Journal of Research in Weed Science

Journal homepage: www.jrweedsci.com

Original Research

Efficacy and selectivity of pendimethalin for weed control in sugar beet (*Beta vulgaris* L.), Gezira state, Sudan

Ahmed M. Yagoob [a], Mohamed S. A. Zaroug [b], Awadallah B. Dafaallah [b,*]

a Crop Protection Directorate, Ministry of Agriculture and Natural Resources, North Darfur State, Sudan.

b Crop Protection Department, Faculty of Agricultural Sciences, University of Gezira, Sudan.

ARTICLE INFORMATION

Received: 03 June 2020

Revised: 09 August 2020

Accepted: 01 September 2020

Available online: 04 September 2020

DOI: 10.26655/JRWEEDSCI.2021.1.2

KEYWORDS

Beta vulgaris

Efficacy

Pendimethalin

Sugar Beet

Weed Control

ABSTRACT

Sugar beet (*Beta vulgaris* L.) is considered as the second most important crop in the world after sugar cane in sugar production. Weed competition is considered as one of the major constrains to achieve maximum sugar beet yield. The objective of this study was to evaluate the efficacy and selectivity of the herbicide Pendimethalin for weed control and their effect on sugar beet growth and yield. A field experiment was conducted during 2017/18 winter season at the experimental farm, Faculty of agricultural Sciences Gezira University, Sudan. The herbicide Pendimethalin (Pendico50% EC) at two rates (3.6 and 4.8 kg a.i. ha^{-1}) was applied as per-sowing, two weeks before planting and irrigated immediately after application. Hand weeded and un-wedded treatments were added as controls. The treatments were arranged in a randomized complete block design in 4 replicates. Data were subjected to analysis of variance procedure (P ≤ 0.05). Pendimethalin at the lower rate (3.6 kg a.i. ha^{-1}) exhibited slight phytotoxicity on sugar beet plant. The herbicide at the lower rate gave 82% grass weed control and 56% broadleaved weed control. The herbicide treatments significantly increased the root length, root diameter and root weight of sugar beet as compared to un-weeded check. Pendimethalin at the two rates tested gave significantly high root weight compared to un-weeded check. The herbicide treatments increased the gross sugar yield. Pendimethalin at 3.6 and 4.8 kg a.i. ha^{-1} gave significantly high gross sugar yield (0.74 – 0.52 ton ha^{-1}) compared to 0.15 kg ha^{-1} gross sugar yield of the un-weeded control. It could be concluded that Pendimethalin at 3.6 kg a.i. ha^{-1} could be used for weed control in sugar beet to be applied and immediately irrigated two weeks before sowing of sugar beet. Further studies are needed to confirm their safety and inclusion in a management program.

Introduction

Sugar beet (*Beta vulgaris* L.), belongs to the family Chenopodiaceae and considered as one of the important sugar crops in Sudan. It is the second crop after sugarcane for sugar production. It can be

Corresponding author, email: awadna@uofg.edu.sd (Awadallah B. Dafaallah).

grown in irrigated schemes of the Sudan. Sugar beet plants are characterized by their slow rate of growth during the early stages from emergence to thinning time. The presence of weeds during the entire growing season decreased sugar beet root yield by 61.2%-92.9% (Salehi et al. 2006). Sugar beet is weak in competing with emerging weeds until it has at least 8 true leaves (May, 2001). Competition between sugar beet and annual weeds could be responsible for sugar yield reductions of 25-100% (Poorazar and Ghadiri, 2001). Weeds are known to cause crop yield losses, reduce harvesting efficiency, reduce quality of the harvest product and perhaps harbor insects and diseases that may harm the crop. Yield losses due to are of the greatest concern and have been predicted using early season assessments of the weed population such as weed seedling density, relative time of emergence, weed pressure, and relative leaf area (Schwizer and May, 1993; Dieleman and Mortensen, 1998). Approximately, 70% of weed species in sugar beet fields are mainly broadleaf annual such as redroot pigweed (*Amaranthus retroflexus* L.) (Weaver and Williams, 1980; Schwizer and May, 1993; Heidari et al. 2007). Weeds such as redroot pigweed and fat-hen (*Chenopodium album* L.) can be taller than the crop canopy. Weeds that emerge 8 weeks after sowing, and particularly after the sugar beet plants have eight or more leaves, are less likely to affect yield (Scott et al. 1979).

Weed control is an essential component of productive agriculture (Mehdizadeh and Mushtaq, 2020; Zain et al., 2020). Herbicides are the primary tool to manage weeds. The range of weed species controlled by each herbicide is also limited (Lajos and Lajos, 2000). For high efficacy of chemical method, the timing of application is very important. Weeds should be at cotyledon stage to ensure successful weed control (Dale and Renner, 2005; Dale et al., 2005). The most popular active herbicides applied so far for weed control in sugar beet are phenmedipham, metamitron, ethofumesate, desmedipham, triflusulfuron-methyl, lenacil, clopyralidand chloredazone (May, 2001; Deveikyte, 2005; Wilson et al. 2005). Triflusulfuron-methyl is selective for the control of annul and perennial broad-leaved weeds and grasses in sugar beet when applied at low rates. Chloredazone is used extensively for broad-leaved weed control in sugar beet. Field observations indicated that weed emergence commenced 30 days after the application of a reduced dose of 1.3 kg ha^{-1} Chloredazone (Majidi et al. 2011). Since sugar beet, is a temperate crop, grown in warm climate of the Sudan, and is a slow growing crop is vulnerable to severe weed competition. It is also sown in widely spaced rows of 80cm distance providing a large surface area for weeds to germinate and grow. When sugar beets are cultivated without any weed control measure, sugar yield losses can reach up to 95% (Petersen, 2003). The highest cost of hand weeding and their damaging effect on sugar beet plants showed that using herbicides is more economic practice. The chemicals so far applied on sugar beet are not satisfactory (Mehdizadeh et al. 2016) with the exception of roundup ready sugar beet. Moreover, most tested herbicides for weed control in sugar beet in Sudan were phytotoxic to the crop. Therefore, there is a need to look for optimum time of application of herbicides which are efficient in control of weed and safe to the crop. Therefore, this research was designed to study efficacy and selectivity of Pendimethalin for weed control in sugar beet (*Beta vulgaris* L.), Gezira State, Sudan.

Materials and Methods

Experimental site

A field experiment was conducted in the season 2017/18 at the Experimental Farm of the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan. Latitude 14° 06´N, longitude 33° 38´E and altitude 407 masl. The area is characterized by hot-semi arid climate. The soil of the experimental site is typical haplusten, line semctitic, isophyperthemic with PH 9.5-8.5 (Adam personal communication).

Field methods

Land preparation was done by disc ploughing, harrowing and leveling, in October 20, 2017. Furrows were opened at 80 cm apart. The experiment was laid out in a randomized complete block design with 6 treatments and 4 replicates. The experimental plots consisted of 5 rows, each 5 m long. The herbicide Pendimethalin (Pendico50% EC) at two rates; 1.92 and 2.4 kg a.i. ha^{-1} was tested as pre-sowing treatments. The Un-weeded (U) and Hand-weeded (H) treatments were also included. Hand weeding was done manually whereby emerging weeds removed by hand biweekly. The herbicides were applied in October 20, 2017 using a knapsack sprayer calibrated to deliver 357.1 l ha^{-1}. Irrigation was given immediately after herbicides application. Sugar beet seeds, variety Linard, were planted two weeks after irrigation. The seeds were sown manually by placing 2-3 seeds/hole in 15 cm spacing. Irrigation was then given biweekly. Urea fertilizer at the rate of 119.1 kg ha^{-1} was applied 30 days after planting. Thinning was done in 15 days after planting to one plant per hole.

Data collection

Seedling emergence and phytotoxicity parameters

Seedling emergence %

The number of emerged sugar beet seedlings was counted in the three middle rows, two weeks after planting. Then, the seedling emergence percent was calculated by the following formula:

$$Seedling\ emergence\ \% = \frac{Number\ of\ emmeged\ seedlings}{Total\ number\ of\ sown\ seeds\ in\ the\ H\ control} \times 100$$

Phytotoxicity

The injury due to herbicide treatments described as phytotoxicity was estimated visually at 4 and 8 weeks after emergence. The phytotoxicity effect was described using the visual rating scale 0-5. Where; 0 = healthy plant, 1 - 2 = slight phytotoxicity, 3 - 4 = moderate phytotoxicity and 5 = high phytotoxicity or dead plant.

Weed parameters

Weed count %

The effects of herbicides treatments on weeds; annual grasses, annual broadleaf and total weed control % were assessed by counting total and individual weed species in 1 m^2 (125×80cm) at 4 and 8 weeks after sowing (WAS). The percent weed control was calculated according to the flowing formula:

$$Weed\ count\ \% = \frac{Wx - Wy}{Wx} \times 100$$

Where; Wx = number of individual weeds in the un-weeded control and Wy = number of individual weeds in the treatment.

Weed ground cover

The percentage weed ground cover was estimated visually. Each plot was assigned aground cover percentage.

Crop parameters

Sugar beet was harvested 5 months after planting to assess the sugar beet growth and yield characteristics. The yield included the quantity and quality characteristics.

Sugar beet growth characteristics

To assess sugar beet growth characteristics, 10 plants were harvested randomly from each plot. The number of leaves/plant was counted and root length and root diameter were measured using verinier. Then, the leaf fresh weight in g/plant and root weight in g/plant were determined.

Sugar beet yield characteristics

The yield quantity was determined by measuring the top yield (ton ha^{-1}), root yield (ton ha^{-1}) and gross sugar yield (kg ha^{-1}). While the yield quality was determined (at Al Gunied Sugar Factory, Gezira State, Sudan) by measuring the following parameters:

Total Soluble Solids (T.S.S) % (Brix %): It was determined using hand Briximeter device.

Sucrose %: It was determined using the Standard Densimetric Device.

Purity %: It was calculated using the following formula:

$$Purity\ \% = \frac{Sucrose\ \%}{T.S.S.\ \%} \times 100$$

Gross sugar yield (kg / ha): It was then calculated using the following formula:

$$Gross\ sugar\ yield\ (kg\ ha^{-1}) = root\ yield\ (kgha^{-1}) \times sucrose\ \%$$

Data analysis

Collected data were subjected to analysis of variance (ANOVA) procedure. Significant ($P \leq 0.05$) means were separated using Duncan's Multiple Range test (DMRT). The statistical analysis was done using the Software MSTAT.

Results and Discussion

Effect of the herbicide on seedling emergence and phytotoxicity

Effect of the herbicide on seedling emergence

The results showed that the herbicide Pendimethalin at rate of 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1} significantly ($P \leq 0.05$) reduced seedling emergence in sugar beet crop compared to the hand-weeded control (100%) (Table 1). The seedling emergence was 72.6% and 87.5%, at the herbicide rate of 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1}, respectively. However, there was significant difference in the seedling emergence between the two rates of the herbicide.

Effect of the herbicide on phytotoxicity

The results showed that Pendimethalin at 3.6 kg a.i. ha^{-1} gave slight phytotoxicity (scale 1) in sugar beet plants (Table 1). However, Pendimethalin at 4.8 kg a.i. ha^{-1} gave moderate phytotoxicity which adversely affect sugar beet plant and significantly reduced sugar beet plant emergence (72.75%) in comparison to other herbicide treatments.

Table 1. Effect of the herbicide on seedling emergence and phytotoxicity of sugar beet crop.

Treatments	Seedling emergence %	Phytotoxicity scale (0-5)
Pendimethalin at 3.6 kg a.i. ha^{-1}	87.50 b	2.00
Pendimethalin at 4.8 kg a.i. ha^{-1}	72.75 c	3.00
Hand weeded control	100.0 a	0.00
Un-weeded control	100.0 a	0.00
SE±	0.87	
CV%	10.94%	

* Where; 0 = healthy plant, 1 - 2 = slight phytotoxicity, 3 - 4 = moderate phytotoxicity and 5 = high phytotoxicity or dead plant. ** Means in the same column of followed by the same letter(s) are not significantly (P ≤ 0.05) different according by Duncan's Multiple Range test.

Effect of the herbicide on weed control

Effect of the herbicide on grasses weeds control

The results showed that Pendimethalin at the two rates tested significantly (P ≤ 0.05) reduced grass weeds infestation as compared to un-weeded check (Table 2). The herbicide at 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1} gave 82% and 84% grass weed control, respectively. There were no significant differences between the two herbicide rates. The grass weed controlled include; *Sorghums sudanensis*, *Echinochloa colon, Brachiaria eruciformis*, and *Eragrostis megatachya*.

Table 2. Effect of the herbicide on control percentage of annual grasses, annual broadleaf, total weed control and weeds ground cover.

Treatments	Control %			Weeds coverage %
	Grass weeds	Broad leaved weeds	Total weeds	
Pendimethalin at 3.6 kg a.i. ha^{-1}	82.00 b	56.50 b	69.25 b	30.75 b
Pendimethalin at 4.8 kg a.i. ha^{-1}	84.00 b	60.00 b	72.00 b	28.00 b
Hand weeded control	100.0 a	100.0 a	100.0 a	0.00 c
Un-weeded control	0.00 c	0.00 c	0.00 c	100.0 a
SE±	1.09	4.47	1.68	0.76
CV%	3.10 %	9.25 %	5.44 %	4.01 %

* Means in the same column of followed by the same letter(s) are not significantly (P ≤ 0.05) different according by Duncan's Multiple Range test.

Effect of the herbicide on broadleaf weeds control

The results showed that Pendimethalin at the two rates tested significantly (P ≤ 0.05) reduced broadleaf weeds infestation as compared to un-weeded check (Table 2). Pendimethalin at 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1} gave 56.50% and 60% % broadleaf weed control, respectively. There were no significant differences between the two herbicide treatments. The broadleaf weeds controlled include; *Ipomoea cordofana, Digera muricata, Sonchus cornutus* and *Amarthus yiridis*.

Effect of the herbicide on total weeds control

The results showed that Pendimethalin at the two rates tested significantly ($P \leq 0.05$) reduced total weed infestation as compared to un-weeded check (Table 2). Pendimethalin at 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1} gave 69.3% and 72% total weeds control, respectively. There were no significant differences between the two herbicide treatments. The total weeds controlled include; *Ipomoea cordofana, Digera muricata, Sonchus cornutus*, *Amarthus yiridis*, *Sorghum sudanens*, *Cynodon dactylon*, *Echinochloa colon*, *Brachiaria eruciformis* and *Eragrostis megatachya*.

Effect of the herbicide on weed ground coverage %

The results showed that Pendimethalin at the two rates tested significantly ($P \leq 0.05$) reduced weed ground coverage as compared to un-weeded check (Table 2). Pendimethalin at 3.6 kg a.i. ha^{-1} and 4.8 kg a.i. ha^{-1} gave 30.75 and 28% weed ground coverage, respectively**.** There were no significant differences between the two herbicide treatments.

Effect of the herbicide on sugar beet crop, growth and number of leaves

Weed competition significantly reduced the number of leaves in the sugar beet by 58.5% compared to the weed free control (Table 3). The high number of leaves/plant (24.6) was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and The low number of leaves/plant (24.1) of sugar beet were obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}. Both were significantly higher than the un-weeded control (12 leaves/plant).

Effect of the herbicide on root length

The results revealed that the herbicide at the two rates tested significantly ($P \leq 0.05$) increased sugar beet root length compared to the un-weeded control (Table 3). The high root length (34.6 cm) in the herbicides treatments was obtained from the application by Pendimethalin at 3.6 kg a.i. ha^{-1} and the low root length (28.7 cm) of sugar beet were obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1} compared to the un-weeded control (15 cm). Unrestricted weed growth significantly increased sugar beet root length by 60%.

Effect of the herbicide on root diameter

Sugar beet root diameter was significantly ($P \leq 0.05$) reduced by 75% in the un-weeded control treatment compared to the hand weeded control (Table 3). The large root diameter (8.6 cm) was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the small root diameter (6.4

cm) of sugar beet were obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1} and both were significantly higher than that obtained in the un-weeded control (2.6 cm).

Table 3. Effect of the herbicide on some growth characteristics of sugar beet.

Treatments	Number of leaves	Root length (cm)	Root diameter (cm)	Leaf fresh weight (g)	Root fresh weight (g)
Pendimethalin at 3.6 kg a.i. ha^{-1}	24.58 b	34.55 b	8.45 b	0.145 b	0.505 bc
Pendimethalin at 4.8 kg a.i. ha^{-1}	24.08 b	28.70 c	6.40 c	0.121 b	0.326 c
Hand weeded control	28.90 a	37.83 a	10.48 a	0.213 a	0.808 a
Un-weeded control	12.00 c	15.00 d	2.625 d	0.015 c	0.061 d
SE±	0.35	0.29	0.19	0	0.02
CV%	3.03%	3.49%	5.23%	9.65%	9.00%

* Means in the same column of followed by the same letter(s) are not significantly ($P \leq 0.05$) different according by Duncan's Multiple Range test.

Effect of the herbicide on leaf fresh weight

Unrestricted weed competition reduced leaf fresh weight by 93% compared to the hand-weeded control (Table 3). The result showed that the high leaf fresh weight (0.145 g/plant) was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the low leaf fresh weight (0.121 g/leaf) of sugar beet was obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}. Both were significantly higher than that of un-weeded control (0.015 g/leaf).

Effect of the herbicide on root fresh weight

Sugar beet root growth was significantly ($P \leq 0.05$) reduced by 93% in the un-weeded control compared with the weeded control (Table 3). In general, herbicide treatments significantly increased sugar beet root yield compared to un-weeded. The high root weight of 0.505 g / plant was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the low root weight 0.326 g/plant was obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}, both were significantly higher than that of un-weeded control (0.061g).

Effect of the herbicide on sugar beet yield and yield quantity

Top yield (ton ha^{-1})

Top yield of the un-weeded control was significantly ($P \leq 0.05$) decreased by 83% compared to the hand weeded control (Table 4). The high top yield (1.44 ton ha^{-1}**)** was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the low top yield (1.25 ton ha^{-1}) of sugar beet was obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}. Both were significantly higher than that of un-weeded control (0.49 ton ha^{-1}).

Table 4. Effect of the herbicide on yield quantity of sugar beet**.**

Treatments	Top yield (ton ha^{-1})	Root yield (ton ha^{-1})	Gross sugar yield (kg ha^{-1})
Pendimethalin at 3.6 kg a.i. ha^{-1}	1.44 b	5.00 ab	0.74 bc
Pendimethalin at 4.8 kg a.i. ha^{-1}	1.25 c	3.87 bc	0.52 cd
Hand weeded control	2.01 a	8.00 a	1.43 a
Un-weeded control	0.49 d	1.57 c	0.150 d
SE±	0.06	0.24	0.04
CV%	8.65 %	9.30 %	%9.67

* Means in the same column of followed by the same letter(s) are not significantly ($P \leq 0.05$) different according by Duncan's Multiple Range test.

Root yield (ton/ ha)

Unrestricted weed competition reduced root yield of the un-weeded control by 90% compared to the weeded control (Table 4). The result also showed that the high root yield (5.0 ton ha^{-1}) was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the low root yield (3.87 ton ha^{-1}) of sugar beet root yield were obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}, both were significantly ($P \leq 0.05$) higher than that of the un-weeded control (1.57 ton ha^{-1}) and comparable to hand weeded treatment (2.01 ton ha^{-1}).

Gross sugar yield (kg/ ha)

The result showed that the high gross sugar yield (0.74 kh ha^{-1}) was obtained from the application by Pendimethalin at 3.6 kg a.i. ha^{-1} and low gross sugar yield (0.52 kg ha^{-1}) was obtained from the application of Pendimethalin at 4.8 kg a.i ha^{-1}. Both herbicide rates were significantly higher than that of un-weeded control (0.150 kg ha^{-1}) and comparable to hand weeded treatment (1.43 kg ha^{-1}).

Effect of the herbicide on the yield quality

Sucrose %

The result revealed that the herbicide treatments significantly ($P \leq 0.05$) reduced sugar beet sucrose % as compared to hand-weeded (Table 5). However, Pendimethalin at 3.6-4.8 kg a.i. ha^{-1} gave significantly high sucrose % as compared to un-weeded check. With the highest sucrose % in response to Pendimethalin at 3.6 kg a.i. ha^{-1}.

Total soluble solids (T.S.S. %)

Total soluble solids (T.S.S. %) increased significantly (P ≤ 0.05) in response to herbicide application compared to un-weeded control (Table 5). Pendimethalin at the two rates tested (3.6 and 4.8 kg a.i. ha^{-1}) gave 17.8-18.8% in comparison with un-weeded control (9.5%). There were significant differences between the two herbicide treatments.

Purity %

Purity% increased significantly (P≤0.05) in response to herbicide application (Table 5). Pendimethalin at the two rats tested (3.6–4.8 kg a.i. ha^{-1}) gave 76.0-79.36% and they were significantly different as compared with un-weeded control (47.6%). However, there were no significant differences between the two herbicide treatments compared to hand. In general, the results obtained in this study showed that weed infestation for the whole season in sugar beet caused significant reduction in growth and yield of sugar beet crop compared to hand-weeded control. These findings agreed with Poorazar and Ghadiri, (2001) who reported that competition between sugar beet and annual weeds could be responsible for sugar yield reductions of 25-100%.

Table 5. Effect of the herbicide on the yield quality of sugar beet quality**.**

Treatments	Sucrose % (Pol)	T.S.S % (Brix)	Purity %
Pendimethalin at 3.6 kg a.i. ha^{-1}	14.88 b	18.75 b	79.36 b
Pendimethalin at 4.8 kg a.i. ha^{-1}	13.50 c	17.75 c	76.00 b
Hand weeded control	18.50 a	19.00 a	97.25 a
Un-weeded control	4.50 d	9.50 d	47.36 c
SE±	0.45	1.13	2.33
CV%	6.11 %	3.92 %	5.77 %

* Means in the same column of followed by the same letter(s) are not significantly (P ≤ 0.05) different according by Duncan's Multiple Range test.

The herbicide Pendimethalin at 3.6 - 4.8 kg a.i. ha^{-1} gives high seedling emergence (72.8 – 87%) in sugar beet crop, although they were slightly phytotoxic the plants. Pendimethalin was reported to injure sugar beet plant. Most tested herbicides for weed control in sugar beet in Sudan were phytotoxic to the crop. To minimize the phytotoxicity the tested herbicides in this study were applied pre-sowing and the plots were irrigated twice before planting sugar beet. Therefore, the herbicide Pendimethalin at 3.6 and 4.8 kg a.i. ha^{-1} applied pre-sowing were slightly phytotoxic on sugar beet plant. This could be attributed to dilution caused by leaching of the herbicide from the soil surface. This could be attributed to dilution caused by leaching of the herbicide from the soil surface. Shaner (2012) reported that pendimethalin dissipated in two phases, an initial rapid loss between application and 3 to 5 days after application and then a slower rate of dissipation, and remained near the soil surface. It was also found that pendimethalin soil half-life ranged from 10.5

to 31.5 days, and was affected mainly by the time interval between application and the first rain event (Claudio et al. 2009).

The results showed that Pendimethalin at the lower rate 3.6 kg a.i. ha^{-1} gave 82% grass weed control and 56% broadleaved weed control. Pendimethalin is selective herbicide effective against most annual grasses and annual broad leaved it can be applied pre-emergence after seeding in cereals, maize and rice or with shallow soil incorporation before seeding beans, cotton, groundnuts and soybeans. In vegetable crops it can be applied pre-emergence or pre-transplanting. It also used to control suckers in tobacco (Charles and Worthing, 1983). Tomlin, (2000) stated that the pendimethalin is used to control weeds in cereals, onions, potatoes, cotton and berry fruits, peas, field beans, soya bean, garlic, hops, fruit, maize, sorghum, rice and carrot. Applied as pre-plant incorporated, pre-emergence, pre-transplanting or post-emergence.

The result showed that high sugar beet growth and yield was obtained from the application of Pendimethalin at 3.6 kg a.i. ha^{-1} and the low growth and yield was obtained from the application of Pendimethalin at 4.8 kg a.i. ha^{-1}. They were significantly higher than that un-weeded control and often and comparable to hand weeded treatment. The high top yield (1.44 ton ha^{-1}), root yield (5.0 ton ha^{-1}) and gross sugar yield (0.74 kg ha^{-1}) and was obtained from the application of Pendimethalin at 1.92 kg a.i. ha^{-1}. It was significantly higher than that of the un-weeded control and comparable to hand weeded treatment. These results were in agreement of that reported by Maher, (2013) who found that the highest root diameter was obtained when sugar beet was weed free the whole season and the lowest root diameter was obtained from weed infestation for whole season. This could be due to the effect of herbicide treatment in controlling weeds and thus reducing the competitive effects of weeds on sugar beet growth and yield. In general, there were significant differences in efficacy and selectivity between the two herbicide rates.

Conclusion

The results showed that the Pendimethalin at 3.6 kg a.i. ha^{-1} was relatively safe as it causes slight phytotoxicity to sugar beet when applied two weeks before crop sowing. It was considerably controlled grassy weeds in sugar beet and hence the sugar beet yield was increased compared to the un-weeded control. Therefore, it is possible to use Pendimethalin effectively, selectivity and safely to minimize weed infestation in sugar beet two week before sowing the crop where the crop is very weak to compete with weeds.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

Charles R, Worthing B. 1983. The *pesticide manual*. Seven Editions. British Crop Production Council, Pp. 423.

Claudio A, Alister P.A, Gomez S.R, Marcelo K. 2009. Pendimethalin and oxyfluorfen degradation under two irrigation conditions over four years' application. J Environ Sci Health Part B. 44(4): 337-343.

Dale T.M, Renner K.A. 2005. Timing of post emergence micro-rate application sbased on growing degree days in sugar beet. J Sugar Beet Res. 42: 87-102.

Dale T.M, McGrath J.M, Renner K.A. 2005. Response of sugar beet varieties and populations to post emergence herbicides. J Sugar Beet Res. 42: 119-126.

Deveikyte I. 2005. Sensitivity of *Tripleurospermum perforatum* and *Chenopodium Album* on low rates of phenmedipham, desmedipham, etofumesate, metamitron and chloridazon. Lucrari Stiintifice, Universitatea de Stiinte Agricole Si Medicina Veterinara "Ion Ionescu de la Brad" Iasi, Seria Agronomie, (48): 386-392.

Dieleman J.A, Mortensen D.A. 1998. Influence of weed biology and ecology on development of reduced dose strategies for integrated weed management.

Heidari G.H, Dabbagh M.A, Javanshir A, RahimzadehKhoie F, Moghaddam M. 2007. Influence of redroot pigweed (*Amaranthus retroflexus* L.) emergence time and density on yield and quality of two sugar beet cultivars. J Food Agric Environ. 5: 261-266.

Heydens W.F, Lamb I.C, Wilson A.G.E. 2010. Chloracetanilides. In: Handbook of Pesticide Toxicology. Third Edition. Pages 1753-1769. https://doi.org/10.1016/C2009-1-03818-0.

Lajos K, Lajos M. 2000. Weed control with reduced herbicide applications in sugar beets Hungary. J Plant Disease Protec. 7: 623-627.

Maher O. 2013. Determination of critical period of weed Competition with sugar beet (*Beta vulgaris* L.) and weed control, Department of Agronomy Faculty of Agriculture Assiut University.pp.63.

Majidi M, Heidari G, Mohammadi K. 2011. Management of broad- leaved Weeds by combination of herbicides in sugar beet production. Adv Environ Biol. 5(10): 3302-3306.

May M. 2001. Crop protection in sugar beet. Pesticide Outlook. 12: 188-191.

Mehdizadeh M, Alebrahim M.T, Roushani M, Streibig J.C. 2016. Evaluation of four different crops' sensitivity to sulfosulfuron and tribenuron methyl soil residues. Acta Agric Scand B Soil Plant Sci. 66:706-713. https://doi.org/10.1080/09064710.2016.1212919

Mehdizadeh M, Mushtaq W. 2020. Biological Control of Weeds by Allelopathic Compounds from Different Plants: A BioHerbicide Approach. In: Egbuna C, Sawicka B. Natural Remedies for Pest, Disease and Weed Control. Academic Press. 107-117. https://doi.org/10.1016/B978-0-12-819304-4.00009-9

Petersen J. 2003. A review on weed control in sugar beet: from tolerance zero to period threshold. In Derjit (ed): Weed biology and Management. Kluwer Academic Publishers, Dordrecht. 467-483.

Poorazar R, Ghadiri H. 2001. Competition of wild oat (*Avena fatua* L.) with three wheat (*Triticum aestivum* L.) cultivars in greenhouse: Plant density effect. Iran. Iranian J Crop Sci. 3: 59-72.

Salehi F, Esfandiari H, Mashhadi H.R. 2006. Critical period of weed control in sugar beet in Shaheekord Region. Iranian J Weed Sci. 2(2): 1-12.

Schwizer E.E, May M.J. 1993. Weeds and weed control. In Cooke, D.A. and Scott, R.K. (eds). The Sugar Beet Crop: Science into Practice. Chapman and Hall, London: 485-519.

Scott R.K, Wilcockson S.J, Moisey F.R. 1979. The effects of time of weed removal on growth and yield of sugar beet. Agric Sci. 93: 693-709.

Senseman S.A. 2007. Herbicide handbook. 9th ed. Weed Science Society of America, Champaign, IL. 458 pp.

Shaner D.L. 2012. Field dissipation of sulfentrazone and pendimethalin in Colorado. Weed Technol. 26(4): 633-63.

Tomlin C. 2000. The pesticide Manual.Twelfth Edition.*Crop* Protection Publication. Pp533.

Weaver S.E, Williams E.L. 1980. The biology of Canadian weeds *Amaranthus hybridus* (*Retro flexus* L)., (*Amaranthu spowellii* S). Wats. and (*Amaranthus hybridus* L.). Canadian J Plant Sci. 60:1215-1234.

Wilson R.G, Smith J.A, Yonts C.D. 2005. Repeated reduced rates of broadleaf herbicides in combination with methylated seed oil for post emergence weed control in sugar beet (*Beta vulgaris* L,). Weed Technol. 19: 855-860.

Zain S.A.M, Dafaallah A.B, Mohamed S, Zaroug M.S. 2020. Efficacy and Selectivity of Pendimethalin for Weed Control in Soybean (*Glycine max* (L.) Merr.), Gezira State, Sudan. Agric Sci Pract. 7(1): 59-68.

Cite this article as: Ahmed M. Yagoob, Mohamed S. A. Zaroug, Awadallah B. Dafaallah. 2021. Efficacy and selectivity of pendimethalin for weed control in sugar beet (*Beta vulgaris* L.), Gezira state, Sudan. *Journal of Research in Weed Science*, 4(1), 16-28. DOI: 10.26655/JRWEEDSCI.2021.1.2