Incidence of Temperature-Related Abiotic Diseases in Spanish Garlic Bulbs

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Abstract

Several alterations of growth physiology and bulb formation in garlic (*Allium sativum* L.) crops, such as "rough" and "burst" bulbs, have been related by different authors with low temperatures during bulbs storage and crop development. These physiopathies affect both the yield and the quality of garlic crops. Incidence of such diseases in Spanish garlic (variety "purple of Las Pedroñeras") were studied during two consecutive years. Experimental design was factorial taking the bulb storage temperature (5°, 10°, 15° and 20°C) as variable factor. Growth indexes during crop development and final quantity of defective bulbs were evaluated. Experimental results show significant differences between treatments, with the higher incidence of both physiopathies in those bulbs stored at 5°C. The 15° and 20°C storage temperatures clearly reduce the risk of these abiotic diseases and tend to increase the yield and the final quality of the crop.

Keywords: garlic; physiopathies; temperature; rough

INTRODUCTION

In order to bulbing and differentiate the axillary buds which later will produce cloves, garlic (*Allium sativum* L.) needs to accumulate a determined number of cold hours (RAHIM & FORDHAM 1988), being such thermoperiod a characteristic of each ecotype. An excess of cold hours accumulation during the storage of the seeding bulb and the period prior the beginning of the crop bulbing, can promote abundant side buds which develop their own extra cloves and form irregular protuberances around the main bulb known as *rough*, producing garlic cloves without any commercial value (see Figure 1). This alteration uses to be more frequent in those years characterized by excessively cold winters combined with bulb storage temperatures between 0° and 5°C. On the other hand, the lack of cold during both the storage of the bulb and the culture, avoids the differentiation of the axillary buds and thus producing an only great clove on each bulb (BREWSTER 1997). These abiotic diseases cause important losses in crop quality, therefore affecting its profitability.

The effects of the cold about the yield and the quality of garlic crops are mainly quantitative, as SOARES and CASALI (1986) and CASTILLO *et al.* (1999) have stated. Furthermore, these effects increase with the storage time of the seeding bulbs at low temperatures. Several authors (CARVALHO *et al.* 1980; EL MOTAZ BILLAN & OMAR 1971; LEDESMA *et al.* 1980; STARIKODA 1978; MESSIAEN 1974; CHENG 1975) have reported physiological alterations (rough) and yield losses due to small bulb size after storage at temperatures lower than 6°C. Thus, optimal seeding bulb storage conditions are that of temperature between 14°C and 18°C and 60% of relative humidity (CARVALHO *et al.* 1980).

MATERIAL AND METHODS

Field experiments (factorial design with four repetitions) were carried out, using the bulb storage tem-

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perature (5, 10, 15 and 20°C) as the sole variable factor. The elementary plot area was 40 m^2 (eight central lines of 10 m length) in irrigated Alfisol-type soil located in Albacete province (La Mancha region, WSW of Spain).

Dry bulbs of the local ecotype "*Ajo Morado de Cuenca o Pedroñeras*" (Cuenca or Pedroñeras' purple garlic) with 45–55 mm ø were used to plant the crop. Bulbs were randomly divided into four even lots and stored in controlled-temperature chambers at 5, 10, 15 or 20°C during 110 days (1999/2000 campaign) or 105 days (2000/2001 campaign). Manual planting with a framework of 50 × 12–15 cm was carried out in the last week of January, harvesting the crop in the end of July.

The following parameters were measured for each treatment and repetition: yield of fresh plant and bulb, weighted on the harvest day; yield of the air-dryed bulb, weighted on September; percentage of bulbs into the different commercial size categories: > 55 mm ø, 55–50 mm 8 ø, 50–45 mm 8 ø and < 45 mm ø; and percentage of rejected stuff including rough and ill, hollow or burst bulbs.

RESULTS AND DISCUSSION

a) Yield of fresh plant and bulb and weight losses by the drying process

The highest fresh plant yields were obtained with the higher storage temperatures (Table 1), although in the 1999–2000 campaign the observed differences between the four studied temperatures were not significant. However, in the following campaign (2000–2001) there are significant differences between the lower (5 and 10°C) and the higher temperatures (15 and 20°C). This result agrees with that of MANN and MINGES (1958), and could be explained because the storage at low temperatures should increase the strength of the growing plants which bulbify quickly, thus shortening the crop cycle and early becoming senescent and dry.

In both campaign, the lowest yield of dry bulb was observed in those crops corresponding with the lower storage temperature (5°C). This can be justified taking into account the higher degree of physiological alterations (see Figure 1) and the shortening of the crop cycle promoted by the storage at low temperature, in good agreement with that reported by different authors (CARVALHO *et al.* 1980; LEDESMA *et al.* 1980: STARIKODA 1978; MESSIAEN 1974).

The weight loss after the drying process is positive and significantly correlated in both campaigns with the higher temperatures of storage: the higher values of weight losses are observed in those plants growing from bulbs stored at 20°C. Thus, the storage at high temperatures seems clearly to promote an elongated crop cycle which implies higher water contents for the same harvest date. Weight losses that accompany the drying of the bulbs diminish when decrease the storage temperature. This fact is in total agreement with that observed for the full plant.

Table 1. Garlic yield (kg/ha) and weight losses (%) depending on bulb storage temperatures

Year	Treatment	Fresh plant (kg/ha)	Dry bulb (kg/ha)	Weight losses by leafs elimination (%)	Weight losses by drying process (%)
2000	5°C	12 205.5^a	7 993.9^a	27.0^a	10.2c
	10°C	13 127.6^a	8 937.6^a	22.9^a	11.8bc
	15°C	13 169.5^a	9 277.1^a	19.3^a	12.8b
	20°C	12 645.9^a	8 317.9^a	21.2^a	15.6^a
	Mean	12 787.1	8 631.7	22.7	12.6
2001	5°C	12 571.9^b	7 683.4^b	32.9^a	8.7^b
	10°C	13 465.9^b	7 746.5^b	36.0^a	9.4^b
	15°C	17 685.6^a	9 895.7^a	35.7^a	12.4^a
	20°C	16 666.6^a	9 305.6^a	34.6^a	14.5^a
	Mean	15 097.5	8 657.8	34.8	11.3

On each column and year, distinct letters mean significant ($P < 0.05$) differences

Section of a garlic bulb in the stage of cloves differentiation, affected by cold-excess

Garlic plant in the stage of bulb developing, showing symptoms of coldexcess

Garlic bulbs with two extra cloves (left and middle) and rough (right)

Figure 1. Garlic plants and bulbs with cold-excess symptoms

Table 2. Commercial qualities expressed as percentages of dry bulb yield depending on bulb storage temperatures

Year	Treatment	Higher categories (%)	Lower categories (%)	Rough (%)	Burst (%)
2000	5°C	23.9^{b}	2.2^{a}	31.9^{a}	41.9^{a}
	10°C	90.4^{a}	6.0^{a}	3.6^{b}	0.0^{b}
	15°C	86.9^{a}	5.9^{a}	5.0^{b}	2.2^{b}
	20°C	85.1^{a}	9.7^{a}	5.2^{b}	0.0^{b}
	Mean	71.6	5.9	11.43	11.0
2001	5°C	36.5^{b}	3.6^{a}	35.6^{a}	23.8^{a}
	10°C	51.5^{b}	9.7^{a}	18.3^{a}	20.3^{a}
	15°C	68.2^{a}	1.0^{a}	29.9^{a}	0.0^{b}
	20°C	74.5^{a}	3.1^{a}	22.4^{a}	0.9^{b}
	Mean	57.7	4.3	26.6	11.3

On each column and year, distinct letters mean significant ($P < 0.05$) differences

b) Commercial quality of the dry bulbs

Table 2 shows the results obtained after the size analysis. It is evident that higher storage temperatures (15 and 20°C) are positive and significantly correlated with the better quality classes, even reaching 85–90% of the total production. It is also evident that the higher degree of rejected stuff, i.e. the higher prevalence of physiopathies, corresponds with those plants growing from bulbs stored at 5°C: 73.8% of this bulbs in the first and near 60% in the second campaign show some type of rejecting defect (rough and ill, hollow or burst bulbs). These results agree with previous reports (CARVALHO *et al.* 1980; EL MOTAZ BILLAN & OMAR 1971; LEDESMA *et al*. 1980; STARIKODA 1978; MESSIAEN 1974; CHENG 1975) which state that storage temperatures lower than 6°C promote physiological alterations (rough) and yield reduction by shortening the crop cycle and decreasing the bulb size.

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