Critical Period of Weed Control in Sugar beet in Shahrekord Region

F. Salehi[1], H. Esfandiari[1] and H. Rahimian Mashhadi[2]

[1]Agricultural and Natural Resources Research Center of Chaharmahal and Bakhtiari Province [2] College of Agriculture, Tehran University

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ABSTRACT

Weed competition is one of the yield-limiting factors of sugar beet production in Iran. Weed competition may reduce the root and sugar yield, depending on the weed density and the intensity of weed competition with the crop. In order to determine the critical period of weed control (CPWC) in sugar beet in Shahrekord region, an experiment was arranged in a randomized complete block design with 14 treatments and four replications in 1999 and 2000. Treatments included weed-free plots until 2, 4, 6, 8, 10 and 12 weeks after planting (WAP) in 2000 (in 1999 based on the stages of crop growth in the form of weed control, treatments were until 4, 6, 8, 10, 12 and 14 – leaf stages of sugar beet) and weed-infested plots from 2, 4, 6, 8, 10 and 12 weeks after planting sugar beet in 2000 (in 1999 based on the stages of crop growth in the form of weed interference until 4, 6, 8, 10, 12 and 14 - leaf stages of sugar beet). Two control treatments (full-season control of weeds and full-season interference of weeds) were also included. The results showed that weed infestation significantly ($P<0.01$) reduced the root and sugar yield of sugar beet in all treatments. Total root yield loss of the crop

Correspondence to: F. Salehi, E-mail: foroud_salehi@yahoo.com

in full competition was 92.9 % in 1999 and 61.16 % in 2000 compared to weed free control treatment. Based on 10% loss of yield, the beginning of the critical period of weed control (CPWC) was 25 and 5 days after planting for the first year and the second year, respectively. On this basis, the end of the critical period of weed control was 78 days for the first year and 88 after planting for the second year. Dominant weeds in this experiment were *Amaranthus retroflexus*, *Chenopodium album*, and *Echinochloa crus-galli*. Considering the high density of weeds in the experimental site, a long critical period of 82 days existed five days after planting. Also, with regard to late planting date of sugar beet (from May to June), competition between weed and crop may start sooner, causing considerable yield loss in sugar beet.

Key words: Sugar beet, weed control and critical period.

چکیده

رقابت علف‌های هرز یکی از عوامل محدود کننده کشت و تولید چغندرقند در ایران هستند. عملکرد ریشه و عملکرد شکر با رقابت علف‌های هرز کاهش می‌یابد و بستگی به توانایی رقابت علف‌های هرز، تراکم آنها و مدت زمان رقابت آنها با گیاه زراعی دارد. به منظور تعیین دوره بحرانی کنترل علف‌های هرز چغندرقند در شهرکرد در شرایط آلودگی طبیعی مزرعه، آزمایشی با استفاده از ۱۴ تیمار و چهار تکرار به صورت بلوک‌های کامل تصادفی در سال‌های ۱۳۷۸ و ۱۳۷۹ اجرا گردید. تیمارها شامل کنترل علف‌های هرز تا ۲، ۴، ۶، ۸ ، ۱۰ و ۱۲ هفته پس از کاشت چغندرقند در سال ۱۳۷۹ (در سال ۱۳۷۸ براساس مراحل رشد گیاه زراعی به‌صورت کنترل علف‌های هرز تا مرحله ۴، ۶، ۸ ،۱۰، ۱۲ و ۱۴ برگی چغندرقند) و سپس رشد علف‌های هرز تا پایان فصل رشد و تداخل علف‌های هرز تا ۲، ۴، ۶، ۸ ،۱۰و ۱۲ هفته پس از کاشت چغندرقند در سال ۱۳۷۹ (در سال ۱۳۷۸ براساس مراحل رشد گیاه زراعی به صورت تداخل علف‌های هرز تا مرحله ۴، ۶، ۸ ،۱۰، ۱۲ و ۱۴ برگی چغندرقند) و سپس حذف علف‌های هرز تا پایان فصل رشد بودند و دو تیمار شاهد (کنترل تمام فصل علف‌های هرز و تداخل تمام فصل علف‌های هرز) نیز درنظرگرفته شد. نتایج نشان داد که آلودگی به علف‌های هرز عملکرد ریشه و قند چغندرقند را درکلیه تیمارها کاهش داد ($P<0.01$). کاهش عملکرد ریشه در سال ۱۳۷۸ در تیمارهای تداخل تمام فصل علف های هرز ۸۹/۹ درصد و در سال ۱۳۷۹ حدود ۶۱/۲ درصد نسبت به تیمار شاهد عاری از علف‌هرز بود. براساس کاهش ۱۰٪ عملکرد، دوره بحرانی کنترل علفهای هرز در سال ۱۳۷۸ از روز ۲۵ بعد از

کاشت و در سال ۱۳۷۹ از روز ۵ بعد از کاشت شروع شد. دوره بحرانی کنترل علف‌های هرز سال ۱۳۷۸ در ۷۸ روز بعد از کاشت و سال ۱۳۷۹ در روز ۸۸ بعد از کاشت به اتمام رسید. علف‌های هرز غالب دراین آزمایش عبارت بودند از تاج‌خروس (*Amaranthus retroflexus*)، سلمه‌تره (*Chenopodium album*) و سوروف (*Echinochloa crus-galli*). نتایج نشان داد که باتوجه به تراکم بالای علف‌های هرز در منطقه مورد آزمایش دوره بحرانی کنترل علف‌های هرز طولانی مدت می‌باشد(۸۲ روز که از روز پنجم پس از کاشت شروع شد). همچنین با توجه به کاشت چغندرقند در اردیبهشت ماه تا اواسط خرداد ماه، علف‌های هرز خیلی زود رقابت خود را با گیاه زراعی شروع می‌کنند.

واژه‌های کلیدی: کنترل علف‌های هرز چغندر قند، دوره بحرانی.

INTRODUCTION

Weeds are limiting factors in sugar beet production (Cooke & Scott, 1993). Integrated weed control management is necessary for minimizing weeds interference and maximizing the crop yield (Schweizer, 1983; Cooke & Scott, 1993). Weeds compete with sugar beet for light, nutrients and water. Sugar beet can tolerate weeds until 2-8 weeks after emergence, depending on the weed species, planting date, the time of weed emergence relative to crop and environmental conditions (Cooke & Scott, 1996). The presence of weeds can decrease sugar beet yield by 90%. For example, a single presence of barnyardgrass *Echinochloa crus-galli* (L.) *Beauv.* plant per 1.5 m^2 resulted in yield reduction of 5 to 15 % (Norris, 1996).

The critical period of weed interference refers to the period during which a crop must be kept free of weeds in order to prevent yield loss. It represents the time interval falling between two separate components: (a) the minimum length of time after seeding that a crop must be kept weed-free so that later-emerging weeds do not reduce yield, and (b) the maximum length of time that weeds which emerge with the crop can remain before they become large enough to compete for growth resources (Radosevich & Holt, 1984; Zimdahl, 1987; Weaver *et al*., 1992; Baziramakenga & Leroux, 1994; Ghadiri, 1996).

In recent years, sustainable agriculture has gained more attention, especially in

developed countries targeting to minimize the use of herbicides. Knowledge and awareness of critical period of weed control can be of great help to weed scientists (Weaver *et al*., 1992; Mesbah *et a*l., 1994; Ghersa *et al*., 2000). Applying herbicides in this period reduced use of herbicides and decreased their persistence in soil. On the other hand, herbicide application may cause weed resistance to herbicides, environmental pollution, underground water contamination and related expenses (Radosevich & Holt, 1984; Zimdahl, 1987; Mesbah *et al*., 1994; Eghtedari Naeini, 1996; Ghadiri, 1996; Javanbakht Hesar, 1996).

In principle, all factors influencing the intensity of interference between crop and weeds can affect the starting time and length of the critical period of weed control. These factors can be summarized as weed density, time of weeds emergence, light, crop species, crop density and planting arrangement, temperature, soil moisture, soil fertility, weed species and planting date (Zimdahl, 1987; Weaver *et al*., 1992; Klingman & Ashton, 1993; Baziramakenga & Leroux, 1994; Eghtedari Naeini, 1996; Ghadiri, 1996; Javanbakht Hesar, 1996).

According to Dawson (1977), irrigated sugar beet should be free from weeds for 10 to 12 weeks after planting, thereafter it could compete with weeds until the end of season and those weeds emerging later would be suppressed by sugar beet. Shahbazi and Rashed Mohassel (2000) mentioned that the critical period of weed control was 4-6 weeks after sugar beet emergence. An further experiment in Arsanjan (Fars province) showed a 30-day critical period of weed control for sugar beet, starting 40 days after planting (Rezaee & Ghadiri, 1998). Another experiment in Birjand, using a cultivator in the 30^{th} day and hand weeding twice in the 60^{th} and 90^{th} day after sugar beet emergence, showed that sugar beet had the highest sugar yield and the highest economic return (Zamani, 1998).

Objective of this study was to determine the critical period of weed control in sugar beet in Chaharmahal & Bakhtiari province (Chahartakhte Research Station).

MATERIALS AND METHODS

To determine the critical period of weed control in sugar beet, an experiment was conducted in Shahrekord region (32° 18′ N, 50° 56′ E, 2085 m asl), consisting of 14 treatments in a randomized complete block design with four replications in 1999 and 2000. Weed free treatments included the removal of weeds at 2, 4, 6, 8, 10 and 12 weeks after planting (WAP) sugar beet crop in 2000 (corresponding to 4, 6, 8, 10, 12 and 14 – leaf stages of sugar beet crop in 1999). In weed infested treatments, weeds were allowed to interfere with sugar beet crop 2, 4, 6, 8, 10 and 12 weeks after planting (WAP) sugar beet crop in 2000 (corresponding to 4, 6, 8, 10, 12 and 14 - leaf stages of sugar beet crop in 1999). Two control treatments (full-season control of weeds and full-season interference of weeds) were also included. Plots consisted of four 10 m rows spaced 61 cm apart. Seedbed was prepared in 15 May (in 1999 and 2000) and fertilized according to the soil test recommendations. Afshari sugar beet cultivar was sown at Chahartakhte Research Station in 20 May. The plant spacing on rows was 20 cm and row spacing was 61 cm. Thinning was carried out at the 4-leaf stage of sugar beet. Sugar beet root was harvested from the two center rows in an area measuring 1.5 by 8 m in 20 September. Sucrose percentage and the concentration of impurities (sodium, potassium, amino-N) were measured at Sugar Beet Research Institute in Karaj. Weed density was determined, using five 1×1 m quadrates during the entire growing season. Data were analyzed using SAS statistical software (SAS Institute, 1997). The critical period of weed control was computed by fitting Logistic and Gompertz models to root yield and sugar yield as a function of weed free and weed infested periods using Slide (Ver.1) and Curve Expert (Ver.1.3) statistical packages.

RESULTS AND DISCUSSION

Yield Components of Sugar Beet

Weed infestation reduced root yield in all treatments. The presence of weeds during the entire growing season decreased root yield by 92.9 % and 61.2 % in 1999 and 2000,

respectively, as compared to full season weed free check. Although sugar content did not show any significant difference between various treatments in both years, weed infestation decreased sugar yield, their corresponding yields decreased considerably in infested treatments. For example, season-long weed infestation decreased sugar yield by 84.87% and 62.1 % in 1999 and 2000, respectively, as compared to weed free check (data not shown). The concentration of sugar beet impurities such as potassium, sodium and amino nitrogen were not affected by weed competition (data not shown).

Effect of Weed Free Period on Weed Dry Matter and Density

The dominant weeds observed in 1999 were common lambsquarters *Chenopodium album* L., redroot pigweed *Amarnthus retroflexus* L., barnyardgrass *Echinochloa crus-galli* (L.)Beauv., and green foxtail (*Setaria viridis* (L.) P.Beauv.). With the exception of barnyardgrass, the same weed species were dominant in 2000. Weed free periods resulted in lower weed densities and biomass (Figure 1).

Critical Period of Weed Control

Weed interference caused a sharp decline in sugar beet root yield (Figure 2). Based on 10 % permissible decrease in root yield, weeding should start from 25 and 5 days after planting in 1999 and 2000, respectively (Figure 2). For the given 10% root yield reduction, weed control should be continued until 78 and 88 days after planting in 1999 and 2000, respectively (Figure 2).

Weed interference caused a sharp decline in white sugar yield (Figure. 3). Based on 10 % permissible decrease in root yield, weeding should start from 27 and 5 days after planting in 1999 and 2000, respectively (Figure 3). For the given 10% root yield reduction, weed control should continue until 73 and 87 days after planting in 1999 and 2000, respectively (Figure 3).

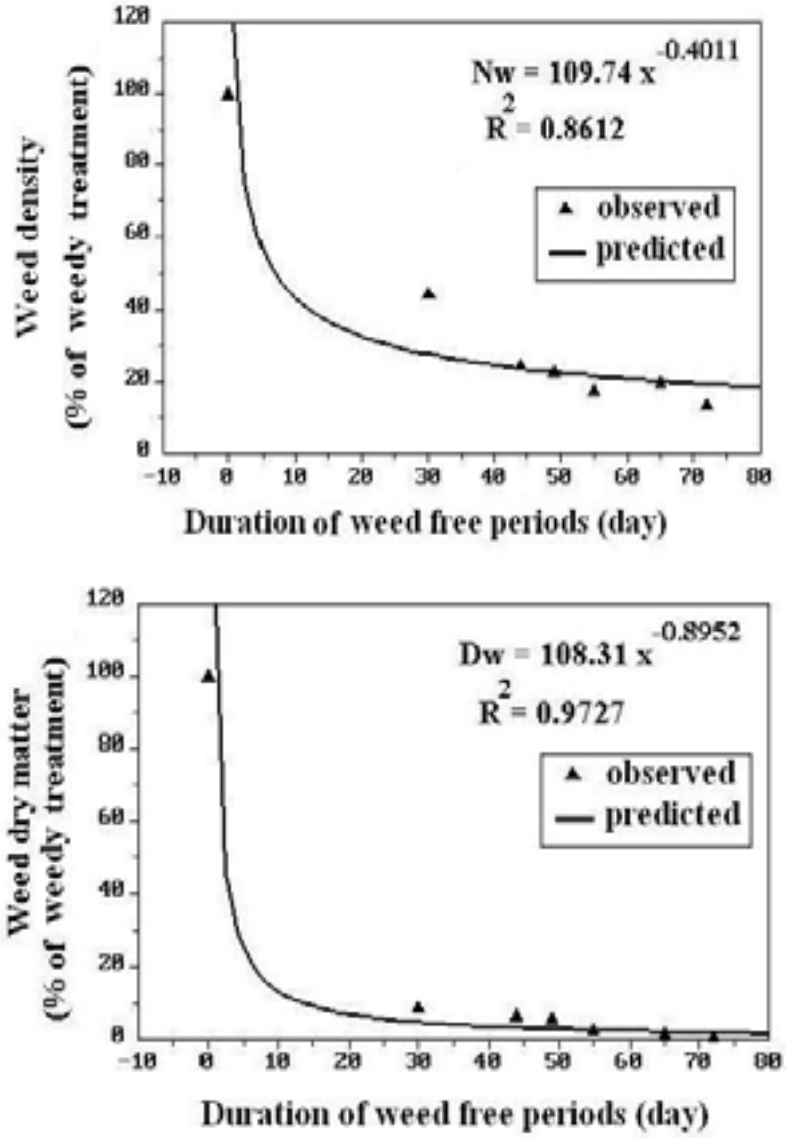

Figure 1. Effect of weed free period on number of weeds and dry weight in sugar beet in two years.

Results indicated a long critical period of weed control in sugar beet due in part to the high density of weeds in this area. Based on a 10% reduction in economic return of sugar beet (white sugar yield), weed control for an 82 day period, initiating from the fifth day after planting, in Shahrekord region is essential. Under high weed infested conditions, not only the critical period of weed control starts earlier, but also it may last for a longer period of time. This has been also reported for other crops such as potato and maize (Eghtedari Naeini, 1996; Javanbakht Hesar, 1996).

Emergence time of weeds influences the critical period of weed control (Zimdahl, 1987; Weaver *et al*., 1992; Mesbah *et al*., 1994; Ghadiri, 1996). In Shahrekord, sugar beet is planted in May and June; this delay in seedbed preparation and planting may lead to earlier germination of weeds over the sugar beet crop. Therefore, critical period of weed control starts earlier and its duration is longer.

At early growth stages, sugar beet has a low competitive ability against weeds; as a result critical period would start sooner. In 1999, presence of weeds for the entire growing season reduced root yield by 92.9% relative to weed free control. In 2000, the reduction was 61.2%. A similar 71% root yield reduction was also observed by Shahbazi and Rashed Mohassel (2000). Dawson (1977) showed that annual weeds that are germinate during a 2-week period after planting or a 4-week period after two-leaf stage in sugar beet reduce root yield by 26 to 100%. Therefore, effective control of weeds at early stages seems to be more important than that of later developed stages. The closure of crop canopy at later growth stages suppresses the late-emerging weeds. The increased period of weed competition reduces the photosynthesis and crop growth (Zimdahl, 1987; Ghadiri, 1996). Longer presence of weeds caused more use of environmental resources (light, water, and nutrients) and more accumulation of dry matter in weeds, making the critical period longer and, therefore reducing root and white sugar yield of the sugar beet crop.

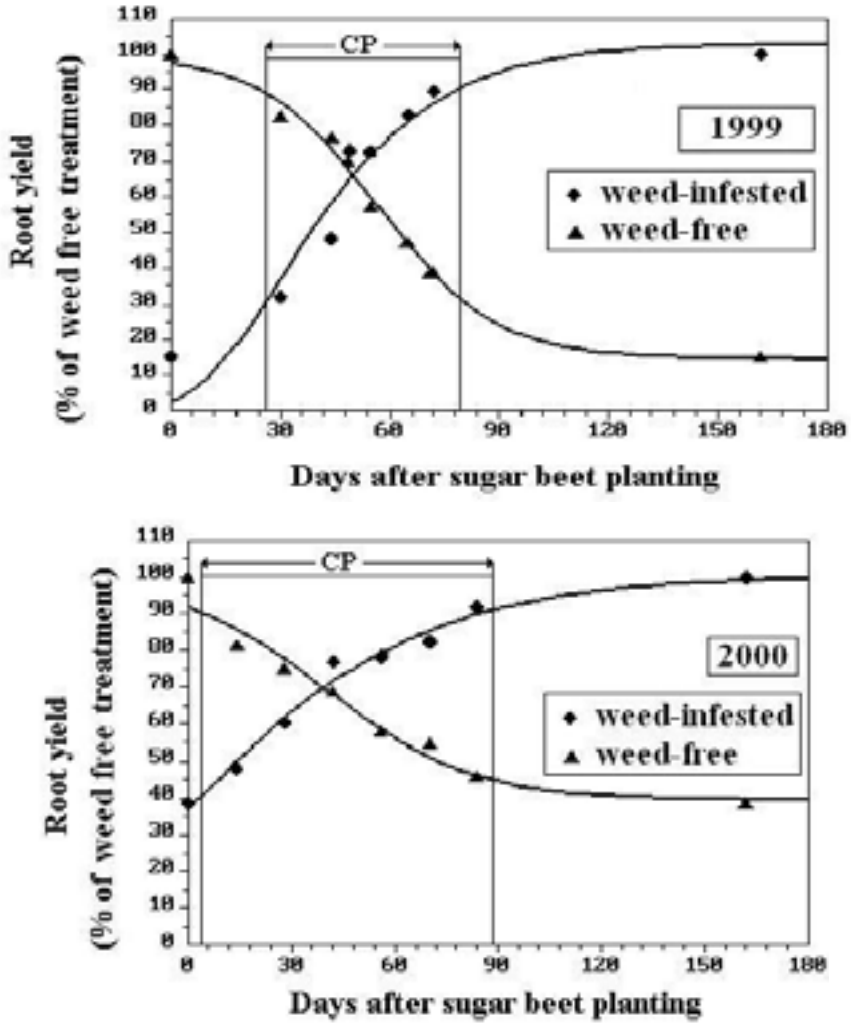

Figure 2. The critical period of weed control (CP) based on 10 % reduction in sugar beet root yield in 1999 and 2000.

Gompertz equations: 1999 $y = 103.32\exp(-3.65\exp(-0.04177^{x}))$

2000 $y = 101.03\exp(-1.01\exp(-0.02736^{x}))$

Logistic equations: $1999y=((1/(0.218\exp(0.0625(x-30))+1.1778))+((1.1778-111)/1.1778))*100$

$2000y=((1/(1.482\exp(0.0472(x-37))+1.6639))+((1.6639-1)/1.6639))*100$

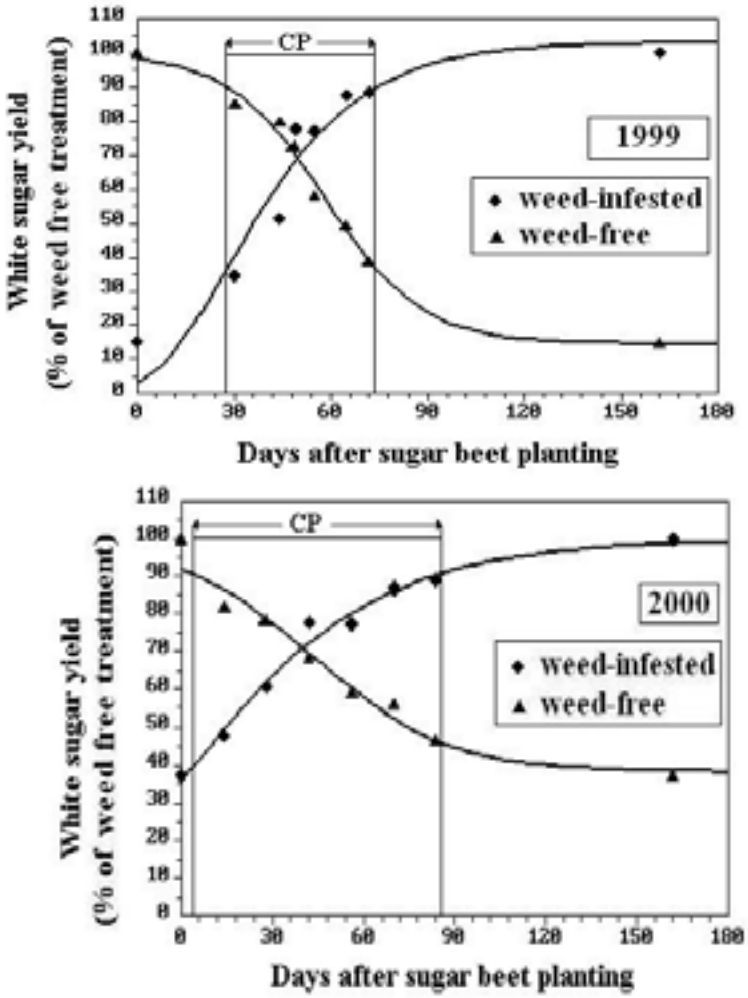

Figure 3. The critical period of weed control (CP) based on 10 % reduction in white sugar yield in 1999 and 2000.

Gompertz equations: 1999 $y=103.55\exp(-3.51\exp(-0.04356^{x}))$

2000 $y=100.28\exp(-1.03\exp(-0.02745^{x}))$

Logistic equations: $1999y=((1/(0.173\exp(0.0671- x -30))+1.1759)) + ((1.1759- 1)/1.1759))*100$

$2000y= ((1/1.26\exp(0.0671(x- 37)+ 1.6294)) + ((1.6294-1)/1.6294))*100$

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