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Case Study of Maize Growth in Different Soil Conditions [!]

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In 1989, the soil in a section of a maize field in the experimental farm of Kyushu University was moved and subsequently leveled by machine. But in 1990, the maize growth of the above treated field was not vigorous from an early stage compared with the growth of maize in an adjacent area. Growth analysis of the maize was then carried out to identify the nature of the growth retardation, and physical and chemical soil analyses were carried out to investigate the reason for the growth difference between the adjacent maize fields. The final dry matter weight of the treated and untreated areas was about 1400 and 2000 gm^{-2}, respectively, and maximum LAI were 4.7 and 7.2, respectively. Though no difference in soil chemicals was found, soil properties were so different that maximum water capacity, and porosity were smaller and also bulk density was larger, in the treated area. These results suggest that the soil aeration is insufficient and consequently root development has been retarded leading to poor growth. Compacting of soil by machine might be the cause of the growth problems.

INTRODUCTION

In the Kyushu University farm, 2.5 ha of land has been cultivated with maize as a fodder crop. In 1989 the soil of a section of this field was moved and leveled by machine. During cultivation on 1990, we found from an early stage of growth that maize in the treated field above was poor compared with the untreated field, although the fields were adjacent and the system of cultivation was the same.

In this paper, the growth differences between the two locations above are described and then the reasons for these differences are discussed using physical and chemical soil analysis.

MATERIALS AND METHODS

The map of the maize field is shown in Fig. 1. The west side from point **A** is the area of vigorous growth and the east side from point **B** represents the area of poor growth.

The following growth analysis of maize and physico-chemical properties of the soil was carried out.

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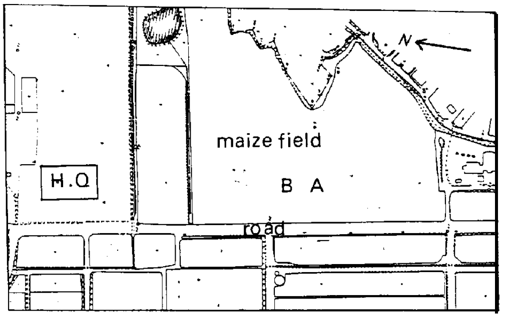

Fig. 1. Map of the maize field in Kyushu University farm.

1) **Field management and growth analysis.**

A compound fertilizer containing N, P_2O_5 and K_2O was applied as a basal dose at 340 kg/ha, and Mg as MgO at 150 kg/ha and Ca as lime at 250 kg/ha. In addition, 120 kg of N was also applied as urea in both areas as top dressing 35 days after sowing. The basal dose was applied 2 days before sowing. Maize seeds variety p3358 were sown on May 9 1990. Row to row distance was 65 cm and plant to plant distance was 25 cm sown by a sowing machine. No irrigation was required from sowing to harvest. The crop was not infected by disease or insects. The samples at the locations **A** and **B** in Fig. **1** were taken seven times from May 29 to July 28. Each sampling of **1** x 0.65 m^2 was replicated three times. After separating leaf, leaf sheath and stem, cob and tassel, leaf area was measured by a leaf area meter (AAM-8, HAYASHI Inc.) and each part of the sample was dried at 80-85 °C in an oven for about 48 hrs. The light intensity in the canopy was measured by a Sunfleck Ceptometer (Decagon Device Inc.) and clipping the leaf at each level of forage was done on July 6.

2) **Physical and chemical analysis of soil**

Soil was sampled at **A** and **B** locations. Initially the soil was collected from each location at three depths (O-10, 10-20 and 20-30 cm) for analysis of physical properties, maximum water capacity and moisture equivalent analysis. Finally soil was collected at each location from three points at two different depths (0-17 cm, and below 19 cm) for the analysis of particle size, soil pH, electric conductivity and chemical analysis.

Soil texture was classified according to USDA system (USDA, 1975). Maximum water capacity and field moisture capacity were measured using the soil pillar (Klute 1965) and centrifugal (Peters 1965) methods, respectively. Wilting point was estimated approximately from the moisture equivalent values (Shiina, 1977). Particle size distribution was carried out according to the normal method.

Soil pH was measured by a glass electrode method. Soil Electric Conductivity (EC) was measured using a soil-water ratio of 1 : 5. Total nitrogen was determined by the Kjeldahl method. Available phosphorus was analyzed by the Bray pl test method (Jackson 1962). Potassium was analyzed by the Flame photometry method (Jackson 1962).

RESULTS

Growth characteristics

Total dry matter for the **A** location gradually increased until the final harvest.

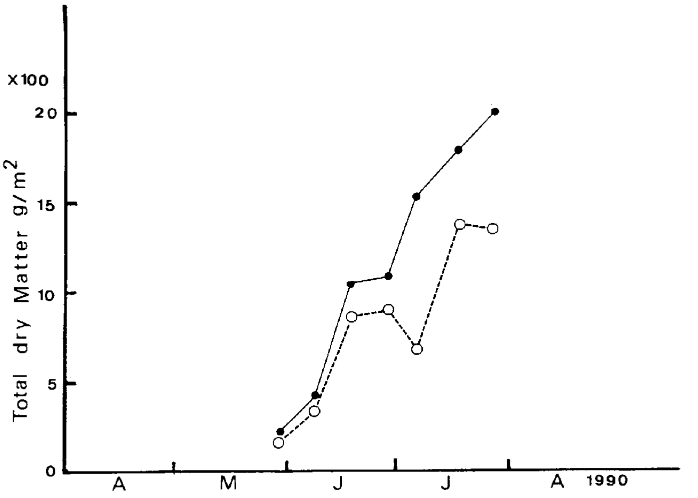

Fig. 2. Seasonal change of total dry matter weight of maize ···●···; ···o···; A and B location in fig. 1, respectively.

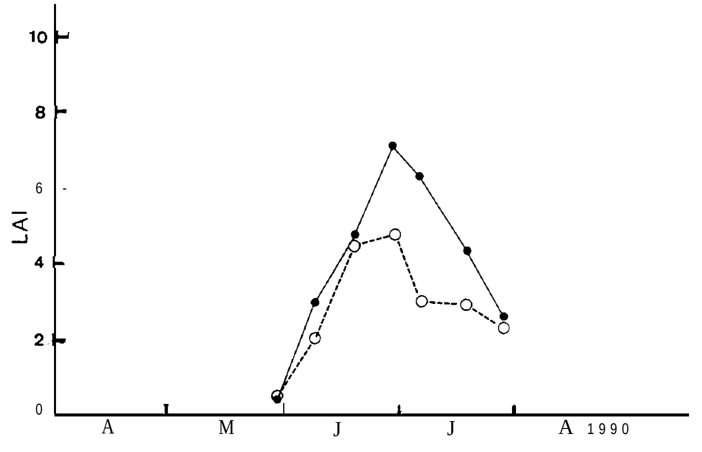

Fig. *3.* Seasonal change of leaf area index (LAI) of maize. ··· ● ···; ··· ○ ···; A and B location in fig. 1, respectively.

Poor dry matter weight was recorded at the **B** location where the trend of increase was not regular. A downward tendency in dry matter production at the **B** location was observed at the final harvest (Fig. 2). Maximum dry matter was found to be 2000 g/m² at the 7th harvest for the **A** location and 1382 g/m² at the 6th harvest for the **B** location. Leaf area index (LAI) for both locations increased steadily up to the 4th harvest (Fig. 3). Then the LAI declined sharply. From an early stage of plant growth, LAI was smaller at the **B** location than at-the **A** location (Fig. 3). The highest LAI at

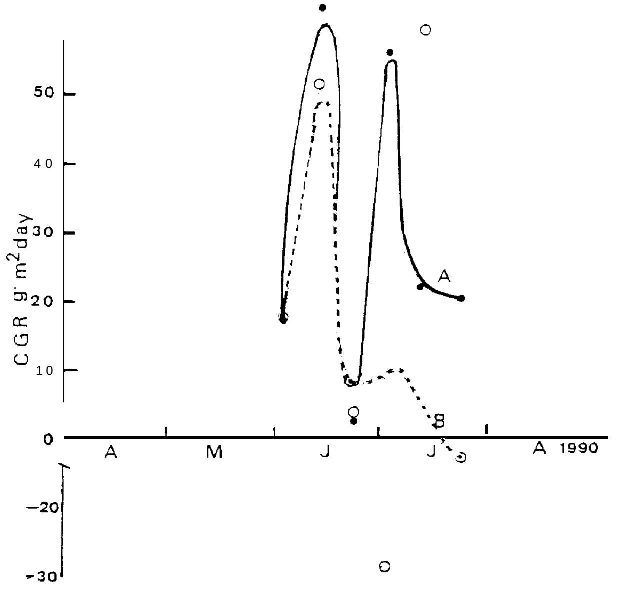

Fig. 4. Seasonal change of crop growth rate (CGR) of maize. ···●···; ···○···; A and B location in fig. 1, respectively.

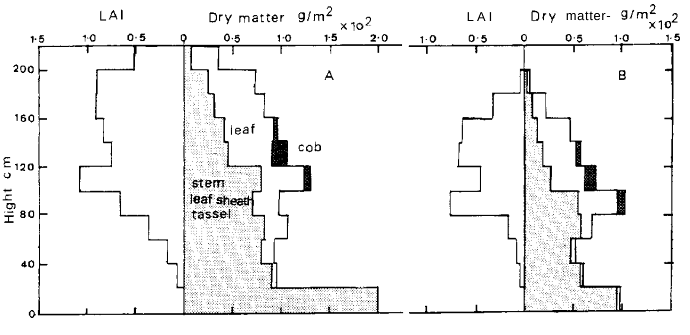

Fig. 5. Production structure of maize. A, B show the A and B location in fig. 1, respectively.

the 4th harvest was 7.2 and 4.8 for the **A** and **B** locations respectively. Crop growth rate increased steadily up to the 2nd harvest and a decreasing trend was recorded in the next two harvests (Fig. 4). However, at the 5th harvest, crop growth rate increased in both locations.

Production structure and extinction coefficient.

Vertical distribution of LAI was not very different between **A** and **B** locations (Fig. 5). The relationship between cumulative leaf area index and light intensity in the canopy shows a higher extinction coefficient (K) at location **B.** Extinction coefficients were 0.268 and 0.449 at **A** and **B** locations respectively (Fig. 6).

Soil physical and chemical properties.

The soil pH and EC are almost the same at both locations (Table 1). Maximum water capacity and field moisture equivalent are also almost the same (Table 2). Course sand and fine sand percentage is the same (Table 3). Air phase percentage is less at the **B** location than at the **A** location. On the other hand moisture percentage is greater at the **B** location than **A** location (Table 4). Soil chemical analysis shows no difference between **A** and **B** locations (Table 5).

Table 1. Soil pH and EC*

Location* *	Depth (cm)	Soil pH	EC (μS/cm)
A	o-17	4.8	80
	17–	4.9	128
B	o-19	5.9	135
	19–	6.2	111

* : electric conductivity.
** : shown in Fig. 1.

Table 2. Maximum water capacity and moisture equivalent.*

Location* *	Soil depth (cm)	Maximum water capacity (%)	Moisture equivalent (%)	Wilting point (%)	Available water (%)
A	0–10	34.5	20.8	11.3	23.2
	10-20	30.8	19.7	10.7	20.1
	20–30	31.2	20.6	11.2	20.0
B	0–10	31.0	20.3	11.3	19.7
	10-20	25.8	19.2	10.4	15.4
	20-30	27.7	21.1	11.5	16.2

* : moisture equivalent PF=2.7.
** : shown in Fig. 1.

Table 3. Particle size distribution of soils.

Location*	Soil depth (cm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay-soil (%)	Soil Texture* *
A	o-17	23.5	24.3	42.8	9.4	L
	17—	23.1	23.8	46.4	6.7	L
B	o-19	21.4	26.5	48.5	3.5	L
	19—	20.3	25.1	50.0	3.6	SiL

* : shown in Fig. 1.
** : L: loam
SiL : silty loam

Table 4. Selected physical properties soils at the location* A and B.

Location*	Soil depth (cm)	Air phase (%)	Moisture phase (%)	Solid phase (%)	Specific gravity	Porosity (%)	Bulk density (g/cm³)
A	0-10	32.5	24.6	42.9	2.7	57.2	1.16
	10—20	20.5	29.1	50.4	2.7	49.6	1.36
	20-30	19.9	31.0	49.0	2.7	51.0	1.32
B	O-10	27.8	26.0	46.0	2.7	53.8	1.25
	10-20	6.7	37.7	55.6	2.7	44.4	1.50
	20-30	11.1	41.6	47.3	2.7	52.7	1.28

* : shown in Fig. 1.

Table 5. Nutritional status of N, P and K of Soils.

Location*	Soil depth (cm)	Total nitrogen (%)	Available P (ppm/dry soil)	Exchangeable K (me/100g dry soil)
A	o-17	0.10	113	0.68
	17—	0.10	112	0.66
B	o-19	0.11	82	0.68
	19—	0.11	65	0.51

* : shown in Fig. 1.

DISCUSSION

A major objective of this experiment is to investigate the cause of the differential growth in maize at two locations **A** and B shown in Fig. 1. As Figs. 2 and 3 show, the maize growth at location **A** is very vigorous. The difference in crop growth rate between **A** and **B** locations increases with the stage of growth (Fig. 4). In our study, the dry matter production at the **A** location increased steadily until the final harvest. At the **B** location, however, the dry matter production tended to decrease before the final harvest although the soil status was same.

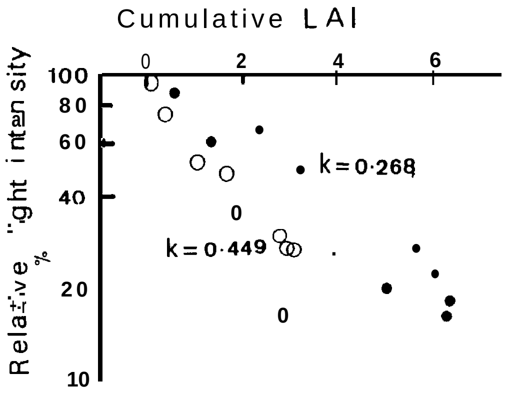

Fig. 6. Relationship between cumulative LAI and relative light intensity in the canopy of maize. Symbols ● and o show the A and B location in fig. 1, respectively.

First, we must consider light interception by the canopy. Hirota and Takeda (1987) simulated canopy photosynthesis of a C_4 plant that was higher using a large extinction coefficient (K) than using a small one in LAI < 6, because the single leaf photosynthesis of a C_4 plant increases with light intensity under natural conditions. Also in this experiment, although the extinction coefficient at the A location is smaller than at the B location (Fig. 6), this does not indicate effective light use by the canopy at the A location, because the maize is a C_4 plant, and consequently photosynthesis is not saturated due to light intensity (Hesketh and Moss, 1963, Singh, et al., 1974). On the other hand, even considering soil chemicals, there is no clear difference between A and B locations (Table 5). But we can see the differences in physical soil properties

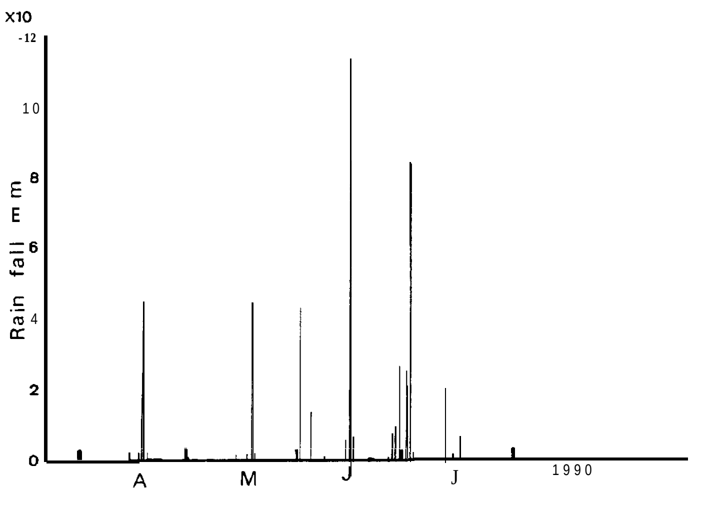

Fig. 7. Daily rainfall during growing period of maize (1990).

(Table 4). Air phase percentage at the **A** location is larger than at the **B** location. And the porosity (%) in the soil at the **A** location is larger than at the **B** location in the range between 0 to 20 cm soil depth and bulk density was also lower at the **A** location at the same depth. These results indicate that root growth may be larger at the **A** location than the **B** location because of higher oxygen content in the air near the root (Grable and Siemer 1968). On June 15 1990 the rainfall was 113.5 mm (Fig. 7). After rainfall, water could not drain away as quickly at the **B** location as it could at the **A** location. We can see in Fig. 1 that from June 18 to 28 plant growth was retarded in both locations.

Finally, we found that due to the land leveling, top soil was removed. For this reason the **B** location downsoil was compact and plant roots could not develop. Physical properties of the soil were not favorable for the optimum growth of the maize crop.

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