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Full Length Research Paper

Seedling characters at different temperatures in pearl millet (*Pennisetum glaucum* (L.) R. Br.)

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The effect of six temperatures ranging from 20 to 45°C on the germination and seedling length of six grain pearl millet genotypes (KS, AM, HG, EC, ZZ and D) was determined. There was significant variation in germination and seedling length across temperatures and among genotypes. As a result, significant temperature × genotype interactions occurred. Emergence problems, due to poor germination and inadequate seedling length, were likely found in certain genotypes at high and low seed temperature. The optimum temperature for coleoptile and radicle elongation was 30°C.

Key words: Germination, pearl millet, temperature, seedling length, root length, genotype, coleoptile, Tunisia.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is one of the most extensively cultivated cereals after rice, wheat and sorghum in arid to semi-arid regions. It is a principal food cereal cultivated on 25 million ha of the drought prone semi-arid regions of Africa and Indian subcontinent and has been grown most extensively as a forage crop in USA, Australia, Southern Africa and South America (Burton, 1980; Anand and Andrews, 1993; Burton and Wilson, 1995).

In Tunisia, pearl millet is not a staple food of rural populations as in the other countries of Africa. Nevertheless, it occupies a very important part of the surfaces every year in the Central and Southern parts of the country. The first imperative of a satisfactory culture consists of its suitable establishment and the success of the phases of germination that determines the entire period of vegetation. In fact, when establishment levels are low, higher seedling rates are required, yield is reduced and replanting may be necessary, all of which reduce financial returns. Furthermore, the response of seeds to temperature variations could also be an indicator of the plant's tolerance at the later stages of development.

Considering all these problems, we understand the interest of the attempts made on germination under variable temperature conditions, to identify the populations which adapt to low or high temperatures. Seedling tests, under variable temperature, may help select genotypes adapted to different geographical regions and aim at assessing them.

There are many advantages in early planting of crops (Totok et al., 1997). It allows for safe harvesting before the onset of rain or frost that may decrease seed yield and quality. It enables the marketing of an early and competitive produce (Blum, 1988), and increases the number of options available for subsequent crops (Kane and Grabau, 1992). To develop early planting genotypes of pearl millet, information concerning germination at low temperatures are important, because low temperature stress is the most common environmental stress affecting germination (Blum, 1988). In addition to reduction in germination, subsequent seedling growth is also inhibited at low temperatures.

On the other hand, many authors (M'ragwa et al., 1995; Yoshida and Sumida, 1996) found that seedling root length and coleoptile length in pearl millet were heritable and further selection gain was possible.

The aim of this work include assessing: (a) The variability among genetically diverse pearl millet genotypes for germination and for coleoptile and radicle lengths, (b) the interaction between elongation and temperature, and (c) selection of genotypes for early (for grass exploitation) or late planting (for seed exploitation).

MATERIALS AND METHODS

Seeds of six genetically diverse genotypes (KS, AM, HG, EC, ZZ and D) were germinated in controlled temperature incubators at six constant temperatures (20, 25, 30, 35, 40 and 45°C). Fifty randomly

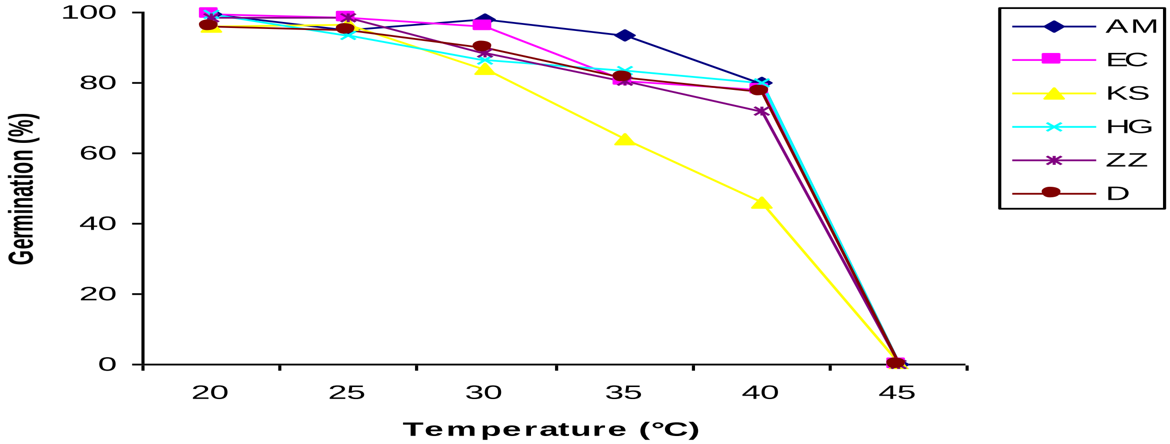

Figure 1. Effect of temperature on the germination of six ecotypes of pearl millet. L.S.D. (P=0.05) = 10.8.

Table 1. Effect of temperature on the germination of 6 autochthonous ecotypes from Tunisia.

Genotype	Germination %	
	20°C	40°C
AM	99.3	80.0
KS	96.0	46.0
ZZ	98.7	72.0
HG	99.3	80.0
EC	99.3	78.0
D	98.0	77.3

L.S.D. (P=0.05): 10.8.

chosen seeds of each population were placed on a filter paper in a Petri dish (9 cm in diameter), with 4 Petri dishes per group. The Petri dishes were kept at several temperatures for one week in order for the seeds to germinate. However, 1 ml of distilled water was supplied to each Petri dish daily. After seven days of incubation, the shoot length of germinated seeds was measured, and the same procedure was applied for root length.

Autochthonous genotypes were collected from different ecological regions in Tunisia. Three pearl millet populations were tall in stature (KS, EC and ZZ) while the others were short (HG, AM and D). Data were analyzed with analysis of variance (ANOVA), and means were separated by the least significant difference (L.S.D.) using P< 0.05.

RESULTS

Effect of temperature on germination

The effect of temperature on the germination of the six genotypes is shown in Figure 1, and the temperature × genotype interaction was significant at P<0.05. At 20, 25 and 30°C, germination was high (90% or more) with no significant differences among genotypes (Figure 2), while at a temperature above 30°C, germination declined in some genotypes, particularly in KS and EC. However, germination was low in all lines at 40°C and was completely inhibited at 45°C.

The optimum temperature range for germination varied from 20 to 40°C for AM and from 20 to 30°C for EC and only from 20 to 25°C for KS. The effect of temperature on the germination of the six genotypes is shown in Table 1. Germination of KS at 40°C was low when compared with the other genotypes (Table 1).

Effect of temperature on seedling length

The effect of temperature on final seedling length of the six genotypes is shown in Figure 2, and the temperature × genotype interaction was significant at P<0.05. Mean seedling length (coleoptile) varied from 15.13 (ZZ at 30°C) to 6.33 cm (KS at 20°C). There was genetic diversity in seedling length and its response to temperature. KS produced its longest seedling (11.4 cm) at 40°C, whereas AM produced its shortest seedling (8.9 cm) at 20°C. However, the situation was reversed. Among the six genotypes, KS produced the longest

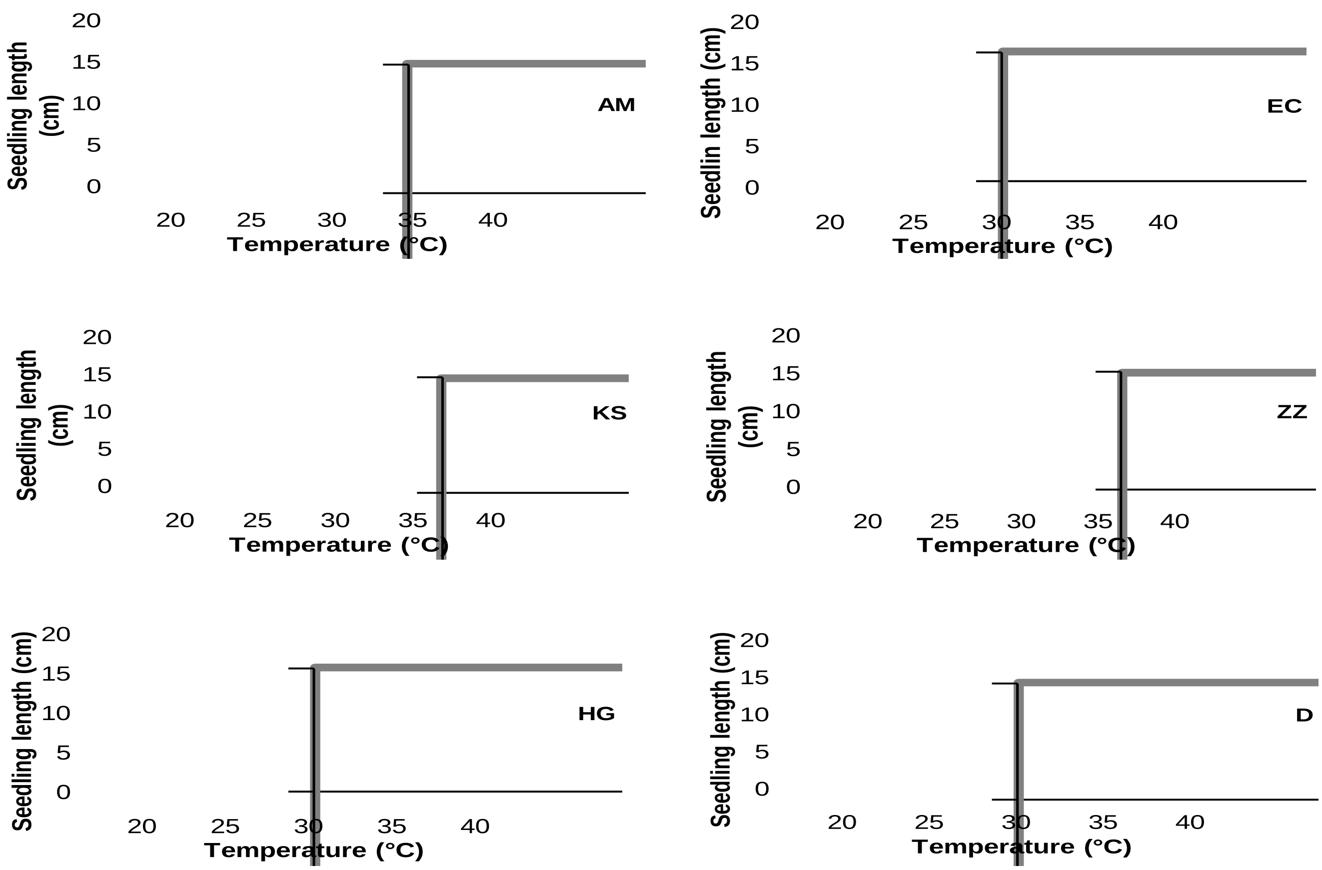

Figure 2. Effect of temperature on the seedling length of six ecotypes of pearl millet. L.S.D.: (P=0.05) between genotypes = 0.7, (P=0.05) between temperatures = 0.61, (P=0.05) interaction (genotypes × temperatures) = 2.07.

seedling at high temperatures of 30, 35 and 40°C.

Effect of temperature on root length

As for coleoptile, 30°C remained the most favorable temperature for good root development (Figure 3). At this temperature, mean root length (radicle) varied from 18 (ZZ and KS) to 12.2 cm for HG. There was genetic diversity in root length and some genotypes seemed to have more than one thermal optimum.

DISCUSSION

For millet, it was shown that the optimal germination temperature was close to 25°C. Nevertheless, the six genotypes continued their germination properly at higher temperatures. Generally, we can classify the favorable temperature for physiological germination of millet between 20 and 35°C. At 45°C, the germination of pearl millet was null.

This flexibility of germination, resulting in an aptitude to germinate in a relatively spread out thermal range, confers on millet an adaptive advantage at high temperatures, but not at a low one. Popignis (1985) found out that for three Brazilian cultivars of millet, the optimal germination temperature was 25°C and the germination capacity remained good in the temperature interval ranging between 20 and 30°C. In the same context, Albuquerque et al. (2004) noted that optimum germination was obtained at those temperatures, but the speed of optimal germination was found at 25°C. For Nigerian genotypes of pearl millet, Roussel (1978) found that the thermal optimum was 30°C and that 45°C constituted a temperature limit for germination. In a test on 8 genotypes of sorghum, Radford and Hanzell (1990) showed that the germination rate was higher than 90% for all genotypes in the temperature interval ranging between 25 and 35°C. Temperatures higher than 35°C and lower than 25°C caused a drop in germination rate.

Vadel (1999) announced that at 40°C, the germinative capacity of Sorghum was 60% and was null at 45°C. So, millet seems to be more resistant to extreme temperatures, since it keeps a germinative faculty of 72% at 40°C. Moreover, the flexibility of germination depended on the genotype. AM genotype, although preferring a temperature close to 25°C for its germination, continued

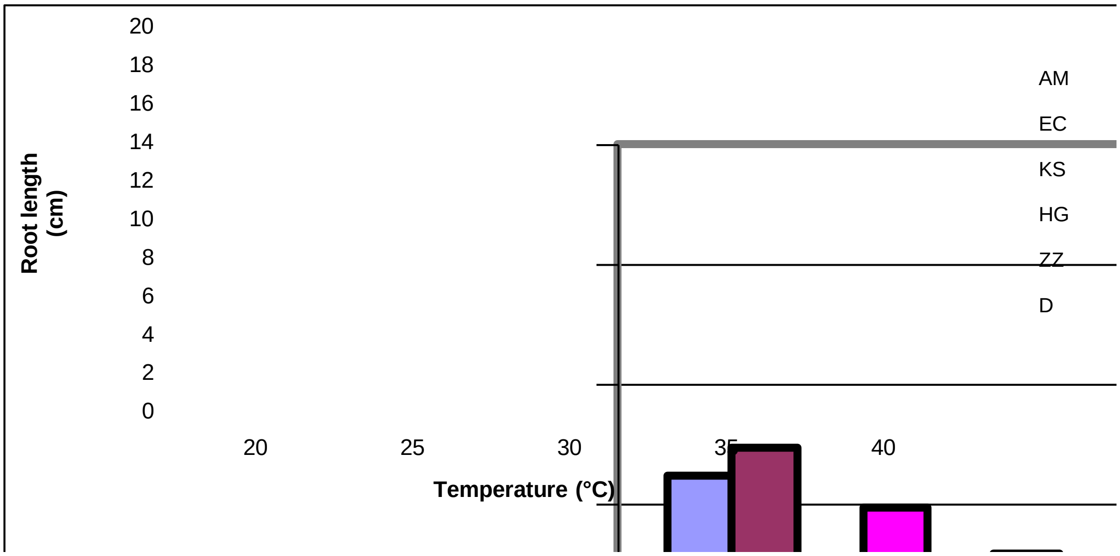

Figure 3. Effect of temperature on the root length of six ecotypes of pearl millet. L.S.D.: (P=0.05) between genotypes = 1.06; (P=0.05) between temperatures = 0.99; (P=0.05) interaction (genotypes x temperatures) = 3.14.

to germinate at rates that are statistically non different extreme temperatures of 20 and 40°C. This response can constitute an adaptative mechanism to ecological conditions for this genotype. In the same way, it was found that the germinative capacity of KS (high stem) was lowest. This same result was corroborated by Totok (1998), who stipulated that the germination percent of the populations of millet with short straw was higher than that of genotypes with high stem.

As regards the emergence of seedling length, variability for coleoptile's dimension was shown. Gay (1983) showed that coleoptile's length was relatively constant for a given genotype. This same result was announced by Peacock (1982) for sorghum and millet varieties. Genotype D (small size) presented the shortest coleoptile. This result was in agreement with Totok et al. (1997), where short coleoptiles were obtained for dwarf populations of millet and long ones for those with high size.

Seedling length was also influenced by temperature, in that maximum elongation was obtained at 30°C for all genotypes. The temperature × genotype interaction was significant and it indicated that two genotypes can have a behavior that is reversed for a given temperature.

The genotypes with low percentage germination and short coleoptile at low temperatures would slightly be adapted to cold areas at the time of sowing (ex: KS at 20°C). According to Richards et al. (2002), for wheat sowing, short coleoptiles were the result of low emergence and this was incompatible with good culture development. Moreover, the selection of wheat with long coleoptile is a research program at the International Maize and Wheat Improvement Center (CYMMYT) (Richards and Luckas, 2001). In the same way, seeds with good vigor will give robust seedlings, which will be provided by fertile plants and may express the agronomic potentialities of the variety.

As for coleoptile, 30°C was the most favorable temperature for good root length. At this temperature, the longest roots were those of AM and KS (higher than 18 cm) and the shortest ones were those of HG (12 cm). There was genetic diversity in root length and some genotypes seemed to have more than one thermal optimum, which could constitute a mechanism and flexibility of adaptation to ecological conditions and would offer more chances to these genotypes to settle. Among these genotypes, KS radicle was short and was inversely proportional with the size of the plant (KS presented a long stem).

Studying Indian millet genotypes, M'ragwa et al. (1995) showed that the length of the coleoptile and radicle were heritable characters and would support selection according to the required goal. Moreover, many positive correlations between these characters and the components of yield were established. Indeed, the selection of seeds giving lengthy coleoptile would result later in long and heavy candles in the dwarf populations. On the other hand, the selection of seeds with long radicle for the long stem populations would be favorable to the good development of candles.

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