Greenhouse Seed Production of Two Dwarf Green Bean Cultivars in Relation to the Duration of Irrigation

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Abstract. As good quality irrigation water becomes increasingly scarce in the Mediterranean region, especially in coastal areas where greenhouses are located, methods of economizing water consumption are essential. Therefore, the effect of the duration of irrigation on the quality and yield of seed of two cultivars of dwarf green bean (‘Larma’ and ‘Montano’, Phaseolus vulgaris L.) was studied during fall and spring in Greece. Seeds were sown on 11 Sept. 2000 (fall crop) and 23 Feb. 2001 (spring crop) in peat compost and when the plants had two expanded leaves (11 and 20 days after sowing, respectively), they were transplanted to the soil of an unheated, plastic-covered greenhouse. The following irrigation treatments were applied: 1) irrigation for the entire duration (control), 2) irrigation until the first pods were dry, 3) irrigation until ≈50% of the pods had filled, and 4) irrigation till flowering. Fall cultivation was not suitable for seed production due to low yield and reduced seed quality. By contrast, the spring crop had a higher yield, seed size and good germination. Stopping irrigation of the spring crop at the drying of the first pods achieved an ≈20% saving in water without significantly affecting seed yield or quality. Earlier discontinuation of irrigation to achieve greater savings of water caused a reduction in yield, but did not affect seed quality.

In the countries of the Mediterranean basin, greenhouse crops are largely concentrated in coastal regions so as to benefit from the warm climate (Castilla, 1992; Olimpios, 2002). In Greece, vegetable seed crops, especially those for the production of basic (foundation) seed, are also grown under cover to avoid pathologic infections and contamination from cross-pollination (Saplaouras et al., 2001). As a result of intensive cultivation, the supply of water of a quality suitable for irrigation is limited (Antonopoulos, 1991; Kerkides et al., 1997), and because this problem is exacerbated in areas with large numbers of greenhouses, the introduction of desalinization units for water purification has been proposed (Olimpios, 2002).

A lack of soil moisture during the flowering and pod growth of beans causes a reduction in yield, whereas irrigation before the flowering stage increases vegetative growth at the expense of flowering (Salter and Goode, 1967). Irrigation of runner beans, starting from the green flower-bud stage, increased yields of fresh pods by 36% in comparison with nonirrigated controls, but when irrigation was started just 1 week later (at the red flower-bud stage), the increase in yield was only 17% (Blackwall, 1963). In arid or semi-arid regions, irrigation during vegetative growth is especially benefic-}

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irrigation was applied to all plants until the onset of flowering, but thereafter the plots were arranged in a completely randomized design with four replicates of each treatment receiving the following irrigation schedule: 1) irrigation until harvest (control), 2) irrigation until the first two to three pods had dried, 3) irrigation until ≈50% of the pods had filled, and 4) irrigation until the start of flowering.

Plants were irrigated 2 to 3 times a week with 1.5 to 2 L water per plant, while the quantities of water consumed by evaportranspiration were estimated by weighing four 15-L plastic pots each containing two plants planted in soil, prior to and after irrigation. Pods were harvested from 1 Nov. until 5 Dec. 2000 (51 to 85 d from sowing, fall crop) and from 15 to 27 May 2001 (81 to 93 d from sowing, spring crop). The number and weight of pods and seeds were recorded. Seeds were tested for germination according to the ISTA rules (Anonymous, 1985). Results were tested for significance by analysis of variance and comparison of means by the least significant difference test (p = 0.05).

Results and Discussion

The vegetative growth of beans in the fall was faster than in the spring due to the higher temperatures during the first month after sowing (Table 1), and this resulted in earlier onset of flowering (35 to 37 d and 55 to 58 d, respectively). However, the progressive reduction in temperature and day length in the fall resulted in a longer period of pod maturation, and the duration of harvest was 34 d, in comparison with just 13 d in the spring. The fall cultivation of beans for seed required less irrigation than in the spring, which also related to the lower mean temperatures during the former (Table 1). On the other hand, the yield of dry pods and seed was less in the fall (Table 2) than in the spring (Table 3).

In both cultivations, discontinuation of irrigation when the first two to three pods had dried did not cause a significant reduction in the weight and number of pods or seeds per plant in comparison with the control (irrigated until harvest). Water shortage, especially during flowering, is known to reduce yield of seed and fruit (Salter and Goode, 1967), but discontinuation of irrigation at a stage when 50% of the pods had filled also caused a significant reduction in yield (Tables 2 and 3). Legumes respond positively to irrigation during pod swelling because the increased hydraulic conductivity will compensate for the reduced root growth at this stage (Salter and Drew, 1965). However, the present results show that irrigation after pod swelling is not necessary, therefore water saving can be achieved during the maturation period.

The lower seed yield of the fall crop resulted principally from a reduction in the number of pods per plant, but in ‘Larma’ the seeds of the fall crop were smaller in size (determined as the weight of 100 seeds) than those of the spring crop (Tables 2 and 3). Seed size and the number of seeds per pod of ‘Montano’ in the fall were only affected by irrigation when
Table 2. The effect of the duration of irrigation on the production of dry pods and seed by ‘Larma’ and ‘Montano’ during fall.

| Treatment | Pods/plant (no.) | Seeds/pod (no.) | Seeds/plant (no.) | Wt of seeds/plant (g) | Wt of 100 seeds (g) | Germination (%) |
|-----------|------------------|-----------------|-------------------|-----------------------|-------------------|-----------------|
| Larma     |                  |                 |                   |                       |                   |                 |
| 1         | 83               | 8.3 a           | 4.1 a             | 34.2 a                | 6.3 a             | 81 a            |
| 2         | 68               | 8.1 a           | 4.0 a             | 32.2 a                | 6.2 a             | 71 a            |
| 3         | 44               | 4.8 b           | 3.4 b             | 16.1 b                | 2.9 b             | 55 b            |
| 4         | 34               | 2.4 c           | 2.1 c             | 5.2 b                 | 1.0 b             | 52 b            |
| Montano   |                  |                 |                   |                       |                   |                 |
| 1         | 83               | 13.5 a          | 3.7 a             | 50.3 a                | 10.8 a            | 88 a            |
| 2         | 68               | 12.5 a          | 3.9 a             | 48.8 a                | 9.9 a             | 85 a            |
| 3         | 44               | 7.4 b           | 3.5 a             | 25.9 b                | 5.4 b             | 72 b            |
| 4         | 34               | 2.9 c           | 2.7 b             | 7.7 c                 | 1.4 c             | 58 b            |

Table 3. The effect of the duration of irrigation on the production of dry pods and seed by ‘Larma’ and ‘Montano’ during spring.

| Treatment | Pods/plant (no.) | Seeds/pod (no.) | Seeds/plant (no.) | Wt of seeds/plant (g) | Wt of 100 seeds (g) | Germination (%) |
|-----------|------------------|-----------------|-------------------|-----------------------|-------------------|-----------------|
| Larma     |                  |                 |                   |                       |                   |                 |
| 1         | 92               | 17.1 a          | 3.9 a             | 66.2 a                | 18.4 a            | 98 a            |
| 2         | 80               | 15.8 a          | 3.9 a             | 61.5 a                | 15.8 a            | 90 a            |
| 3         | 72               | 10.6 b          | 2.9 b             | 30.9 b                | 7.2 b             | 95 a            |
| 4         | 57               | 8.1 b           | 3.3 b             | 27.0 b                | 6.0 b             | 95 a            |
| Montano   |                  |                 |                   |                       |                   |                 |
| 1         | 92               | 21.9 a          | 4.5 a             | 99.7 a                | 19.3 a            | 100 a           |
| 2         | 80               | 20.4 a          | 4.5 a             | 92.2 a                | 17.8 a            | 100 a           |
| 3         | 72               | 14.8 b          | 4.3 a             | 61.3 b                | 10.7 b            | 100 a           |
| 4         | 57               | 12.7 b          | 4.0 a             | 50.8 b                | 9.1 b             | 85 b            |

it was stopped at the start of flowering (stage 4). The number of seeds per pod of ‘Larma’ declined when irrigation stopped at stages 3 and 4, but seed size was unaffected. In the spring, the seed size of both cultivars was reduced when irrigation ceased at stages 3 and 4, but the number of seeds per pod was affected only in ‘Larma’. Seed germination of both cultivars was high (95% to 100%) during the fall crop and from 15 May 2001 (2), 7 May 2001 (3), and 22 Apr. 2001 (4) in the spring crop.

The saving of water achieved by stopping irrigation at stages 2 to 4 was 12%, 60%, and 80%, respectively, for the fall seed crop, and 20%, 40%, and 70% respectively for the spring crop. The fall cultivation of beans for seed cannot be recommended due to low yield and reduced seed quality (i.e., lower germination). By contrast, the spring crop produced almost double the amount of seed in comparison with the fall crop, and seed germination was high. Irrigation of the spring crop may be stopped at the onset of drying of the pods (but not earlier) without a reduction of yield or seed quality. In this way a 20% saving in water consumption may be achieved. Economy of water use and the search for drought-resistant varieties are vital aspects for the future of agriculture, not only in Greece and other Mediterranean countries, but in other arid and semi-arid areas, e.g., southeastern Kenya (Shisanya, 2002).

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