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Article
Araştırma

POSSIBILITIES OF REDUCING HERBICIDE USE IN WEED CONTROL IN SUGAR BEET PRODUCTION

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ABSTRACT : Full mechanized systems are put into practice in weed control of sugar beet in the world. Herbicide usage has a significant role in these systems. Different weed control strategies are needed in order to prevent accumulation of herbicides, applied successively and intensively, to the soil. In this study, effects of combinations of tractor hoeing and band applications of herbicides at low rates on reducing herbicide use per unit area were investigated along with their effects on weed control, sugar beet yield and quality in 2005-2007. According to the results, hand hoeing twice + thinning (control), tractor hoeing twice + thinning, low-dose post-emergence band herbicide application twice + tractor hoeing twice, low-dose post-emergence overall herbicide application three times, low-dose post-emergence band herbicide application once + thinning + tractor hoeing once, low-dose post-emergence band herbicide application once + tractor hoeing twice, low-dose post-emergence band herbicide application three times + tractor hoeing once and low-dose post-emergence band herbicide application twice + tractor hoeing once resulted in 98.6, 96.7, 89.9, 88.4, 85.7, 78.4, 76 and 68 % weed control respectively. In terms of root and sugar yield, following the control treatment (58.98 and 9.77 t ha^{-1}), tractor hoeing twice + thinning (58.07 and 9.63 t ha^{-1}), low-dose post-emergence overall herbicide application three times (57.14 and 9.4 t ha^{-1}), low-dose post-emergence band herbicide application twice + tractor hoeing twice (56.33 and 9.33 t ha^{-1}), respectively, were most effective although there were no significant differences among them. The other treatments produced significantly lower root and sugar yields compared to the control. The results indicated that tractor hoeing twice + thinning and low-dose post-emergence band herbicide application twice + tractor hoeing twice (full mechanized system) gave better performance than the treatments with the other band spraying combined with a tractor hoe and this full mechanized treatment saved 70% in the amount of herbicide sprayed per unit area compared to low-dose post-emergence overall herbicide three times in the arid and semi-arid regions.
Key words: Sugar beet, weed control, herbicide, low dose, band spraying.

ŞEKER PANCARI TARIMINDA YABANCI OT KONTROLÜNDE HERBİSİT KULLANIMINI AZALTMA OLANAKLARI

ÖZET : Dünyada şeker pancarı tarımında yabancı ot kontrolünde tam mekanize sistemler devreye girmektedir. Bu sistemlerde herbisit kullanımı önemli bir yer tutmaktadır. Üst üste yoğun bir şekilde uygulanan herbisitlerin toprakta birikimini önlemek için farklı yabancıot kontrol stratejilerine ihtiyaç vardır. Bu çalışmada 2005-2007 yıllarında birim alana atılacak herbisit miktarını azaltmak amacıyla, traktör çapası ve herbisitlerin düşük dozlarının çıkış sonrası band usulü uygulama kombinasyonlarının, yabancıot ile şeker pancarının verim ve kalitesi üzerindeki etkisi incelenmiştir. Sonuçlara göre, 2 kez el çapası + seyreltme (kontrol) %98.6, 2 kez traktör çapası + seyreltme %96.7, 2 kez çıkış sonrası düşük doz band herbisit + 2 kez traktör çapası %89.9, 3 kez düşük doz çıkış sonrası tam alan herbisit uygulaması %88.4, 1 kez düşük doz çıkış sonrası band herbisit + seyreltme + 1 kez traktör çapası %85.7, 1 kez düşük doz çıkış sonrası band herbisit + 2 kez traktör çapası %78.4, 3 kez düşük doz çıkış sonrası band herbisit + 1 kez traktör çapası %76 ve 2 kez düşük doz çıkış sonrası band herbisit + 1 kez traktör çapası %68 oranında yabancıot kontrolü sağlamıştır. Kök ve şeker verimleri bakımından, kontrol (58.98 ve 9.77 t ha^{-1}) ile kıyaslandığında aralarındaki farklar önemli olmamakla birlikte en iyi sonuçlar sırasıyla, 2 kez traktör çapası + seyreltme (58.07 ve 9.63 t ha^{-1}), 3 kez düşük doz çıkış sonrası tam alan herbisit uygulaması (57,14 ve 9,4 t ha^{-1}), 2 kez düşük doz çıkış sonrası band herbisit + 2 kez traktör çapası (56.33 ve 9.33 t ha^{-1}) uygulamalarında elde edilmiştir. Diğer deneme konularının kök ve şeker verimleri ise istatistiki açıdan kontrolden daha düşüktür. Sonuçlar, kurak ve yarı-kurak bölgelerde 2 kez traktör çapası + seyretltme ve tam mekanize uygulama sistemi olan 2 kez düşük doz çıkış sonrası band herbisit + 2 kez traktör çapasının, diğer band herbisit uygulamalarının yer aldığı kombinasyonlardan daha iyi sonuç verdiğini ve tam mekanize uygulamanın 3 kez düşük doz çıkış sonrası tam alan herbisit uygulamasına kıyasla, birim alana atılan herbisit miktarında %70 tasarruf sağladığını ortaya koymuştur.
Anahtar sözcükler: Şeker pancarı, yabancıot kontrolü, herbisit, düşük doz, band uygulaması

1. INTRODUCTION

Weed control, one of the most important farming practices in sugar beet production is essential to achieve maximum yield and quality. Previously, weeds were used to be controlled by hand, then by hand hoeing (Schweizer and May, 1993). When herbicides for sugar beet were first introduced, they seldom controlled all the weeds emerging in the crop in different periods. Therefore, hand labour and later tractor hoeing were used to supplement them. Coupled with decreases in labour forces, mechanization was introduced into farming practices, which resulted in a replacement of hand hoeing with herbicide treatment and machine hoeing. During the 1960s, in order to reduce herbicide costs band treatment over the sugar beet rows and cultivation between the rows were put into practice (May and Wilson, 2006).

In the late 1970s, a low-volume, low-dose system for the control of broad-leaved weeds was adopted in many northern European countries for most post-emergence herbicide applications. This technique reduced traditional doses of the active ingredients of herbicides by two-thirds in the UK and in many parts of Europe (Smith, 1983). FAR systems (a main low dose system, comprising three main elements: F: phenmedipham, A: activator herbicide which is ethofumesate or triallat, R: residual herbicide which is metamitron or chloridazon or lenacil) in Europe (Hermann et al., 1992) or micro-rate systems in the USA (Dexter et al., 1997) were developed in the 1990s to reduce doses still further. Normally FAR treatments are a combination of phenmedipham, ethofumesate, a residual component (metamitron, lenacil or chloridazon) plus mineral or vegetable oil according to conditions reducing herbicides at two-third rate. But in this system, typically one or two extra spray omissions are necessary compared to other current systems. The micro-rate systems use the principle of combining desmedipham plus phenmedipham with trisulfuron methyl and clopyralid plus a methylated vegetable oil.

When using FAR and micro-rate systems, application of herbicides over the whole sugar beet area when weeds are at the stage of cotyledon or early true leaves is essential. For satisfactory weed control, herbicides must be applied four times (once at pre-emergence and three times at post-emergence) in FAR system and three, four or more times in micro-rate system (May and Wilson, 2006).

With the advent of self-steered band sprayers, low-dose technique was adapted for band spraying (McClean, 1982). Wevers (1992) reported that the reduction of herbicide costs sometimes reached up to 30% on weedy, sandy and organic soils. Although a low-dose system of band treatment (combined pre-emergence application once with post-emergence application twice) could reduce chemical costs by 65% and it required three times more man-hours than an overall spraying system. Also, band sprayings were limited due to heavy rain in wet seasons. As a result, growers switched from band to overall treatments. At the same time, the achievement of this system was affected by variable seasons (McClean and May, 1986) as well as pre-emergence residual herbicide sprayings.

The effectiveness of pre-emergence residual herbicides decreases with reductions in rainfall or soil moisture content. Furthermore, these applications reduce root yield of sugar beet under heavy rainfall due to phytotoxicity on sugar beet as a result of their high availability (Campagna et al., 2000). As a consequence, the application of post-emergence herbicide has become more and more important. Considering insufficient effectiveness of one time full rate herbicide application on weed, a low-dose technique of post-emergence for weed control was adapted in the 1980s (Schweizer and May, 1993; May, 1996; Schäufele, 2000). The usage of low-dose herbicide three times or more not only increase their effectiveness but also decrease amount of their residues in soils.

Data for water quality monitoring show that herbicides are the most frequently detected group of pesticides in underground and surface waters (Carter, 2000). Several herbicide residues were found in soils (Eronen and Mutanen, 2000). In recent years, the successive and intensive usage of herbicides at full rate has resulted in residue in the soil and thereby caused environmental pollution. On the other hand, herbicides are leached from the soil into the underground water and threat human health. Therefore, it is very important that herbicides are applied in optimum dose and time.

After several new type of machine hoes were developed, a stage of trials were carried out to make use of them widespread (Miller and Fornstrom, 1989; Tugnoli et al., 2002).

In dry seasons, weeds may be harder to kill by herbicides because of large amounts of wax on their leaves. Tractor hoes perform much better to kill surviving weeds between the rows in dry conditions because less rerooting of the weeds is likely to occur (May and Wilson, 2006).

Weather conditions are changeable and have generally dry seasons in arid and semi-arid regions such as Turkey. Efficient weed control in sugar beet could increase the yield by 25-40 % in these regions (Özgür, 1980; Gürsoy, 1982). In some fields of Turkish sugar beet growing areas, weeds between the rows are controlled by implementing firstly hand hoeing, secondly thinning with hand hoeing within the rows and finally hand hoeing between the rows. Consequently, this method gives a very good control.

Studies in weed control of sugar beet, included not only low-dose post-emergence herbicide application but also machine hoeing, were carried out (Buzluk and Acar, 2002; Kaya and Buzluk, 2006). Also, low-dose post-emergence herbicides plus vegetable oil in FAR system in Europe did not differ from only low-dose post-emergence herbicides without vegetable oil in Turkey (Özgür and Kaya, 2000). A relatively effective weed control was achieved with application of low-dose post-emergence herbicide mixtures three times (Özgür and Kaya, 2000). On the other hand, the results indicated that treatments with different machine hoes also gave a relatively satisfactory weed control (Buzluk and Acar, 2002). Hand hoeing labor cost is getting higher and higher. Machine hoeing is efficient for the control of inter-row weeds but not within the row and this can be regarded as one of its most important disadvantages.

With the aim of reducing amount of herbicides applied to per unit area in arid and semi-arid regions, it was investigated the effects of low-dose post-emergence band herbicide sprayings combined with tractor hoeing on weed control, and sugar beet yield and quality.

2. MATERIALS AND METHODS

The study was carried out in field plots of Sugar Institute in Konya during 2005-2007. The trials including 54 plots were established in an area of 3623 m² in a randomized complete block design with six replications. Plots (2.25 x 10.0 m) were sown in five rows and only inner three rows were harvested. Soil type was clay-loam (11% sand, 30% silt, and 60% clay, pH 8, 1.5% organic matter). The cultivar Leila, obtained from Kleinwanzlebener Saatzucht A.G.– Einbeck (Germany) and treated with fungicides (hymexazol and thiram) and an insecticide (imidacloprid), was used in this study. Soil was prepared by stubble tillage following the harvest of cereal in autumn. After the fertilization as recommended (N: 160 (80+80), P_2O_5: 8 (5+3), K_2O: 7 kg ha^{-1}) in a conventional way, the trial field was ploughed again. For seed bed preparation in the spring, the remaining part of the fertilizers was applied into the soil. Then the trial field was drilled with a combi-crumbler. The seeds were then sown by mechanical precision drilling machine in 5 rows, in 45 cm row width and at 8 cm seed space. Other cultivation techniques were also implemented in the conventional way.

Hand hoe with a sharpened blade of 15 cm and a handle of 140-150 cm was used in the control treatment. A rotary hoe, rear mounted to a tractor, adjusted to 30 cm working width and 3-8 cm working depth, with 4-5 km h^{-1} working speed, and 25 kW power was used in the required treatments. The herbicide mixture, Betanal Progress OF [phenmedipham (9.2 %) + desmedipham (7.2 %) + ethofumesate (11.3 %), 1.2 l ha^{-1}], Pyramine DF [chloridazon (65 %), 1.0 kg ha^{-1}], and Lontrel 100 [clopyralid (12.6 %), 0.5 l ha^{-1}], was used in the low-dose post-emergence overall sprayings. Band application of the herbicide mixture at 55% reduced rate (Betanal Progress OF 0,540 l ha^{-1}, Pyramine DF 0.450 kg ha^{-1}, and Lontrel 100 0.225 l) was applied onto the rows in the trial plots in 20 cm width by a sprayer mounted on a tractor combined with tractor hoeing. Betanal Progress OF and Lontrel were added to the mixture to control weeds at the cotyledon stage while Pyramine DF to provide residual control at the beginning of germination. The herbicide mixtures were applied post-emergence by a sprayer mounted on a tractor. Low-dose post-emergence overall sprayings were applied by using 11002 flat fan nozzles (220 l ha^{-1} volume capacity) and low-dose post-emergence band sprayings were applied with 8001 even flat fan nozzles (100 l ha^{-1} volume capacity).

All sprays were applied at the cotyledon stage of the weeds and according to the growth stage of the sugar beet plants (Table 1). After all treatments were done, the weeds in all trial plots were counted in the area of 1 m² by a frame with the dimensions of 0.185 x 1.35 m. The weed species were identified based on the descriptions given by Davis (1965-88) and the identified weed species and density were given in Table 2.

Table 1. The treatments and weed management order at sugar beet growth stages.

Treatments	Weed management order at sugar beet growth stages				
	Cotyledon stage (BBCH:10)	2-4 true leaves stage (BBCH:12-14)	4-6 true leaves stage (BBCH:14-15)		8-10 true leaves stage (BBCH:19)
1. Untreated				Thinning by hand	
2. 2xHH+T (control)		Hand hoeing		Thinning by hand hoe	Hand hoeing
3. 2xTH+T		Tractor hoeing		Thinning by hand hoe	Tractor hoeing
4. 3xOH	BPO+P+L mix	BPO+P+L mix	BPO+P+L mix	Thinning by hand	
5. 1xBH+2xTH	BPO+P+L mix	Tractor hoeing		Thinning by hand	Tractor hoeing
6. 2xBH+2xTH	BPO+P+L mix	BPO+P+L mix, Tractor hoeing		Thinning by hand	Tractor hoeing
7. 2xBH+1xTH	BPO+P+L mix	BPO+P+L mix		Thinning by hand	Tractor hoeing
8. 3xBH+1xTH	BPO+P+L mix	BPO+P+L mix	BPO+P+L mix	Thinning by hand	Tractor hoeing
9. 1xBH+T+1xTH	BPO+P+L mix			Thinning by hand hoe	Tractor hoeing

BPO: Betanal Progress Of (1.2 kg ha^{-1}), P: Pyramine DF (1 kg ha^{-1}), L: Lontrel 100 (0.5 kg ha^{-1})
HH: Hand hoeing, T: Thinning by hand hoe, TH: Tractor hoeing, OH: Overall herbicide application, BH: Band herbicide application

Table 2. Weed species and average density in the untreated plots of the trial field in 2005-2007.

Family	Weed species	Average weed density (number m^{-2})			
		2005	2006	2007	Average
	Dicotyledons				
Amaranthaceae	*Amaranthus blitoides* S.Wats.	39.67	5.50	5.00	16.72
	Amaranthus retroflexus L.	0.67	0.83	0.50	0.67
Chenopodiaceae	*Chenopodium album* L.	10.67	7.17	7.33	8.39
	Chenopodium urbicum L.	0.83	-	-	0.28
	Chenopodium vulvaria L.	0.50	-	10.33	3.61
	Salsola kali L.	-	-	0.33	0.11
Convolvulaceae	*Convolvulus arvensis* L.	5.00	-	1.83	0.72
Fumariaceae	*Fumaria parviflora* Lam.	0.17	0.17	7.83	2.72
Papaveraceae	*Papaver rhoeas* L.	-	0.33	-	0.11
Asteraceae	*Lactuca serriola* L.	0.33	0.17	-	1.67
	Sonchus asper (L.) Hill	0.83	0.67	0.50	0.67
Brassicaceae	*Sinapis arvensis* L.	-	0.17	-	0.06
	Conringia orientalis (L.) Andrz.	-	-	0.67	0.22
Solanaceae	*Solanum nigrum* L.	0.17	-	-	0.06
	Monocotyledons				
Poaceae	*Alopecurus myosuroides* Hudson	-	-	0.17	0.06
	Avena fatua L.	2.17	0.50	-	0.89
	Echinochloa crus-galli (L.) P.Beauv.	6.33	-	-	2.11
	Total	67.34	15.51	34.49	39.07

Effectiveness of weed control was determined by the Abbott's formula after calculating the angle values of the weed density per plot. The data were tabulated and evaluated through analyses of variance using a package statistics program, Mstats-C Version 1.42. Then, the Duncan Test was used to determine the differences among the means of the treatments.

3. RESULTS AND DISCUSSION

The results of the trials, presented as means of the years of 2005, 2006 and 2007, are given in Figure 1, 2, 3, and 4. The treatment of hand hoeing twice plus thinning (the control) produced the lowest weed density. All the other treatments produced higher weed densities (Figure 1). In terms of effectiveness of weed control, the best results were obtained from the control and tractor hoeing twice plus thinning treatments. The differences between both treatments were not significant. The others, compared to the control, showed lower effectiveness of weed control. The effectiveness of weed control was 98.6% in hand hoeing twice plus thinning, 96.7% in tractor hoeing twice plus thinning, 89.9% in low-dose post-emergence band herbicide twice plus tractor hoeing twice, 88.4% in post-emergence low-dose overall herbicide three times, 85.7% in low-dose post-emergence band herbicide once plus thinning plus tractor hoeing once, 78.4% in low-dose post-emergence band herbicide once plus tractor hoeing twice, 76% in low-dose post-emergence band herbicide three times plus tractor hoeing once and %68 in low-dose post-emergence band herbicide twice plus tractor hoeing once (Figure 1).

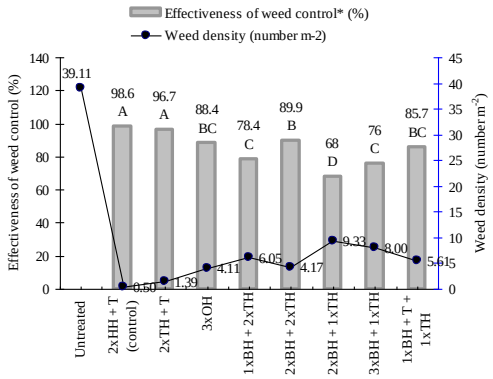

Figure 1. Mean effectiveness of weed control and weed density of the treatments in 2005-2007 ($P<0.05$) (HH: Hand hoeing, T: Thinning by hand hoe, TH: Tractor hoeing, OH: Overall herbicide application, BH: Band herbicide application, *percentage reduction in the number of weeds vs. the untreated control set at 100)

The results of root yield were compatible with those of sugar yield. Tractor hoeing twice plus thinning, low-dose post-emergence overall herbicide three times, low-dose post-emergence band herbicide twice plus tractor hoeing twice and the control treatments gave 58.07 and 9.63 t ha^{-1}; 57.14 and 9.4 t ha^{-1}; 56.33 and 9.33 t ha^{-1} and 58.98 and 9.77 t ha^{-1} root and sugar yields respectively although the differences among them were not statistically significant. Root and sugar yields of the treatments of low-dose post-emergence band herbicide application three times plus tractor hoeing once (54.87 and 9.08 t ha^{-1}) and low-dose post-emergence band herbicide once plus thinning plus tractor hoeing once (53.88 and 8.98 t ha^{-1}) were statistically the same as those of the treatments of low-dose post-emergence overall

herbicide three times (57.14 and 9.4 t ha^{-1}) and low-dose post-emergence band herbicide twice plus tractor hoeing twice (56.33 and 9.33 t ha^{-1}) but statistically lower than those of the control (58.98 and 9.77 t ha^{-1}) (Figure 2 and 4).

There were no differences among the treatments in terms of quality parameters such as sugar content and extractable sugar content (Figure 3).

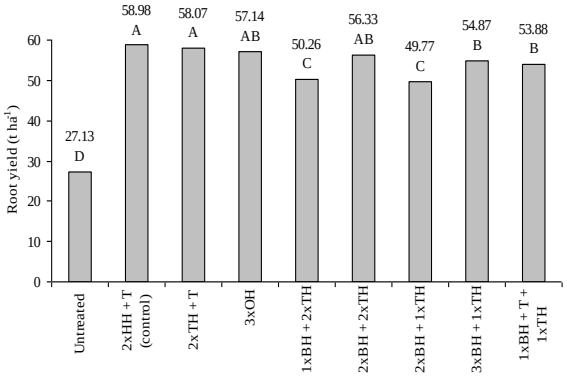

Figure 2. Mean root yields of the treatments in 2005-2007 (P<0.05) (HH: Hand hoeing, T: Thinning by hand hoe, TH: Tractor hoeing, OH: Overall herbicide application, BH: Band herbicide application)

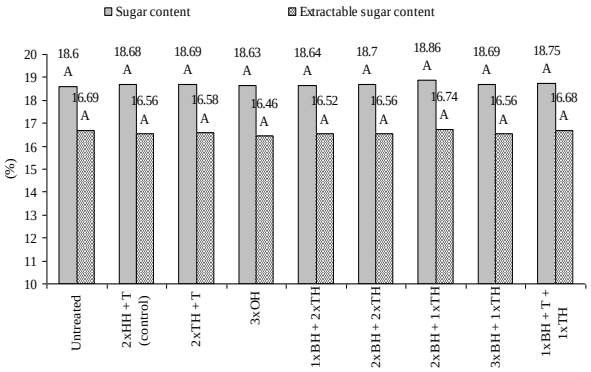

Figure 3. Mean sugar and extractable sugar contents of the treatments in 2005-2007 (P<0.05) (HH: Hand hoeing, T: Thinning by hand hoe, TH: Tractor hoeing, OH: Overall herbicide application, BH: Band herbicide application).

Although lower effectiveness of weed control were obtained with low-dose post-emergence overall herbicide three times and low-dose post-emergence band herbicide twice plus tractor hoeing twice compared to the control and tractor hoeing twice plus thinning, all of them gave similar results in terms of root and sugar yields. Low-dose post-emergence band herbicide twice plus tractor hoeing twice was statistically lower than the control in terms of effectiveness of weed control. On the contrary, they performed as well as the control in terms of root and sugar yield. Consequently, uncontrolled weed density up to 10.6% did not result in an economically significant loss of root and sugar yields.

In the study, the differences among the treatments in terms of weed density and effectiveness of weed control were not consistent with root and sugar yield, because uncontrolled weeds up to a given density level did not result in an economically loss of root and sugar yields and different weed species in the plots led to different damage. Brandes et al. (1998) also reported that a certain infestation of weed could be tolerated. Likewise, the results in this study showed that a weed infestation of 10.6 % did not cause a significant loss of root and sugar yield. Schweizer and Dexter (1987) stated that competition from uncontrolled annual weeds can reduce root yield by 26-100%. The untreated in this study gave a 54 % loss of root yield compared to twice hand hoeing plus thinning. These results were in line with those obtained by Kaya and Buzluk (2006).

At the same time, this study showed that when weeds were not controlled at all, weed growth resulted in losses by 54 % for beet yield and 53.7 % for sugar yield which were higher than the losses stated by Özgür (1980), Gürsoy (1982), and Kaya and Buzluk (2006). In terms of sugar and extractable sugar content, the results obtained in this study are match those of Campagna et al. (2000), Ransom et al. (2002), and Kaya and Buzluk (2006).

In the past, limited effectiveness was obtained with one application of pre-emergence or post-emergence full rate of herbicides. Low-dose applications of herbicide 3 to 5 times instead of one full rate application increased the effectiveness on weeds but the amount of herbicide applied per unit area was not decreased. In the study, the treatments, combined a low-dose post-emergence band application of herbicides with a tractor hoeing in the system of the full mechanized weed control, provided a satisfactory weed control.

McClean and May (1986) stated that low-dose band spraying could reduce chemical costs by 65% only when the weather is favorable and band sprays could not be used in adverse seasons. They also reported that the treatment, band application three times plus tractor hoeing twice, saved 41% compared to low-dose overall application. It is very difficult to use this system in practice in wet or rainy regions.

Hand labour has extremely decreased in sugar beet growing recently. Consequently, pre- or post-emergence herbicide application is necessary. Without using hand labour, the spectrum and duration of action of herbicides must be extend to kill the weeds more effectively as it has been implementing in Europe from 1990s up to date. To increase the duration of action of herbicides, low doses of each active ingredient were added to the mixture. By spraying the mixtures four or five times overall, a good weed control was obtained. In the low dose overall system, totally high amount of herbicide is used per unit area. Any adverse effects have not been observed with the

implement of mixtures of several herbicides and on the weed resistance to herbicides. In this study, without decreasing herbicide doses in the low dose overall systems, a band spraying of herbicides combined with tractor hoeing controlled weeds effectively.

The results in this study showed that full mechanization system, combined low-dose post-emergence band herbicide twice with tractor hoeing twice and semi- mechanization system, tractor hoeing twice plus thinning, gave a good weed control. Arid and semi-arid climatic conditions in Konya allowed us to use band sprays and tractor hoe on time. Thinning is done by hand labour. If there is enough man labour, this semi-mechanization system can be used without spraying any chemicals. As suggested by Kaya and Buzluk (2006), low-dose post-emergence overall application of herbicides three times provided satisfactory weed control without implementing any other additional technique in arid and semi-arid regions. With using low-dose band sprays twice plus tractor hoeing twice, not only one application but also the amount of herbicide was saved by spraying larger area in the way of band application compared to overall application. Thus, total saving was 70% in the amount of herbicide, by applying low-dose post-emergence band herbicide twice plus tractor hoeing twice compared to low-dose post-emergence overall application three times.

Wilson (2005) suggested that beet yield was 15% greater with low-dose overall herbicide application compared to band herbicide application. On the contrary, in this study band sprayings twice combined with tractor hoeing twice and low-dose overall treatments three times gave the same root yields.

Four overall applications in the micro rate systems provided satisfactory yields (Ransom et al., 2002). In this study, the same results were obtained with both low-dose overall application three times and low-dose band application twice plus tractor hoeing twice.

Carter (2000) reported that herbicides were frequently detected in underground and surface waters and Eronen and Mutanen (2000) found several herbicide residues in soil. With decreasing amount of herbicides sprayed into soil, herbicide accumulation will be reduced especially in the soils of arid and semi-arid regions where degradation is low. As a result, possible phytotoxic damage to following crops and environmental pollution will be prevented.

In this study, tractor hoeing twice plus thinning gave a good performance as well as band sprayings twice combined with tractor hoeing twice. These results show that tractor hoeing twice plus thinning can control weeds without applying any herbicide in arid and semi arid regions since weeds do not germinate and grow vigorously on the rows during spring seasons which sugar beet is very sensitive to weeds in 2005-2007. Killing weeds on the row and thinning are done together in the treatment of twice tractor hoeing plus thinning.

4. CONCLUSION

In this study it was found that the best results were obtained by hand hoeing twice plus thinning and also tractor hoeing twice plus thinning can control weeds without applying any herbicide in arid and semi arid regions. At the same time a satisfactory weed control was accomplished by combining low-dose band sprays with tractor hoeing in the full mechanized system and saving in the amount of herbicide usage per unit area were achieved in arid and semi-arid regions when compared to humid regions in Europe. With low-dose post-emergence band sprays twice plus tractor hoeing twice, one herbicide spray was saved and 70% saved in total amount of herbicide usage compared to low-dose post-emergence overall application.

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