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Weed competition in cauliflower (*Brassica oleracea* L. var. *botrytis*) in the Jordan Valley

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ABSTRACT

A field experiment was carried out in 1996/1997 and repeated in 1997/1998 at the Jordan University Research Station located in the central Jordan Valley to determine the effect of weed competition on growth and yield of cauliflower *Brassica oleracea* var. *botrytis* cv. "White Cloud". The treatments consisted of either allowing weeds to infest the crop or maintaining plots weed-free for increasing durations after transplanting. Results showed that longer periods of weed/cauliflower competition greatly reduced crop growth and head yield. Average reductions in shoot dry weight and head yield were 81% and 89%, respectively. Maintaining a weed-free crop for any period after transplanting increased cauliflower growth and head yield compared with the weed-infested control. Weed competition for 14 days after transplanting reduced cauliflower average head yield by 41%. To determine the critical period of weed competition and the influence of weed infestation on cauliflower head yield the Gompertz and logistic equations were fitted to data representing increasing duration of weed-free and weed-infested periods, respectively. Based upon an arbitrary 5% level of head yield loss, the critical period of weed competition occurred at 0–38 days after cauliflower transplanting which corresponded with the rapid increase in weed biomass. Results indicated that early weed removal is necessary to prevent yield loss.

1. Introduction

Weeds interfere with crop plants severely reduce crop growth and lower yield and quality (Zimdahl, 1980; Qasem, 2003). Many workers denied any alternative (e.g. adding more water and/or fertilizers) to weed control if crop yield losses are to be avoided or minimized (Qasem, 1987; Dimson, 2001). Weed competition early in the season may lead to irrecoverable growth and yield losses of cole crops and add appreciably to the cost of farm operations, while for optimum yield, crops must be kept weed-free for almost the entire growing season. However, yield loss of crops planted for seed production may reach 100% if broadleaf weeds are not controlled and was less severe for grassy weeds (Dimson, 2001).

Cauliflower has been mentioned as one of two crucifer crops that tolerate weed competition and can shade the soil effectively after establishment (Anonymous, 2000). As crop plants grow older, they compete well with weeds (Lanini et al., 2002) and can effectively establish a canopy and shade out weeds between the rows (Anonymous, 2000). However, Hemery et al. (1981) reported that the crop should be kept weed-free from planting to earthing up (autumn and early winter cauliflower) or from earthing up to harvest (late winter cauliflower). Weed control during the first 30 days of plant establishment is the most important, after which cauliflower can better compete with weeds and shades the underlying soil and inhibit weed seed germination (Dimson, 2001). Weaver (1984) reported that optimum period for weed control in cabbage is usually within the first 3–4 weeks after transplanting, while Turner et al. (1999) mentioned a range of between 3 and 8 weeks provided effective weed control is achieved at this time in brassica crops. In contrast, uncontrolled weeds reduced cauliflower curd yield by 37–59% (Govindra et al., 1983). Weed competition for the first 15 days resulted in significant yield loss but weeds had no adverse effect when emerged 16 days after transplanting. The highest yield was with a single hand weeding at 30 days after transplanting, intermediate yield was obtained at 15 or 45 days and the lowest was with a single hand weeding at 60 days after transplanting (Singh and Tripathi, 1982).

Cauliflower is one of the main vegetable crops grown under rainfed and irrigated conditions in Jordan. Sometimes it occupies a significant area in the cultivated land in the Jordan Valley, although in certain years the crop is used for grazing due to over production and low prices. However, the crop is continued to be cultivated and farmers are encouraged to produce it on a large scale while the cost of production is still reasonable. One of the limiting factors of production is the losses caused by weeds and their control cost, with 76% average reduction in head yield when weeds were left

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uncontrolled for the entire growing season (Qasem, 2007). In many cultivated vegetable crops (including cauliflower) farmers relay mainly on plastic mulching, hoeing and hand weeding for weed control. However, with the present trend toward increased reliance on organic farming in vegetable production, herbicide use is becoming more restricted. Therefore, in order to develop efficient integrated weed management system determination of the critical weed competition period "the period after crop emergence or planting at which weeds must be removed for a non-significant yield loss (Nieto et al., 1968)" is essential in reducing weed control expenses. This period has been already determined for a variety of vegetable crops grown in Jordan (Qasem, 1992a, 1995, 1996, 2005; Al-Jebury and Qasem, 2001) and found vary by crop and weeds, their densities, and the agricultural practices employed.

Studies on weed competition in cauliflower in general, and on the determination of the critical period of weed competition under Jordan conditions are lacking, while literature on these aspects has not been well documented worldwide. Therefore, the objectives of this work were to study the competitive effect of weeds on growth and yield of transplanted cauliflower grown under Jordan Valley conditions and to determine the critical period of weed competition in this crop.

2. Materials and methods

2.1. Experimental procedure

A field experiment was conducted at the Agricultural Research Station of the University of Jordan in the central Jordan Valley (255 m below sea level), during 1996/1997 and repeated in 1997/1998 growing seasons. The soil was sandy-loam with 50% sand, 25% silt, 25% clay, 1.3% organic matter content and a pH of approximately 7.6.

Each year, farm animal manure fall applied over the entire experimental area at a rate of 1 MT ha^{-1} prior to plowing. The experimental plots were moldboard plowed to a depth of 20–25 cm followed by a row chisel cultivator. Rows were properly opened using a hand hoe. One-month old cauliflower (*Brassica oleracea* var. *botrytis* L. cv. "White Cloud") seedlings (3–4 leaf-stages) were hand transplanted 50 cm within the row and 100 cm between rows on 3 December 1996 and 19 October 1997. Plot size was 1.5 m wide by 2.2 m in length consisting of eight plants in two rows

Each year, compound fertilizer with 18N:18P and 9K was hand-broadcasted over the entire experimental area at a rate of 217 kg ha^{-1} before planting and urea (46% N) was similarly applied at 135 kg ha^{-1} two weeks after transplanting.

In both years, weeds were allowed to compete with cauliflower plants for 0, 14, 21, 28, 35, 42 and 49 days after transplanting, then removed and plots kept weed-free thereafter until harvesting. In another set of plots, weeds were continuously hand-weeded and kept weed-free for similar periods after cauliflower transplanting after which they were left to grow and compete with the crop until harvesting. Treatments were replicated four times and laid out in a randomized complete block design. Cauliflower plants were irrigated for three hours twice a week through a drip irrigation system with emitters delivering 8 l h^{-1} each.

Crop maturity was assessed on the basis of head size prior to flower opening. All cauliflower plants per plot size were hand harvested on 17 March 1997 and 19 January 1998. Data on cauliflower shoot dry weight (oven dried at 70 °C for 72 h); head weight and number were recorded. For each treatment, weeds from the whole plot area were harvested, oven dried and weighed to obtain a measure of aboveground weed biomass. Weed harvests were taken at the same time of weed removal for treatments where weeds were allowed to grow for different periods after transplanting and at the time of crop harvest in the case of treatments kept weed-free for different periods after planting.

2.2. Statistics

Preliminary analysis indicated no significant differences between experiments in the two years. Therefore, data on cauliflower growth and head yield and that on weed dry weight in the two years were combined together and eight replicates per treatment were considered. All cauliflower data were expressed as a percentage of the weed-free plots (0 time of weed-infested treatment), while weed dry weight was presented as a percentage of their dry weight in the weed-infested plots (0 time of weed-free treatment).

To determine the effects of weed duration on cauliflower growth and head yield a nonlinear regression line (Hall et al., 1992) was compared for average cauliflower shoot dry weight, head yield and number and weed competition or free periods. Similar comparisons were also performed between these treatments and weed shoot dry weight. The Gompertz equation (Cousens, 1988) was used to describe the increasing duration of weed-free on cauliflower head yield:

$$Y = A\exp(-B\exp(-kT)) \quad \text{(I)}$$

where Y is the yield (% of season-long weed-free cauliflower), A is the yield asymptote (% of season-long weed-free cauliflower), B and k are constants, and T is the time from transplanting (days). The logistic equation (Ratkowsky, 1990; Knezevic et al., 2002) was used to describe the effect of increasing duration of weed infestation on head yield:

$$Y = \left(\left(\frac{1}{(D\exp(K(T-x))+F)}\right) + \left(\frac{(F-1)}{F}\right)\right) \times 100\% \quad \text{(II)}$$

where Y is the yield (% of season-long weed-free cauliflower), T is the time from planting (days), x is the point of inflection (days), and D and F are constants. Time (T) was expressed as days after cauliflower transplanting date so the critical period of weed competition could be compared. Using a 5% level of accepted yield loss, the beginning and end of the critical period were determined using the Gompertz and logistic equations. The beginning of the critical period was defined as the time after crop transplanting by which weed competition reduced yields by 5%. Similarly, the end of the critical period was defined as the period at which the crop must remain free of weeds to prevent head yield loss from exceeding 5%. In addition, head yield data were also regressed against weed dry weight for weed-free and weed-infested treatments.

3. Results

3.1. Weed population

The naturally occurring weed population in the experimental site and the average density of weed species are presented in Table 1. *Chenopodium murale* and *Malva sylvestris* were the most dominant weeds in the two years.

3.2. Effect on cauliflower

Weed competition for the entire growing season reduced average cauliflower head yield and shoot dry weight by 89% and 81%, respectively (Figs. 1 and 2a). Head yield was reduced by 42% when plots were kept weed-infested for the first 14 days after transplanting, while plots kept weed-free for similar period provided 4-times higher head yield than that of the weed-infested control (Fig. 1). Yield losses decreased as period of weed-free increased and weed dry weight deceased, with weed growth reached the least (<6% of weed-infested control) at 49 days weed-free period (Fig. 4). At this point