 7 WAS $(p > 0.05)$. For the average number of leaves, V2 produced less leaves (14.07 ± 1.22) compared to V1 (14.05 ± 1.3) and V3 (14.07 ± 1.22).

Table 2: Table presents the stem collar diameter, height and leaves number per plant for three maize varieties.

Parameters	Varieties	Time (WAS) 4 (WAS)	7 (WAS)	10 (WAS)
Diameter (cm)	V1	1.23 ± 0.27a	1.98 ± 0.34a	2.06 ± 0.53a
	V2	1.18 ± 0.28a	1.63 ± 0.25b	1.72 ± 0.33b
	V3	1.16 ± 0.23a	1.68 ± 0.25b	1.78 ± 0.30b
LSD (0.05)		2.12	2.20	0.27
F_{cal}		0.43	9.02	5.78
Height (m)	V1	0.26 ± 0.09a	0.73 ± 0.25b	1.96 ± 0.29a
	V2	0.32 ± 0.09a	0.98 ± 0.31a	1.95 ± 0.24a
	V3	0.29 ± 0.07a	0.95 ± 0.23a	1.90 ± 0.41a
LSD (0.05)		0.39	0.24	0.24
F_{cal}		2.91	11.23	0.28

Leafs number	V1	9.89 ± 1.12a	14.05 ± 1.36a	12.36 ± 1.62a
	V2	9.22 ± 1.44a	13.28 ± 1.49b	12.06 ± 1.64a
	V3	8.94 ± 1.56a	14.07 ± 1.22a	12.61 ± 1.38a
LSD (0.05)		1.19	0.73	1.04
F_{cal}		1.97	6.51	0.84

Values in the columns followed by the same letter are not significantly different at p > 5 %. **V1**: local variety; **V2**: variety CMS 8501; **V3**: variety CMS 8704

3.4. Inventory of diseases on various maize varieties

3.4.1 Pathological diseases: Throughout the experimentation, four principal pathological diseases were identified on plants of various plots (Smut ear, Fusarium ear, Helminthosporiosis and Rust). Diseases were identified based on visual observation. Only the helminthosporiosis was most important.

3.4.2 Physiological diseases: Various physiological diseases were noticed throughout the experimentation (Tab 3). Foliar spots diseases was the most frequent for the three varieties of maize.

Table 3: Table presents the physiological diseases typology on maize varieties plant.

Atypical diseases	Varieties		
	Local variety	CMS 8501	CMS 8704
Phosphorus deficiency	+	+	+
Not full ear	+++	+	+
Ungerminated seeds	+++	+	++
Leaves spots	++	++	++
Plant deformation	+	+	+

+: less frequent; **++**: frequent; **+++**: very frequent

3.5 Incidence and severity of the most representative diseases

3.5.1 Incidence of Helminthosporiosis and foliar spots: The appearance of helminthosporiosis disease on maize plants was observed five weeks after sowing. Regarding foliar spots and helminthosporiosis disease incidence (Table 4), significant differences to treatments were registered with the three varieties 75 days after sowing *($p < 0.05$)*. Generally, incidence of diseases was highest in treatment WT0 compared to treatment WT1 and WT2 for all varieties. The incidence of helminthosporiosis and foliar spots of varieties V2 and V3 was significantly higher in plots control (WT0) compared in plots weeding with hand and chemical weeding. No significant differences to variety and interaction variety*treatment were observed for helminthosporiosis and foliar spots disease incidence.

Table 4: Table presents the incidence of helminthosporiosis, foliar maize spots according to the techniques of weeding at 75 days after sowing.

Varieties	Treatments	Parameters	
		Helminthosporiosis	Foliar spots
V1	**WT0**	26.86 ± 1.81b	14.88 ± 3.25ab
	WT1	17.12 ± 2.42a	11.31 ± 1.78a
	WT2	22,45 ± 5.4ab	18.07 ± 2.61b
V2	**WT0**	10.19 ± 1.57b	14.77 ± 2.04b
	WT1	5.62 ± 1.08a	9.26 ± 2.35a
	WT2	4.16 ± 1.10a	7.05 ± 1.57a
V3	**WT0**	12.23 ± 2.33b	16.29 ± 2.89b
	WT1	5.66 ± 1.55a	9.09 ± 1.97a
	WT2	8.21 ± 1.91a	6.89 ± 1.55a

Values in the columns followed by the same letter are not significantly different at p > 5 %. **WT0**: unweeded; **WT1**: hand weeding; **WT2**: chemical weeding; **V1**: local variety; **V2**: variety CMS 8501; **V3**: variety CMS 8704

3.5.2 Severity of helminthosporiosis, foliar spots: Treatment effect, varietal effect and interaction variety*treatment were not significant for helminthosporiosis severity (*$p > 0.05$*). For the local variety, the severity of helminthosporiosis was 6.36 %; 5.75 % and 5.48 % for WT0, WT1 and WT2 respectively. These results showed that the local variety had the highest severity in all the treatments compared to improve varieties.

Severity of foliar spots for various maize varieties varied with the technique of weeding. The analysis of variance did not reveal any significant differences between treatments and between varieties. V3 registered the lowest severity 2.58 % in

WT2 treatment compared to 2.83 % and 5.22 % for treatments WT1 and WT0 respectively (Tab 5). No interaction variety*treatment significant was recorded. Concerning the deformation of plants, variety CMS 8501 recorded the highest severities 1.50 %, 1.50 % and 0.88 % in WT0, WT1 and WT2 treatments compared to the local variety and variety CMS 8704.

Table 3: Table presents the severity of helminthosporiosis, foliar maize spots and plant deformation according to the techniques of weeding.

Varieties	Treatments	Parameters		
		Helminthosporiosis	Foliar spots	Plant deformation
V1	**WT0**	6.36 ± 0.26	4.03 ± 1.36	0.0 ± 0.0
	WT1	5.75 ± 0.46	2.38 ± 0.43	0.88 ± 0.22
	WT2	5.48 ± 0.21	2.68 ± 0.82	0.67 ± 0.33
V2	**WT0**	5.58 ± 0.88	4.06 ± 1.14	1.50 ± 0.50
	WT1	3.88 ± 1.88	4.25 ± 1.39	1.50 ± 0.24
	WT2	2.08 ± 0.64	2.65 ± 0.74	0.88 ± 0.12
V3	**WT0**	4.06 ± 0.92	5.22 ± 0.50	0.0 ± 0.0
	WT1	2.94 ± 0.37	2.83 ± 0.78	0.0 ± 0.0
	WT2	4.19 ± 0.74	2.58 ± 0.68	0.63 ± 0.25

Values in the columns followed by the same letter are not significantly different at p > 5 %. **WT0**: unweeded; **WT1**: hand weeding; **WT2**: chemical weeding; **V1**: local variety; **V2**: variety CMS 8501; **V3**: variety CMS 8704

3.6 Maize yield: The analysis of variance showed significant differences to varieties and treatments *($p < 0.05$).* No significant differences to interaction between varieties and techniques of weeding *($p > 0.05$)* were observed for yields. The average yield recorded were 513, 1020 and 1032 $kg.ha^{-1}$ for local variety, variety "CMS 8501" and variety "CMS 8704" respectively. Furthermore, treatments WT0, WT1 and WT2 recorded: 727, 930 and 908 $kg.ha^{-1}$ yield respectively.

4. DISCUSSION

Of the three maize varieties used, only the emergence rate of improved varieties is greater than 80 % compared to the local variety, below this rate a seed is considered to be of poor quality [28]. The emergence rate required for a good cereal seeds according to the Direction of Regulation and Quality control of input and agricultural products is 85 % while the experimentation value is lower: 83.18 %. This weak emergence rate could be due to fungi attacks like *Fusarium*, *Penicillium* and *Aspergillus* with a prevalence of the *Fusarium* kind*.* This could be explained by asymptomatic infection (No visible symptoms) of certain species of this genus [29] and their prevalence in tropical and subtropical regions [30]. Indeed, Macdonald and Chapman (1996), Dewaminou (2004) noticed a prevalence of *Fusariam* on all maize samples from eleven countries of Central America, Africa and Asia [31, 32].

The heights of plants varied with weeding techniques over time. The unweeded plots had the highest sizes 49 days after sowing compared to sub-plots, hand and chemically weeded. This result is consistent with those of Ruyet (2006). This increment in height could be due to elongation of internodes in order to avoid shade [33]. Concerning the phytotoxicity of the chemical, no symptom was observed on the three varieties of maize tested, contrary to work of Barroso et al. (2012) which attests that a light chlorosis is observed on the young maize leaves seven days after pulverization of the chemical [22]. Before weeding, two families of bad grass were registered with 82.61 % being dicotyledons and 17.39 % monocotyledons in the experimentation. The high percentage of dicotyledons was due to their capacity to resist dry conditions and especially to quickly take life again in the moisture period.

During the experimentation, four diseases were listed with variable incidences. This result corroborates those of Frangoie et al. (2012) and Delessus (1968) who identified main maize diseases in West Cameroon [34, 3]. In the study conducted, only the local variety was attacked by smut ear. The CMS 8501 and CMS 8704 varieties in view of their selectivity and improvement characters in relation to the local variety do not have the same genotypic variability which would probably be justified by resistance to the pathogen responsible for the disease. Similarly, in the case of fusarium ear, all maize varieties were attacked with very low incidence. This could be explained by the elimination of weeds in manually and chemically weeded plots. Indeed, the presence of weeds can create conditions favoring the development of *Fusarium* spp., For example by increasing the moisture content of the cultures [35].

In this experimentation, Helminthosporiosis and leaves spots were most abundant. Weak disease incidence was noticed in hand weeded sub-plots compared to chemically weeded sub-plots and unwedded control who record highest incidences. This result suggests that the presence of weeds increases disease incidence. These results are in agreement with those of Candy (2006) whose findings reveal that diseases incidences tend to increase on crop when weeds are present on plots [36].

The results on severity of diseases reveal significant increase in rates of attacks on maize plants, lessening photosynthesis and consequently grains production. This result is in accordance with those of Moyal (1991) showing that diseases can cause heavy crop losses when their severity is high [37]. Nevertheless, the highest severity was observed towards end of cycle of the different varieties, and more precisely during the period of seventy-five days after sowing. It is for this reason that they are qualified foliar diseases of end vegetation [24].

The deformations of the plants developed on all the varieties with a severity rather weak in the case of our experimentation. The symptoms of this disease cause losses of yield in maize-grain. Indeed, according to Delassus (1968), the causes of malformations could not be given. Nevertheless, it indicates that too low temperatures or too weak luminosities can involve deformations of the stems and leaves.

It is noted that diseases cause: the shortening of internodes, foliar dryness, and negatively influence the phenomenon of photosynthesis as well as the accumulation of the substances causing non filling of ears, the production of the mycotoxins by ears. The works of Delassus (1963), Moyal (1991), Monde and Luka (2007), and Angra et Mandahak (1985) confirm our results on the impact of diseases in the production of maize [3, 37, 38, 39].

In this work, improved varieties yielded more than local variety. Weed control techniques influenced more or less the yield of maize-grains of the varieties. Manual weeding resulting in good yield. It was also noticed that in chemical weed control and manual weeding, maize grain production was similar despite environmental risk of chemical product used. Our results are in agreement with those of Ruyet (2006) showing that weeds can reduce maize yield due to the fact that they are in competition for hydro-mineral nutrition on one hand and on other hand weeds are reservoir for pathogenous organisms [33].

5. CONCLUSION

The interest of this study was to identify a more productive variety of maize, less susceptible to phytotoxicity of weed killer treatment and less attacked by diseases. We notice that weeding techniques did not have a negative effect on the parameters of growth. No symptoms of phytointoxication were observed on maize plants. Four pathological diseases and five physiological diseases were identified. The incidence of diseases on local variety was high compared to that of improved varieties which were tolerant. Hand weeding which yielded 930 kg/ha was the most adapted variety of maize for small scale producers. Both hand weeding and chemical weeding methods had very significant effects on disease reduction and increase in maize yield. Therefore, chemical weeding could be used to increase production of maize for small producers as in intensive culture but in a reasonable way.

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