

The Effect of Planting Date, Plant Density and Defoliation on Seed Yield and Quality in Two Chicory (*Cichorium intybus* L.) Cultivars

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ABSTRACT

The effects of planting (October or November) or sowing (August or September) dates, plant density (2.8, 5.6 or 11.1 plants m⁻²) and defoliating at marketable vegetable maturity on seed yield and quality of two vegetable chicory cultivars (Cicoria di Galatina and Cicoria da Foglia) were examined over two years in southern Italy. Seed quality was evaluated 4, 12 and 24 months after harvest. A severe frost in January of the second year killed plants, particularly of cv. Cicoria di Galatina, and seed yield data were therefore only available for the first year. Planting date did not significantly affect seed yield, but seed yield increased significantly as plant population increased. Defoliation reduced seed yield by 25%. Seed quality was not affected by plant population or defoliation, but germination was lower for the later planting or sowing. Seed from the first year did not lose its quality after 24 months of storage, but the germination of seed from the second year fell significantly after 24 months of storage.

Additional index words: vegetable chicory, flowering date, frost damage, thousand seed weight, germination.

INTRODUCTION

In Italy around 16,000 ha of chicory (*Cichorium intybus* L.) is grown annually. It is used as a boiled vegetable or eaten raw in salads. In the Puglia region (which grows some 4000 ha), there are many land-races. Some are green with broad leaves which look similar to lettuce (Cicoria pan di zucchero), others have broad red leaves (Radicchio rosso), while others are narrow-leaved (Cicoria da foglia). Plants of these types typically have 70-100 leaves, are 50-60 cm in length and weigh 700-1500 g at commercial vegetable maturity. The yield is from 50-70 t ha⁻¹ at 8% dry matter. Yet another type (Cicoria di Galatina) forms an asparagus like head (asparagus chicory) 10-20 cm in length with 15-20 green stems per plant.

Information on cultural practices for chicory when used as a forage plant can be found in the literature (Hare, 1986; Rumball, 1986; Rolston and Gomez, 1986; Hare and Rolston, 1987; Bertini and Maddaloni, 1989; Hare, Rowarth, Archie, Rolston and Guy, 1990). There is some information for leaf chicory (De Donato, De Ambrogio and Fiore, 1974; Lovato and Montanari, 1989; Bianco, Damato and Fanizza, 1994; Fanizza and Damato, 1995), but little for asparagus chicory (Bianco *et al.*, 1994; Fanizza and Damato, 1995).

For seed production, planting date influences the onset and duration of flowering, and the environment during flowering which can negatively influence pollination, seed filling, seed yield and seed quality. In Italy chicory flowers for two to three months (May to July) so that seed maturity at harvest is variable. This poses a problem for producing homogenous seed lots. Growers have been advised to grow seed crops at a lower plant density than for vegetable production to increase branching, flowers per plant and seed yield. Whether this advice is correct for chicory is not known.

Plant density may affect vegetable seed yield and quality. In fennel (*Foeniculum vulgare* Mill) decreasing plant density increased inflorescence number per plant, but seed yield per unit area was not significantly modified (Damato, Bianco

and Laterza, 1994). In carrot (*Daucus carota* L.) Gray (1981) observed a higher seed yield and thousand seed weight as plant density increased. In chicory (Bianco *et al.*, 1994) in some experiments a lower plant density produced a higher seed yield and germination percentage.

Very little is therefore known about the agronomy of seed production in vegetable chicory. The objectives of this experiment were to examine the effect of planting date, plant density and defoliation on seed yield and seed quality in two chicory cultivars.

MATERIALS AND METHODS

Both experiments were conducted at Rutigliano (Bari, Southern Italy, Lat. 41° 00' 37"). Two cultivars Cicoria da foglia (CF) and Cicoria di Galatina (CG) were established at three plant densities (11.1 plants m⁻² = 30 x 30 cm; 5.6 plants m⁻² = 60 x 30 cm; 2.8 plants m⁻² = 60 x 60 cm). In the first year seedlings were planted on October 1 and again on November 10, 1991 (= first and second planting). In the second experiment seeds were direct sown into the field on August 5 and September 12, 1992 (= first and second sowing). Before planting or sowing 120 kg P₂O₅ ha⁻¹ and 50 kg N ha⁻¹ were broadcast and worked into the soil. During vegetative growth a further 100 kg N ha⁻¹ was applied 20 days after transplanting or thinning, and another 100 kg N ha⁻¹ 40 days later.

Plants were either left intact or defoliated (cutting to leave only some basal leaves on the crown) at vegetable maturity. In 1991/92 this occurred on March 15 and 29 1992, for the first planting date and April 21 and 28 for the second planting date for cultivars CG and CF respectively. In the following season defoliation for both cultivars was on February 3 and April 14 for the first and second sowings.

The design of the experiment was therefore a split-plot with main plot = planting or sowing date, sub-plot = cultivars, sub-sub-plot = plant density and sub-sub-sub-plot = defoliation. There were three replicates.

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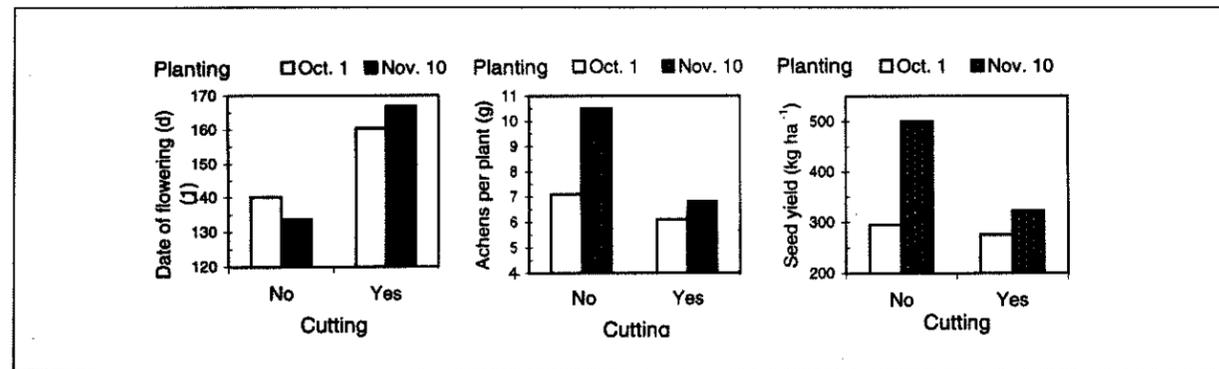


Figure 4. Effect of planting date and defoliation on some plant and seed characteristics (1991/92). (1) Days.

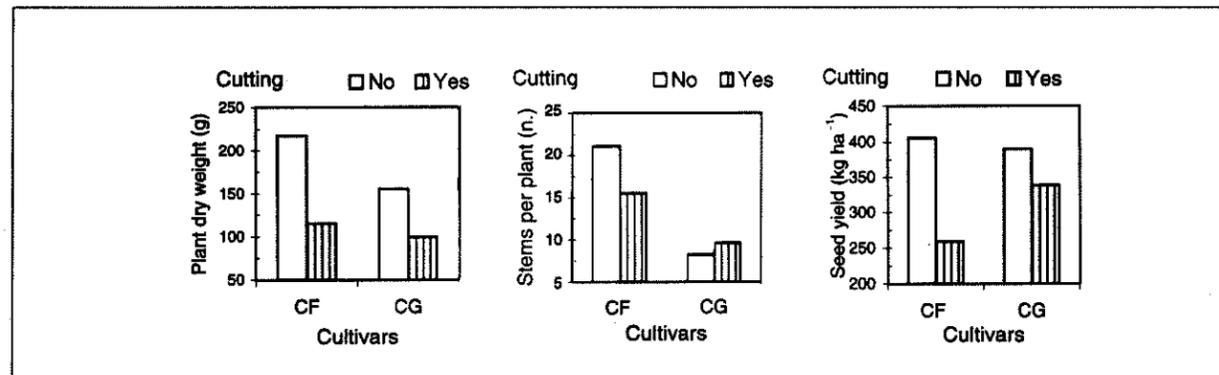


Figure 5. Effect of cultivars and defoliation on some plant and seed characteristics (1991/92). CF = *Cicoria da foglia*; CG = *Cicoria di Galatina*.

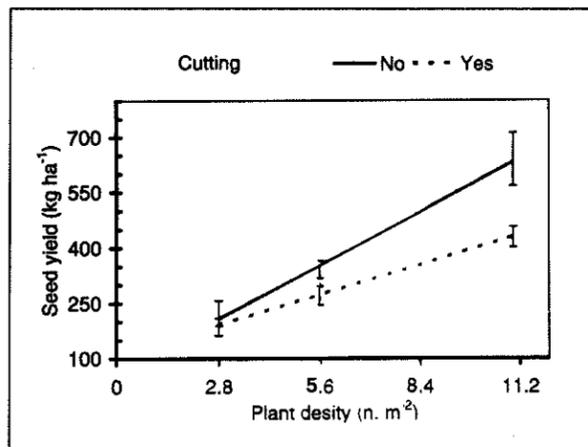


Figure 6. Effect of cutting and plant density on seed yield. (1991/92). Vertical bars indicate standard error.

There were interactions between defoliation and both planting date and cultivar (Fig. 4 and 5). Intact plants from the November planting flowered six days earlier than those from the October planting, but this was reversed for defoliated plants. Yield per plant and per unit area was greater for the second planting in intact plants, but did not differ for defoliated plants (Fig. 4). Defoliation reduced plant dry weight and seed yield in both cultivars (Fig. 5), but stems per plant were only reduced following defoliation in cv. CF. As plant density increased, the increase in the seed yield for intact plants was greater than that for defoliated plants (Fig. 6).

Germination characteristics. 1991/92.

Germination was 63% for cv. CF and 54% for cv. CG four months after harvest (MAH) but had improved to 82% for the former cultivar and 74% for the latter cultivar 24 MAH. Seeds germinated more quickly at 12 MAH (Fig. 7a and c). In cv. CF, 12 MAH T_{25} , T_{75} , T_{90} , T_{175} and T_{190} were shorter and T_{99} and T_{199} were longer (Fig. 7a and b) and showed a quadratic trend; T_{95} was shorter 4 MAH and longer 24 MAH with a linear trend (Fig. 7a). In cv. CG, T_{25} , T_{75} , T_{95} , T_{99} , T_{150} , T_{175} , T_{195} and T_{199} were longer 24 MAH (Fig. 7c and d) and achenes germinated more slowly than in cv. CF. The span of germination was longer in cv. CF and in cv. CG 12 (6.6 d, Fig. 7b) and 24 MAH (8.2 d, Fig. 7d) respectively.

The November planting slightly but significantly ($P < 0.001$) improved germination in cv. CF (76% cf. 71%), but decreased ($P < 0.05$) it in cv. CG (62% cf. 65%). Defoliation and plant density had no effect on germination of either cultivar when seed was tested 4 MAH. However, for cv. CF, germination increased with increasing plant density at 12 and 24 MAH (Fig. 8) and the same response was recorded for the October sowing (Fig. 9).

1992/93.

Germination was again higher for cv. CF than cv. CG (87 cf. 62%) at 4 MAH, but had fallen ($P < 0.001$) in both cultivars by 24 MAH (to 57% and 49% respectively). Storage increased germination rate in both cultivars; 24 MAH 95% of germinated seed was reached 5 days after the test began (Fig. 10, a and b). Germination was slightly but significantly ($P < 0.01$) reduced for the later sowing (74% cf. 78% for cv. CF; 58% cf. 63% for cv. CG), but defoliation and plant density did not affect germination at 4 MAH.

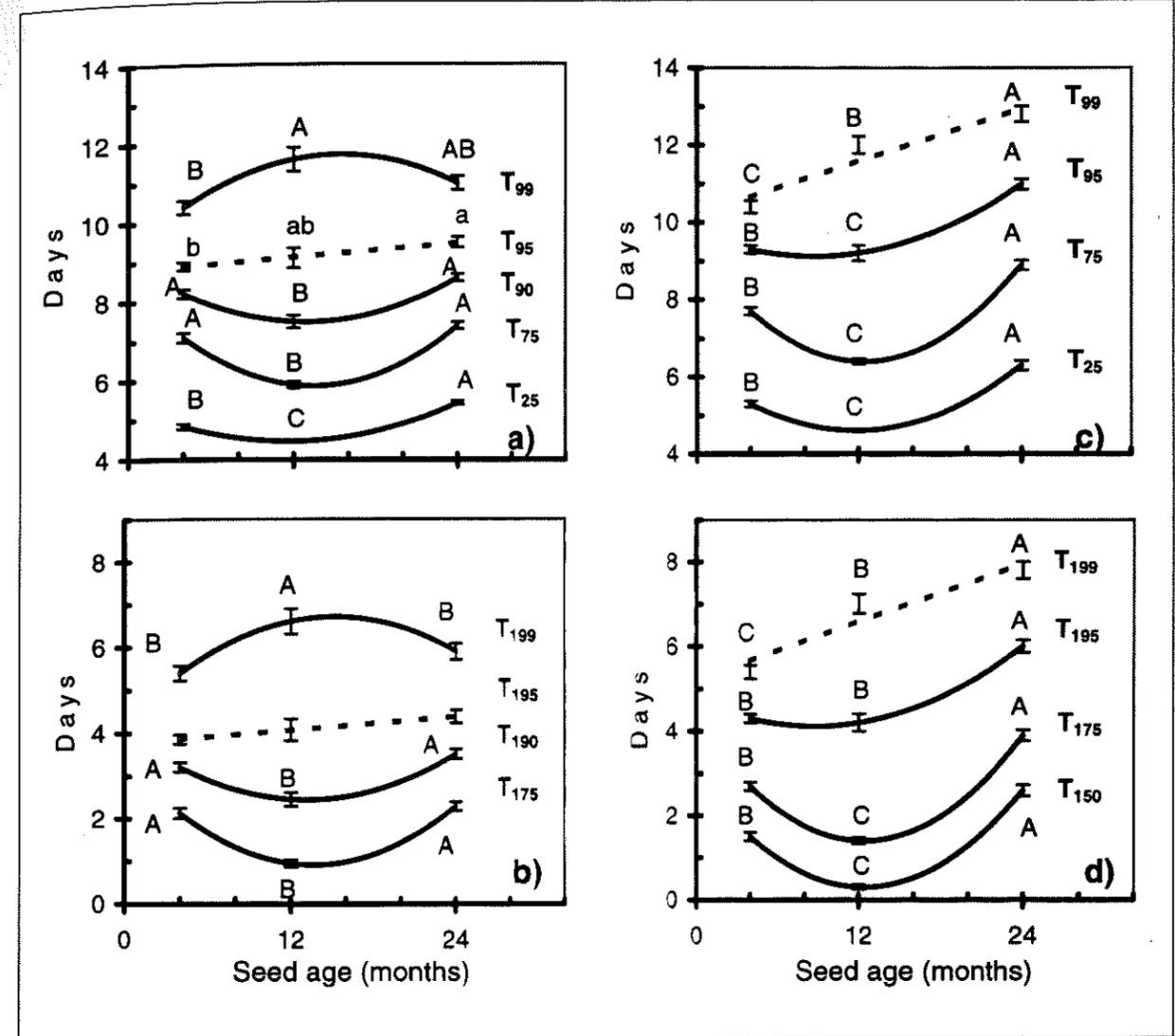


Figure 7. Effect of seed age (months after harvest) on time to reach a predetermined percentage of final germination: a) and b) '*Cicoria da foglia*', and c) and d) '*Cicoria di Galatina*' (1991/92). Vertical bars indicate standard error.

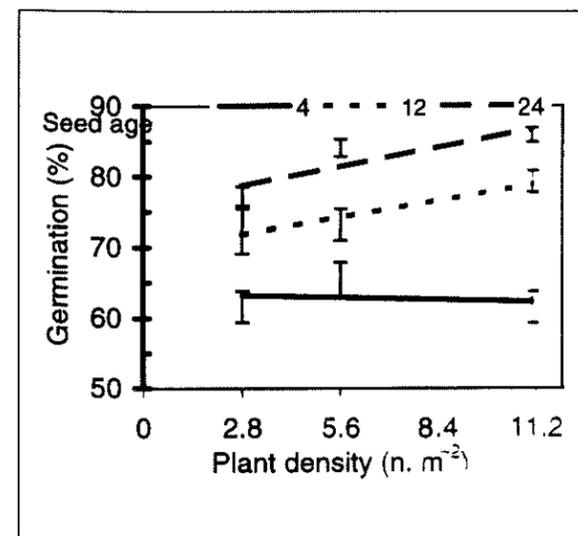


Figure 8. Effect of plant density and seed age (months) on germination percentage in '*C. da foglia*' (1991/92). Vertical bars indicate standard error.

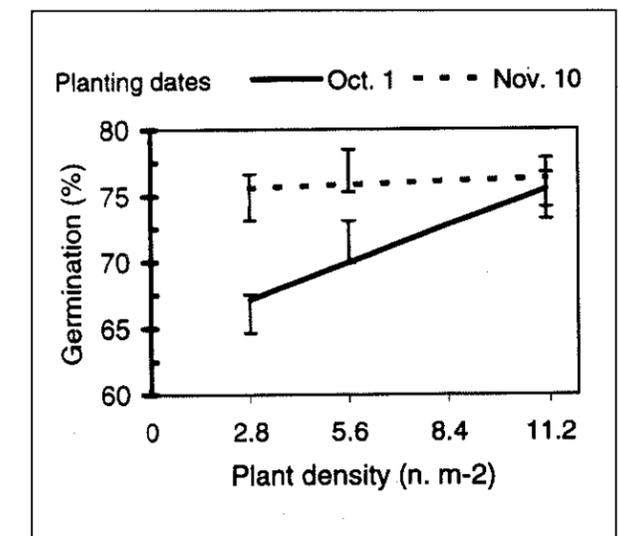


Figure 9. Effect of plant density and planting dates on germination percentage in '*Cicoria da foglia*' (1991/92). Vertical bars indicate standard error.

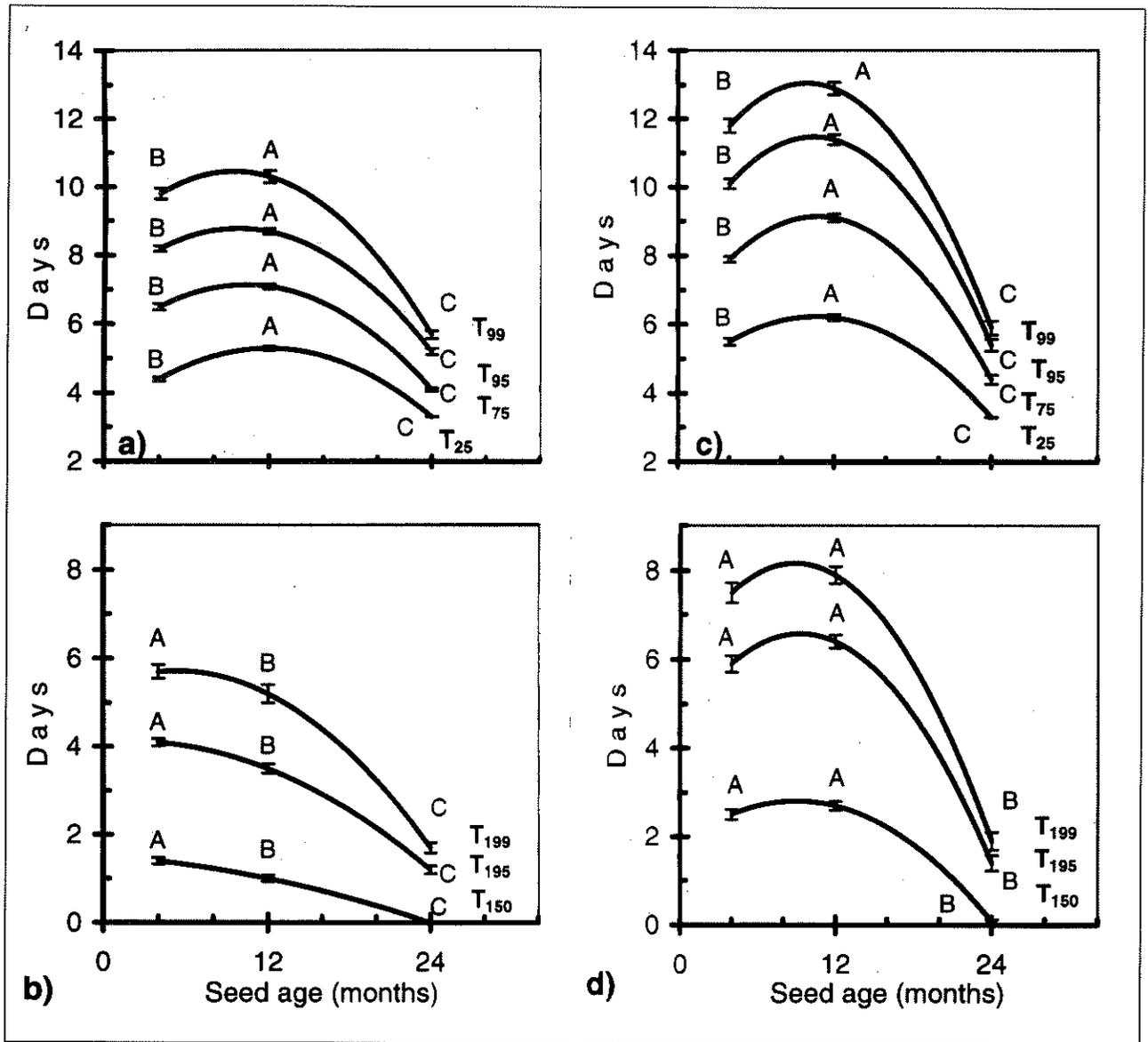


Figure 10. Effect of seed age (months) on time to reach predetermined percentage of final germination: a) and b) 'Cichoria da foglia', c) and d) 'Cichoria di Galatina' (1992/93).

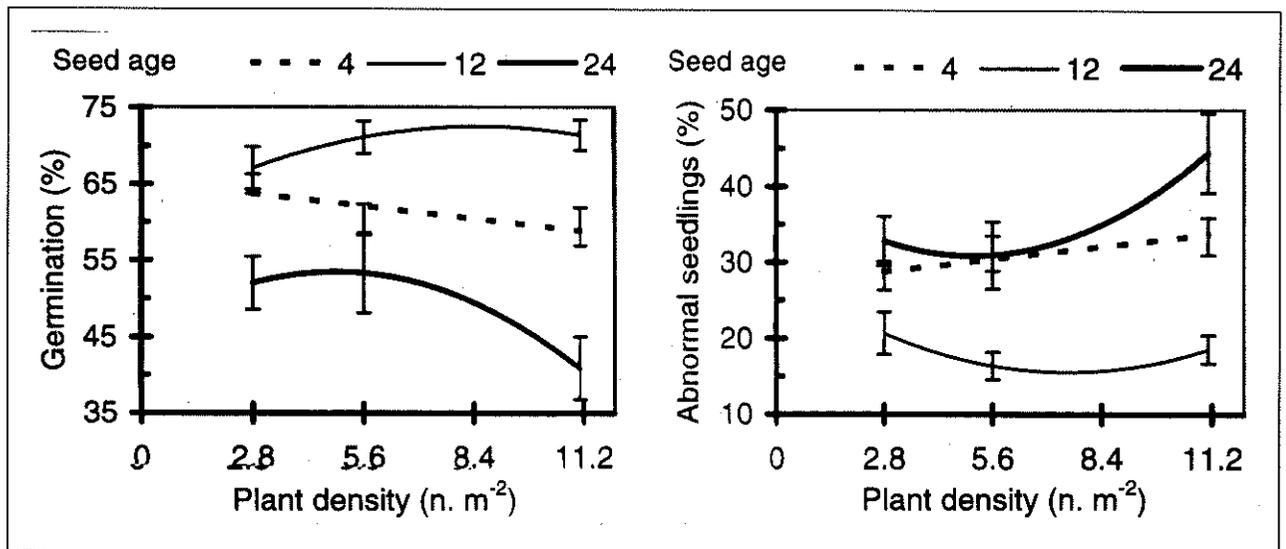


Figure 11. Effect of seed age (months) and plant density on germination percentage and abnormal seedlings in 'Cichoria di Galatina' (1992/93). Vertical bars indicate standard error.

24 MAH in cv GC, germination fell because abnormal seedlings increased as plant density increased (Fig. 11). This also occurred in both cultivars for the late sowing, but not the early sowing (data not presented).

DISCUSSION

Although the November planting produced 44% more seed than the October planting in the first season, the difference was not significant, and although yields in the second experiment were severely affected by frost, again sowing date did not affect seed yield. As noted by Hare *et al.* (1990) for autumn sowings, it is important that the crop becomes well established before winter, to ensure a reasonable seed yield in the following season. One significant difference between the two plantings in the first experiment was the number of plants killed (29%) in the October planting by fungal attack. Control of diseases is one aspect of the agronomy of chicory seed production which requires further work. Cultivar CG was severely damaged by frost in the second experiment, and was more sensitive to frost than cv. CF. Normally cv. CG would outyield cv. CF (Bianco *et al.*, 1994).

The seed yield response to increasing plant population was a typical one, with plant morphology changing significantly. The highest seed yield (534 kg ha⁻¹) was produced from the highest plant density used (11.1 plants m⁻²). What is not known is whether this yield response would have continued to increase with increasing plant density, or whether 11.1 plants m⁻² is a population which is part of the 'seed yield plateau' which occurs (Gray, Steckel and Ward, 1983). Thousand seed weight did not differ with increasing plant density in these experiments, but Bianco *et al.* (1994) have previously recorded differences in this yield parameter as plant population changed.

Defoliation reduced seed yield by around 25%, with the reduction being greater in cv. CG than cv. CF, but did increase thousand seed weight. It had no effect on seed germination. Defoliation did however provide a saleable vegetable product. A cost benefit analysis is required to determine whether the seed yield loss is compensated for in returns from the sale of the defoliated vegetable.

The reason why storing seed improved germination in the first year was not determined. There were some small reductions in the number of abnormal seedlings, but it is most likely that at four months after harvest dormancy was a factor, as no dormancy breaking treatments (ISTA, 1993) were used in the germination testing. The germination decline with storage in the second year was associated with physiological ageing, as abnormal seedlings increased significantly with storage.

The effects of other crop management practices on seed germination were small but sometimes significant. A delay in planting or sowing reduced germination in cv. CG in both years, a result also reported for fennel (Bianco, Damato and Girardi, 1994). Plant population had little effect on germination, a result also reported for carrot (Gray 1981; Gray and Steckel 1983), although in fennel Bianco *et al.* (1994) found better germination at a population of 5.0 plants m⁻² cf. 1.7 plants m⁻².

In conclusion, establishing the chicory crop by sowing in

September or transplanting in November at a population of around 11 plants m⁻² will produce a reasonable seed yield. The decision as to whether to defoliate the crop should be made after an economic analysis.

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