



## **Some Correlation Coefficients of Maize under Soil-application of Pendimethalin in Mubi and Gombe Ecologies of Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author IJD designed the study and performed the statistical analysis. Author EAS wrote the protocol, carried out the field work and wrote the first draft of the manuscript. Authors HJP and MS managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Field experiment was carried out during the wet season of 2012 at the Teaching and Research Farm of Faculty of Agriculture, Adamawa State University, Mubi (Lat.10° 15' N and Long.13° 16' E, altitude of 696 m above sea level) and a Community based Demonstration Farm in Gombe (Lat.11° 30' N and Long.10° 20' E, altitude of 340 m above sea level). Both locations were situated in the Northern Guinea Savanna agro-ecological zone of Nigeria. The study was carried out to determine the level of correlation between weed parameters, growth and yield attributes of maize as affected by pendimethalin application. Treatments which consisted of six different rates of pendimethalin (1.0, 2.0, 3.0, 4.0, 5.0, 6.0kg a.i.ha<sup>-1</sup>) + two control checks (weed free and weedy check) were placed in the main plots as main treatment while maize cultivar SAMMAZ 17 was placed in the sub-plots as sub-treatments in a split plot design and replicated three times. Pendimethalin was pre-emergence- applied a day after sowing (DAS). Weed free check plots (control) were kept weed free by regular weeding. Similarly, all agronomic practices were adequately carried out except those under study. Data collected on weed cover score (WCS), weed fresh weight (WFW), weed dry

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weight (WDW), days to 50% emergence (D50E), crop injury score (CIS), crop vigour score (CVS), establishment count (EC), plant height (PH), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), days to 50% tasseling (D50T), 1000 grain weights (1GWTs) and grain yield (GY) were analyzed using Minitab Version 11 Statistical Software. Results revealed that WCS was significantly higher and strongly correlated with WFW, WDW but was strong and negatively associated with GY of maize in both Mubi and Gombe. D50E, D50T and LAI were positive but contributed weakly to the GY of maize in Mubi. Similarly, D50E, D50T, PH and LAI had same pattern of behavior as the former in Gombe. EC was negative and also contributed weakly to the grain yield of maize in both locations. PH, CVS, CGR, 1GWTs were positive and strongly associated with GY of maize in Mubi. The same trend was also observed for all parameters except PH which though positive it was weakly associated to the final GY of maize in Gombe. Pendimethalin did not posed any significant effect on the post- physico-chemical properties of the soils at the two experimental sites, except in soil-pH, organic carbon, available phosphorus, total nitrogen, magnesium, potassium and sodium in Mubi and available phosphorus, total nitrogen, Calcium, Magnesium and Potassium in Gombe. These soil properties were significantly influenced by rates of soil applied Pendimethalin compared to the control checks.

*Keywords: Pendimethalin; soil; weed; maize.*

## 1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals in Nigeria because of its industrial and domestic uses and it is produced throughout the country's diverse agro-ecologies. Maize production in Nigeria is plagued by many constraints such as biotic and abiotic stresses, prohibitive cost of fertilizer, poor agronomic practices, lack of high-quality seeds and poor extension services [1]. An important biotic constraint is weed infestation. Yield loss due to weeds in maize varies from 28-93%, depending on the type of weed flora, weed intensity and duration of crop-weed competition [2]. Weeds reduce crop yield by competing for space, light, water, soil nutrients and carbon dioxide, interfere with harvesting and increase the cost involved in crop production.

Uncontrolled weed growth had resulted in yield losses of 40-97% in maize [3,4], 91% in sweet potato [3] and 35%, 60%, 75% and 80% respectively even in a yam/maize/okra/sweet potato intercropping systems [5]. Thus, the need for adequate weed control for good crop yield cannot be over emphasized. However, since the bulk of labour requirement in crop production goes into weed control, it implies that the bulk of the total cost of production is gulped by weeding [3]. It was reported that weeding alone accounted for 30-45% of the total cost of maize production in Nigeria [6], while in India, the cost of weeding alone in pineapple production line stands as high as 40% of the total cost of production [7].

Many weed control measures have been proposed, which includes mostly the use of soil herbicides and hoe or manual weeding. Soil herbicide use is known to be effective and fast in action as a weed control measure [8], although it is quite expensive and not economically affordable especially in low input farming systems where weeds are most problematic. Manual weeding of soil is the oldest form of weed control measure as it has been used since time immemorial and it does not involve any expenses, though it is labour intensive, and not attractive.

Asides weed infestation, a major abiotic constraint to maize production in Nigeria is nutrient availability (especially nitrogen) [9] and moisture availability during critical stage of growth [10]. With the deployment of right agronomic practice in controlling weed infestation, issues relating to nutrient and moisture availability can also be resolved. This is because weeds compete for nutrients and moisture with plants on any farmland.

Most of the works in maize relates to either optimum edaphic or climatic conditions and very limited studies exits on the use of soil applied chemicals in combination with manual weeding of soil to handle weed pressure in maize in Gombe and Mubi. Therefore, this work was done to determine the relationship between maize performance characters and weed attributes in soils of Mubi and Gombe under soil-applied chemical using pendimethalin as an option.

## 2. MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farm of Adamawa State University, Mubi (Lat.10° 1' N, Long.13° 16' E and altitude of 696 m above sea level) and at a community based demonstration farm [CBDF] of Gombe State Agricultural Development Project [GSADP] in Gombe (Lat.11° 30' N, Long.10° 20' E and altitude of 340 m above sea level) in the Northern Guinea Savanna ecology of Nigeria [11]. Rainfall distribution pattern of the two locations is unimodal; with peak in August. The average annual rainfall ranges between 1000-1200 mm in both locations.

The experiment had eight treatments which consisted of six different rates of pendimethalin (1.0, 2.0, 3.0, 4.0, 5.0, 6.0 kg a.i.ha<sup>-1</sup>) + two control checks (weed free and weedy check). Pendimethalin rates were placed in the main plots as main treatment while the maize cultivar SAMMAZ 17 was placed in the sub-plots as sub-treatments which were laid in a split plot design and replicated three times. 3-4 seeds of maize cultivar were sown early August at a spacing of 0.75×0.25m for inter and intra row spacing respectively. However, seedlings were later thinned to one plant stand<sup>-1</sup> at 2 weeks after sowing (WAS).

The pendimethalin was applied into the soils as pre-emergence a day after sowing (DAS) using a CP3 knapsack sprayer fitted with green deflector nozzle set at a pressure of 2.1 kgcm<sup>3</sup> and in spray liquid volume of 240 Lha<sup>-1</sup>. Weed free check plots (control) were kept weed free by regular weeding. Similarly, all agronomic practices were adequately carried out except those under study. Data were collected on weed characteristics such as weed cover score (WCS), weed fresh weight (WFW) and weed dry weight (WDW). Other measurements are on growth and yield attributes such as days to 50% emergence (D50E), crop injury score (CIS), crop vigour score (CVS), plant height (PH), leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), days to 50% tasseling (D50T), 1000 grain weights (1GWTs) and grain yield (GY) in both locations.

Composite soil samples from the two locations were collected using soil auger at 0-20 cm depth and analyzed for some physical and chemical properties using standard procedures as described by Black [12]. The relationship between GY and weed control characteristics as well as between GY and other growth

parameters were also determined using Pearson's correlation matrix in Minitab Version 11 Computer Software.

## 3. RESULTS AND DISCUSSION

The physical and chemical properties of the soils in the study sites are presented in Table 1. In the two areas, sand, silt and clay contents are 59.1%, 26.9% and 14.0%, respectively for Mubi soils and 63.6%, 20.2% and 16.2% respectively, for Gombe soils. The textural classification of the soils from the two locations using a USDA textural triangle is sandy loam. The relatively high sand content in the areas reflects the Gombe Sandstone parent material. The parent materials of the soils of northern Nigeria have been noted to influence the texture of the soils derived from them [13]. The silt content in the soils can also be attributed to the effect of parent materials on the soils, as it has been reported that silt content is low in most soils of guinea savanna zones of Nigeria [13].

The soils of the studied sites are generally slightly acidic probably due to high intensity rainfall in the area, which leaches basic cations down the sandy profile. Raji and Mohammed [14] studied nature of soil acidity in Nigerian savannah and reported that the soils are largely strongly to slightly acidic. They submitted that the Northern Guinea Savannah has the highest total potential acidity in comparison to other savannah ecological zones.

In this study, maize exhibited a strong variation to soil-applied pendimethalin in respect to growth and yield parameters and their contribution to GY in both locations. Similar observation was reported by Ageliki, et al. [15] in silty clay loam soil, where guinea corn, oat and sugar beet, all sister grasses, exhibited high sensitivity to soil concentrations of pendimethalin. The weed control checks (weed free and weedy check) in the current work also created a two soil disturbance scenario- low and high soil disturbances [16] and [17] under which soil surfaces, and maize growth and yield parameters and their contribution to GY in both locations were influenced. Under low soil disturbance conditions, most of the available soil nutrient remain on the soil surface even after sowing operations, where it would be susceptible to loss through volatilization and photodecomposition [17]. Conversely high soil disturbance due to the greater soil coverage, would reduce the losses due to volatilization and photodecomposition [16].

WCS was positive and highly significantly correlated with WFW and WDW ( $P \leq 0.01$ ). Similarly, WFW was positive and strongly associated with WDW ( $P \leq 0.01$ ) while GY was also positively related to 1GWTs. However, WCS, WFW and WDW was negative and significantly correlated with GY and 1GWTs in Mubi (Table 2) [18,19,7]. The same trend was obtained in Gombe (Table 3). D50E was strongly and negatively correlated with establishment count (EC), weakly and negatively

related with LAI, CGR but was positively associated with CIS, CVS, PH, D50T, GY and 1GWTs. Plant EC was negatively associated with CIS, CVS, PH, D50T, GY and 1WTs. This also agrees with findings of Mohsan, et al. [20] who reported a negative association between PH and D50T and GY. However, it was positively related with LAI, CGR and RGR which is also in line with the report of Viola, et al. [21] and Venugopal, et al. [22].

**Table 1. Results of some physical and chemical analysis of the experimental sites at 0-30 cm depth during the 2012 cropping season**

Soil properties	Experimental sites	
	Mubi	Gombe
<b>Physical properties</b>		
<b>Particle size analysis (%)</b>		
Sand	59.1	63.6
Silt	26.9	20.2
Clay	14.0	16.2
Texture	Sandy Loam	Sandy Loam
<b>Chemical properties</b>		
Soil $p^H$ 1:2 ( $H_2O$ )	5.90	6.44
Organic carbon ( $g\ kg^{-1}$ )	4.8	4.1
Available P ( $mg\ kg^{-1}$ )	6.88	7.24
Total N ( $g\ kg^{-1}$ )	0.67	0.69
CEC ( $Cmol\ kg^{-1}$ )	3.44	3.70
<b>Exchangeable bases (<math>Cmol\ kg^{-1}</math>)</b>		
Ca	1.92	2.88
Mg	0.40	0.42
K	0.53	0.58
Na	0.34	0.46

**Table 2. Simple correlation coefficient between weed parameters and grain yield as influenced by pendimethalin in Mubi during 2012 cropping season**

	WCS	WFW	WDW	GY	1GWTs
WCS	1.000				
WFW	.968**	1.000			
WDW	.935**	.944**	1.000		
GY	-.740**	-.788**	-.774**	1.000	
1GWTs	-.962**	-.962**	-.890**	.764**	1.000

WCS= Weed cover score; WFW= Weed fresh weight; WDW= Weed dry weight; GY= Grain yield; 1GWTs= 1000 grain weights; \*\* = Significant at 1% level of probability

**Table 3. Simple correlation coefficient between weed parameters and grain yield as influenced by pendimethalin in Gombe during 2012 cropping season**

	WCS	WFW	WDW	GY	1GWTs
WCS	1.000				
WFW	.917**	1.000			
WDW	.821**	.835**	1.000		
GY	-.908**	-.815**	-.673**	1.000	
1GWTs	-.942**	-.943**	-.787**	.909**	1.000

WCS= Weed cover score; WFW= Weed fresh weight; WDW= Weed dry weight; GY= Grain yield; 1GWTs= 1000 grain weights; \*\* = Significant at 1% level of probability

**Table 4. Simple correlation coefficients between grain yield and other characters of maize grown under the influence of pendimethalin in Mubi during 2012 cropping season**

	D50E	EC	CIS	CVS	PH	LAI	CGR	RGR	D50T	GY	1GWTs
D50E	1.000										
EC	-.713**	1.000									
CIS	.564**	-.914**	1.000								
CVS	.046	-.145	.222	1.000							
PH	.226	-.253	.223	.655**	1.000						
LAI	-.067	.008	.305	.802**	.417*	1.000					
CGR	-.069	.139	-.153	.801**	.775**	.273	1.000				
RGR	-.152	.475*	-.497*	.162	.552**	.383	.643**	1.000			
D50T	.637**	-.765**	.676**	.072	.307	-.092	-.090	-.115	1.000		
GY	.163	-.294	.313	.782**	.640**	.605**	.338	.123	.201	1.000	
1GWTs	.278	-.440*	.489*	.887**	.570**	.570**	.082	-.063	-.097**	.764**	1.00

D50E= Days 50% Emergence; EC= Establishment count (2WAS); CIS= Crop injury score; CVS= Crop vigour score (8WAS); PH= Plant height (8WAS); LAI= Leaf area index (8WAS); CGR= Crop growth rate (8WAS); RGR= Relative growth rate (WAS); D50T= Days 50% Tasseling; GY= Grain yield; 1GWTs= 1000 grain weight; \* = Significant at 5% level of probability; \*\* = Significant at 1% level of probability; WAS = Weeks after sowing

**Table 5. Simple correlation coefficients between grain yield and other characters of maize grown under the influence of pendimethalin in Gombe during 2012 cropping season**

	D50E	EC	CIS	CVS	PH	LAI	CGR	RGR	D50T	GY	1GWTs
D50E	1.000										
EC	-.905**	1.000									
CIS	.912**	-.943	1.000								
CVS	.203	-.262	.186	1.000							
PH	.379	-.400	.223	.783**	1.000						
LAI	.312	.399	.308	.722**	.703**	1.000					
CGR	-.095	.040	-.105	.837**	.509*	.439*	1.000				
RGR	-.294	.313	-.328	.684**	.187	.095	.693**	1.000			
D50T	.596**	.467*	.627**	.243	.084	.065	.077	.008	1.000		
GY	.245	-.210	.233	.447**	.827**	.309	.309	.024	.195	1.000	
1GWTs	.590*	-.476*	.485*	.582**	.922**	.429*	.429*	.059	.050	.909**	1.000

D50E= Days 50% Emergence; EC= Establishment count (2WAS); CIS= Crop injury score; CVS= Crop vigour score (8WAS); PH= Plant height (8WAS); LAI= Leaf area index (8WAS); CGR= Crop growth rate (8WAS); RGR= Relative growth rate (WAS); D50T= Days 50% Tasseling; GY= Grain yield; 1GWTs= 1000 grain weight; \* = Significant at 5% level of probability; \*\* = Significant at 1% level of probability; WAS = Weeks after sowing

Table 6. Post effect of pendimethalin on the soil physico-chemical properties at the experimental sites during the 2012 cropping seasons

Treatments	Mubi											
	Sand	Silt	Clay	pH	OC	Av.P	TN	CEC	Ca	Mg	K	Na
<b>Control Checks</b>												
Weed free	58.5	27.4	14.1	5.92a	4.43a	5.90a	0.61a	3.41	1.92	0.42a	0.50a	0.34a
Weedy check	57.5	27.4	15.1	5.75a	4.22b	5.71a	0.58a	3.15	1.87	0.40ab	0.49b	0.33a
<b>Pendimethalin (kg a.i/ha)</b>												
1.0	59	26.8	14.2	5.53b	4.19b	5.51ab	0.58a	3.06	1.55	0.39abc	0.49b	0.33a
2.0	58.1	27.9	14.0	5.33bc	4.15bc	5.50ab	0.56ab	3.06	1.54	0.39abc	0.48bc	0.33a
3.0	56.8	28.3	14.9	5.30c	4.11bcd	5.50ab	0.55ab	3.04	1.54	0.38abcd	0.48bc	0.31bc
4.0	57.1	27.9	15.0	5.25c	4.01cd	4.95b	0.55ab	3.04	1.53	0.35bcd	0.47cd	0.31bc
5.0	58.1	27.3	14.6	5.21c	3.97d	4.95b	0.51b	3.02	1.52	0.34cd	0.47cd	0.30c
6.0	57.2	28.1	14.7	5.18c	3.93 d	4.95c	0.50b	3.01	1.51	0.33d	0.46d	0.30c
LS	ns	ns	ns	*	*	*	*	ns	ns	*	*	*
SE±	1.0	0.55	0.85	0.10	0.08	0.30	0.03	0.20	0.22	0.02	0.00	0.01
<b>Gombe</b>												
<b>Control Checks</b>												
Weed free	64.7	20.7	14.6	5.60	3.30	3.48a	0.55a	2.60	2.00	0.36a	0.36a	0.49
Weedy check	64.7	20.7	14.6	5.60	3.30	3.43a	0.54a	2.58	1.98	0.33ab	0.35ab	0.36
<b>Pendimethalin (kg .i/ha)</b>												
1.0	64.7	20.7	14.6	5.60	3.13	3.41a	0.51ab	2.58	1.97	0.32abc	0.32abc	0.34
2.0	64.7	20.7	14.6	5.48	3.09	3.41a	0.46abc	2.57	1.97	0.28abc	0.32abc	0.34
3.0	63.8	22.2	14.0	5.48	3.09	3.38a	0.43bc	2.41	1.61	0.21bc	0.29abcd	0.34
4.0	62.1	22.1	15.8	5.15	2.75	2.95b	0.42bc	2.36	1.60	0.21bc	0.27bcd	0.29
5.0	61.9	22.3	15.8	5.10	2.75	2.94b	0.41bc	2.33	1.55	0.20c	0.25cd	0.29
6.0	62	22.2	15.8	5.10	2.75	2.94b	0.39c	2.33	1.55	0.19c	0.24d	0.26
LS	ns	ns	ns	ns	ns	*	*	ns	*	*	*	ns
SE±	1.23	0.91	1.54	0.22	0.23	0.18	0.03	0.12	0.18	0.04	0.02	0.12

LS. Level of significance; OC. Organic carbon; Av.P. Available phosphorus; TN. Total nitrogen; \*Significant at 5% probability level; NS. Not significant; Means with the same letter are not significantly different according to DMRT

Furthermore, CIS was positively related to CVS, PH, LAI, D50T, GY and 1GWTs but was negatively associated with CGR as well as RGR. CVS was positively correlated with PH, LAI, CGR, RGR, D50T, GY and 1GWTs. A similar trend was also obtained for plant height with its attributes. LAI was positively correlated with CGR, RGR, D50T, GY and 1GWTs but was negatively associated with D50T. The positive association between PH and CVS indicate that PH is an expression of CVS except in the case of etiolated growth which could result from the competition or struggle to intercept solar radiation, higher GY can result in greater competition for assimilates which can reflect on 1000 lighter weight of grains. This agrees with the findings of several authors [23,24,25,26]. Similarly, CGR was positively associated with RGR, GY and 1GWTs but was negatively associated with D50T. A negative correlation exists between 1GWTs with D50T and RGR but was positively related to GY (Table 4). This was also in line with the findings of Mohsan, et al. [20] who reported a negative association between PH, D50T and GY of maize. This is a common indication of etiolated growth which could have resulted from the competition or struggle to intercept solar radiation. The same pattern was also obtained in Gombe but with little variation only with CVS, RGR, D50T and GY which were independently positively correlated with their parameters (Table 5).

Pendimethalin did not pose any significant effect on the post physical and chemical properties of the soils at the two experimental sites, except in soil pH, organic carbon, available phosphorus, total nitrogen, magnesium, potassium and sodium in Mubi, and available phosphorus, total nitrogen, calcium, magnesium and potassium in Gombe where these soil properties were significantly influenced by rates of soil-applied Pendimethalin compared to the control checks (Table 6). Earlier, [27] particularly showed that leaching of Ca and Mg is largely responsible for acidity development in soils. Also, it may be due to Al saturation of the exchange complex. Acidity (low pH) of the soils may also be due to the effect of cultivation, erosion and leaching of nutrients or a combination of these. The organic matter contents are medium (>2.0%) for the pedons based on organic matter rating of Nigerian soils by Enwezor, et al. [28]. This is evidence of pendimethalin incorporation into the soils. The medium values of organic matter would encourage a rapid leaching of cations into the subsoils from the surface. The soils are low

in ECEC (<12.04 cmol/kg) and low in available P and total N. According to Zarafi [29], the tropics which include northern Nigeria, is characterized by high temperature and low relative humidity conditions that favour rapid decomposition and mineralization of organic matter. The available phosphorus content of the soils was generally low based on the rating for Nigerian soils (<15mg/kg) [28,13]. Generally, the low phosphorus content may be due to high soil acidity [29]. It has been reported that in acid soils, P is fixed by Fe, Al and Mn [30]. The low content of total N in the soils could be attributed to inadequate organic matter of these soils. The levels of nitrogen and phosphorus in the soils may also be due to intensive cropping practices without measures to build up soil nutrient reserves. Considering the critical value for phosphorus, the soils under the various land use types may require phosphate fertilizer application for a sustainable crop yield.

#### 4. CONCLUSION

Results from the degree of association indicated that WCS, WFW and WDW were strong but negatively associated with final GY in both Mubi and Gombe. EC was strong but contributed negatively to the final GY of maize in Mubi and Gombe respectively. CIS and D50T were positive and strongly related to GY and 1GWTs in Mubi while CIS alone was positive and strongly associated with GY in Gombe. CVS and PH were positive but weakly associated with GY. However, LAI, CGR and RGR were negative and weakly associated to final GY and 1GWTs of maize in Mubi and Gombe respectively. Pendimethalin did not posed any significant effect on the post- physico-chemical properties of the soils at the two experimental sites, except in soil-pH, organic carbon, available phosphorus, total nitrogen, magnesium, potassium and sodium in Mubi and available phosphorus, total nitrogen, Calcium, Magnesium and Potassium in Gombe. These soil properties were significantly influenced by rates of soil applied Pendimethalin compared to the control checks.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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